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Minerals Yearbook 1967

Volume I—II

METALS, MINERALS, AND FUELS

Prepared by staff of the
BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR • Stewart L. Udall, Secretary

BUREAU OF MINES • John F. O'Leary, 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 parks and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States—now and in the future.

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Foreword

This edition of the Minerals Yearbook, covering calendar year 1967, marks the 86th year in which the Federal Government has issued, on an annual basis, a report on the U.S. mineral industry. In response to the desires of our readership, this 1967 edition has returned essentially to the Yearbook format in use prior to 1966, with some minor modifications. The general content of this edition follows:

Volume I–II, Metals, Minerals, and Fuels, contains all the chapters on the metal, nonmetal, and mineral fuel commodities that previously appeared in the separate *Volume I, Metals and Minerals*, and *Volume II, Mineral Fuels*. In addition, it includes a chapter reviewing these mineral industries, a statistical summary, and chapters on employment and injuries, and technologic trends. As in Yearbooks prior to 1966, text accompanies the statistical presentation. Some of the longer chapters have been redesigned so that the tabular presentation follows the text, rather than being interspersed throughout the text as in the past.

Volume III, Area Reports: Domestic, contains chapters covering 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. Volume III also has a statistical summary chapter, identical with that in Volume I–II, and a chapter on employment and injuries.

Volume IV, Area Reports: International, which was not published in 1966, has been reinstated. This volume contains 85 chapters presenting the latest available mineral statistics for more than 130 foreign countries and areas, and discusses the importance of minerals to the economies of these nations. A separate chapter reviews minerals in the world economy.

The continuous effort of the Bureau of Mines to enhance the value of the Yearbook for its readership can be aided by comments and suggestions from its users; such comments are invited.

JOHN F. O'LEARY, *Director*

Acknowledgments

The chapters in this volume were prepared by the staff of the Division of Mineral Studies, except for the Review of the Mineral Industries, Statistical Summary, Injury Experience and Worktime in the Mineral Industries, and Helium chapters.

Statistical data on the U.S. mineral industry were collected and compiled by the staff of the Division of Statistics. These data are based largely upon information supplied by mineral producers, processors, and users, and acknowledgment is hereby made of this indispensable cooperation given by industry. Information obtained from individuals through confidential surveys has been grouped to provide statistical aggregates. Data on individual producers are presented only if available from published or other nonconfidential sources, or when permission of the individuals concerned has been granted. Tables on U.S. foreign trade were compiled from Bureau of the Census data.

World production and foreign country trade tables were compiled in the Division of International Activities from many sources including reports from the Foreign Service, U.S. Department of State.

The Minerals Yearbook staff provided general direction on the preparation and coordination of the chapters in this volume and also reviewed the manuscripts to insure statistical consistency among the tables, figures, and text between this volume and other volumes, and between this volume 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 assissted in collecting mine-production data and the supporting information appearing in the Minerals Yearbook by more than 45 cooperating State agencies. These organizations are listed in the acknowledgment section of Volume III.

ALBERT E. SCHRECK,
Editor-In-Chief

Contents

Review of the Mineral Industries

By Olman Hee,[1] Charles L. Readling,[2] and Jeannette I. Baker[3]

Activity in the minerals industries during 1967 was sustained by the seventh consecutive year of economic expansion. Though the opening months of 1967 indicated that the domestic economy was in a brief pause, the second half reflected a strong and sustained recovery. As a result, the U.S. economy as a whole showed record level annual averages for production, sales, and employment.

However, the gains in 1967 were not as great as were those in 1966. For the first 6 months, actual demand failed to live up to expectations, sales fell below production by an abnormally wide margin, and inventories piled up. Expansionary fiscal and monetary policies were put into motion to sustain expansion in the second half of the year. Due to the renewed strength of demand in the third and fourth quarters, consumer prices increased 2.8 percent. In the minerals economy, the copper strike, beginning July 15 and lasting throughout the year, was one of the major problems. Its occurrence had a notable impact on total mineral output, and especially on metal mining production, employment, and income.

The value of the Nation's total output of goods and services—gross national product (GNP)—in 1967 rose $42 billion to a new high of $785 billion. When corrected for price changes, the real value of GNP (in 1958 prices) was $669 billion or an increase of 2.5 percent over the previous year. There was a marked change of pace in economic activity between the first and second halves of the year. Growth of real GNP was at a yearly rate of 1.5 percent in the first half but rose to 4.5 percent in the second half.

Demand on the part of the total private economy in 1967 worked toward restoring a balance between particular sectors that were disrupted in 1966, especially in inventory investment and business fixed investment. Total new construction and expenditures showed renewed strength. Government expenditures for goods and services in 1967 comprised a slightly higher share of GNP compared with 1966, but about the same share as the average for 1955–61.

The Federal Reserve Index of Industrial Production rose 1 percent in 1967 from the 1966 level, with mining, nondurable manufactures, and utilities showing moderate gains, while durable manufacturing registered a decline. Total U.S. employment increased 2.0 percent from 1966 to 1967, and U.S. personal disposable income per capita—corrected for price changes—rose 3.2 percent. Both of these categories showed a slightly lower level of increase compared with 1966. Employment in total mining (including fuels), in 1967, showed a decline, with employment in metal mining declining appreciably. Much of this decline was due to the copper strike, which lasted throughout the second half of the year. Total U.S. unemployment remained at its lowest level in a decade, averaging about 3.8 percent of the total labor force for the second straight year.

Total mining output was up modestly but showed a relatively smaller gain than in 1966. Production in metal mining was down materially in 1967; mining of stone and earth minerals was up slightly; and coal, oil, and gas output was up moderately. The generally rapid gains in production of iron and steel and nonferrous metals of past years were reversed materially in 1967. Production in these two categories in 1967 showed declines of 10 and 13 index points respectively. Trends in imports of ferrous ores and nonferrous base metal ores were mixed

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in 1967. Increases in imports were registered in many iron and steel product categories. Net supply was down in 1967 for many light and heavy metals for which it had tended to peak in 1966.

Developments on the international scene during 1967 left a lasting imprint on the United States and rest-of-the-world economies. Such events, as the strain on the international monetary system, the devaluation of the British pound, the completion of the Kennedy Round tariff negotiations, and the weakening of many nations' gold reserve positions had important implications for continued progress and expansion of the U.S. economy.

Federal Government activities during 1967 were concerned with remedial measures to counteract a sluggish economy in the first and second quarters. Remedial fiscal and monetary policies were set into motion in this period. The investment tax credit restored in the spring of 1967 and renewed emphasis to supply ready credit helped the industrial sector, including some mineral industries, to sustain production and employment. Disposal of stockpile material slowed materially in 1967 with 58 percent less sales commitments made in that year compared with 1966. The Office of Minerals Exploration continued to encourage exploration to locate new domestic sources of essential materials by providing financial assistance. Government assistance programs on 37 contracts were largely directed to exploration for gold, silver, platinum, and nickel.

Anxieties and speculation in the world financial markets contributed to a sharp widening of the U.S. balance of payments deficit in the fourth quarter. The U.S. Government responded decisively with a major program to move our balance of payments strongly toward equilibrium. Measures put into effect to insure strength of the dollar and the health of the economy at home were: Restraint of direct investment by U.S. investors in plant and equipment abroad and restraint of foreign lending by U.S. banks and lending institutions.

Official U.S. holdings of gold reserves declined materially in 1967. These reserves were used primarily to meet the demand for gold on the London free market. A deficit in domestic silver production also induced withdrawal of silver stocks, chiefly U.S. treasury bullion stock.

In an attempt to assure adequate mineral resources for future needs, Bureau of Mines obligations of funds for fiscal 1968 were increased 5 percent. Major thrusts of Bureau of Mines Research programs were directly concerned with future supply and demand contingencies with respect to minerals and fossil fuels. Programs also were planned to alleviate land and air pollution. In addition, the Bureau sponsored a number of outside and inhouse projects on solid waste disposal. These projects dealt with scrap processing, municipal wastes, and mine waste. Current projects in metals research included new processes for the economical recovery of copper, and the recovery of gold from electronic scrap, scrap solder, and carbonaceous ores. Programs also were under way in nonmetallic minerals research to stimulate production of minerals in short supply. Research on recovery of sulfur from gypsum and from effluent of coal-burning plants was undertaken.

Ongoing and contemplated Bureau programs have been encouraging and promoting the advancement of technology to provide for the Nation's future mineral and fossil fuel needs at reasonable cost and at no sacrifice in environmental quality.

The most pressing problems besetting the mineral industries are for the most part not problems related to individual commodities or groups of commodities. Rather, they are problems of total mineral production, broadly defined, plus the wise use of minerals and mineral products. Rapidly changing demands for materials and products are bringing to the fore changes in our mineral needs. Government policies and activities can help to assure that an adequate flow of minerals and mineral products is forthcoming in the years ahead.

SUPPLY AND DEMAND

Production.—Domestic production of primary minerals and mineral fuels in 1967 was valued at $23.7 billion in current dollars, or $0.7 billion more than in 1966 (table 1). In 1957–59 constant dollars, the value of mineral production was $22.7 billion, or 1.8 percent more than in 1966. In 1967, fuels showed the only constant dollar increase, 4.8 percent. Nonmetals, declined 0.2 percent, and metals, 13.9 percent.

Overall, total mineral production in the United States in 1967 showed only a modest increase. While production of mineral fuels continued strong, output for nonmetallic minerals was up only slightly, and for primary metals, it was down moderately to substantially. The Bureau of Mines index of physical volume of production (1957–59=100) showed ferrous metals down moderately and nonferrous metals down substantially. Figure 1 shows historical trends of production for selected major mineral commodities. The chart indicates: The relatively rapid rise of copper production from 1959–60 to 1966 and the precipitous drop in output in 1967; the irregular but moderately rising pattern for iron ore production through 1966 and a moderate downtrend in 1967; and the reversal of the downtrend of consumption of coal—1947–54

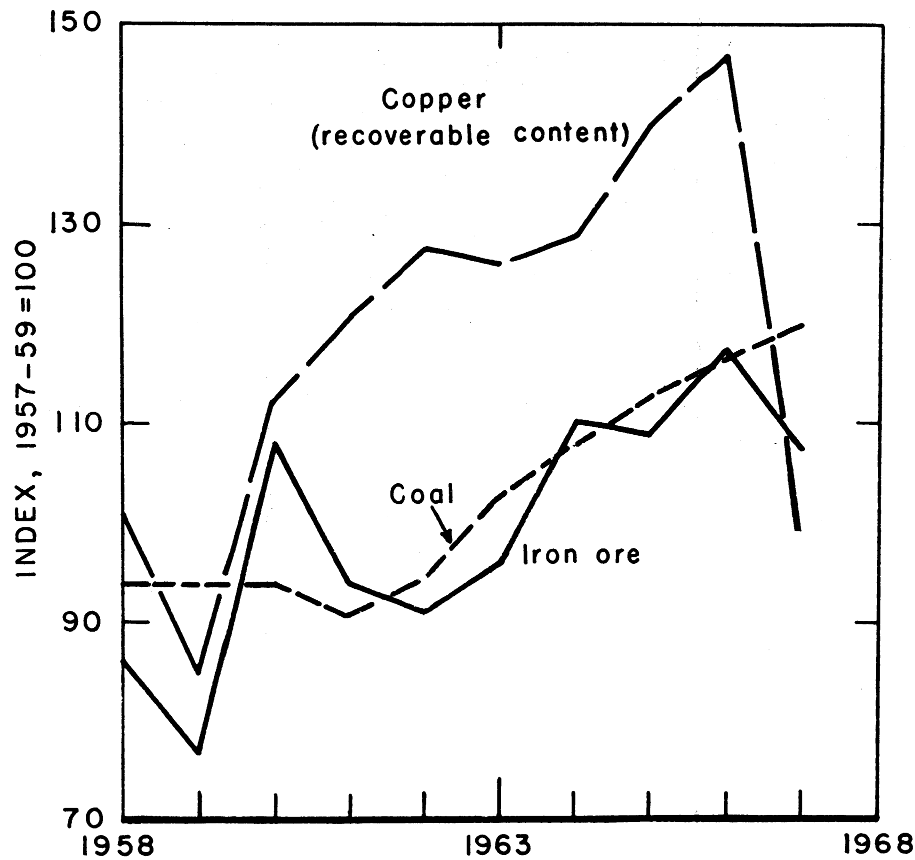

Figure 1.—Indexes of physical volume of mineral production for selected items in the United States.

(not shown in chart) and the beginning of a sustained increase in 1962. The index for iron ore for 1967 was 108, down 10 index points; the index for copper was 99, down 49 index points; and the index for coal was 120, up 4 index points. Copper production showed the biggest change, due to the strike which continued during the latter half of 1967. (See table 2 in the statistical summary which shows both production and value for minerals and mineral fuels in 1967.)

The Federal Reserve Board (FRB) index of industrial production for both mining and total U.S. production showed only slight relative gains in 1967. The preliminary published data show that the index of total industrial production increased 1.7 points to 158.0, while the total mining component of the index rose 3.0 points to 123.5. The primary metals component was down 10.2 points to 132.5; ferrous metals was down 9.4 points to 126.8; nonferrous metals and products was down 13.1 points to 153.1; stone and earth minerals was up 1.9 points to 135.4; and coal, oil and gas was up 4.6 points to 122.4.

Mining components of the FRB index of industrial production reflect the same trends as the Bureau of Mines index of physical volume of production. Among the ferrous metals and ores, iron ore production was down 7 percent and steel production declined 5 percent. In the nonferrous metals category, copper production from domestic ores was down 33 percent; primary aluminum production was up 10 percent; and primary lead and zinc production were down 3 and 4 percent, respectively.

Among the major nonmetals produced in 1967, cement, stone, sand, and gravel combined constituted about 70 percent of the total value of nonmetals production. Cement production in 1967, at 385.8 million barrels, was down 4 percent; crushed and broken stone output was down 4 percent; and sand and gravel production was down 3 percent.

In 1967, the fossil fuels group produced a total heat or caloric value equivalent to 52,862 trillion British thermal units (Btu). Heat value of primary electricity produced at hydropower and nuclear-powered plants when added to that of mineral fossil fuels brought the total to 55,276 trillion Btu. This was a record level and 5.8 percent higher than in 1966.

Primary fossil fuels continued to supply the bulk of the Nation's energy supplies during 1967. Natural gas and component liquids remained the ranking energy source during the year with a marketed production of 18,171.3 billion cubic feet, 36 percent of total energy output. Crude petroleum held its position with a production of 3,215.7 million barrels, accounting for 33 percent of total energy produced. Because of the Arab-Israeli conflict in June 1967 domestic production of crude petroleum was increased to compensate for lower imports and to provide more crude for export. Production of bituminous coal and lignite gained 17.1 million short tons to a total of 551 million short tons, continuing its upward trend of past years. Anthracite continued to show a slight decline with a production of 12.3 million short tons. Bituminous coal and lignite accounted for 26 percent of total energy during the year. The balance of supply, approximately 5 percent, came from primary electricity generated at hydropower and nuclear-powered plants.

The net supply of most minerals declined in 1967. Among the exceptions to the general decline in supply of ferrous and nonferrous metals were manganese, lead and titanium which showed slight increases. For nonmetals, exception to the decline in supply were potash, sulfur, and salt. Among the ferrous metals, imports for iron ore and pig iron changed little in 1967 over those in 1966. Among the nonferrous metals, imports for copper, lead, and tin increased substantially. Imports in the nonmetals category were mostly unchanged in 1967.

Changes in the relative shares of domestic and foreign sources of supply occurred in a few selected minerals from 1966 to 1967. More reliance upon foreign sources for copper and lead resulted in 1967. Fewer supplies from foreign sources occurred for cobalt, uranium, and mercury. Contracts in force by AEC for imports of uranium expired in 1966. Though private industry imported 1,300 tons of uranium in 1967, total uranium imports declined in that year.

Consumption.—Among the major metals, changes in 1967 in both ferrous and nonferrous commodity categories were mainly downward (table 7). Iron ore and raw steel consumption (ferrous category) were down 6,623 thousand long tons and 6,888 thousand short tons, respecitively. Among the nonferrous group, copper consumption was down 18 percent while, by contrast, aluminum consumption was up 0.2 percent. Uranium consumption (U_3O_8) fell 1,062 short tons during the year to a total of 8,425 short tons.

A forecast made from an econometric model as a part of a comprehensive Bureau of Mines study of demand for aggregate steel and steel products, using steel prices, price of substitutes, and income as the chief explanatory variables, gave a projected consumption to 1980 of 154.0 million short tons.

Among the major nonmetals, cement consumption dropped to 378 million barrels in 1967, or 16 million barrels less than in 1966. Crushed stone for all uses totaled 784 million short tons or 27 million short tons under 1966. Sand and gravel consumption dropped to 905 million short tons in 1967 from 934 million short tons in 1966. Among the important nonmetal commodities which registered increases in consumption in 1967 were potash raw materials, up 3 percent; phosphate rock, up 2 percent; sulfur, up 2 percent; and salt, up 7 percent.

Forecasts from a Bureau study of demand for chemical raw materials, using own price, price in an alternative use, and income as explanatory variables gave projected consumption estimates to 1980 for phosphorus (P_2O_5 content) as follows: For agricultural use, 7.9 million short tons; for industrial use, 4.3 million short tons; and for export use, 6.0 million short tons.

Total energy consumption in the United States reached a new high in 1967, 58.9 quadrillion Btu, an increase of 3.3 percent over 1966. It was estimated that by the year 1980 U.S. energy requirements will total about 88 quadrillion Btu. Among the energy resources available in 1967, petroleum and natural gas liquids were 43 percent of total energy resources consumed; natural gas was 31 percent; and 4 percent came from hydropower and nuclear.

Natural gas consumption rose to 17,685 million cubic feet in 1967, an increase of 4.9 percent over that of 1966. Liquefied natural gas consumption also increased in importance in 1967 relative to total gas energy consumption. The technology of liquefied natural gas has given natural gas a mobility which could permit this type of fuel produced in foreign areas to be utilized and marketed in the United States.

Petroleum registered a gain in 1967 of 3.9 percent, increasing to 4,584 million barrels. Due to increasing demand, there was increased activity to tap new sources and to develop new techniques in crude petroleum. During the fall of 1967, the first synthetic crude oil was produced from tar sands in North America. This oil was produced by a process which separated the refinable bitumen from sand, shale, and clay. Synthetic oil produced from oil shale could provide an alternative source of petroleum products in the United States. This synthetic oil may become fully competitive with natural crude.

Bituminous coal consumption in the United States in 1967 was about 480 million short tons, a decrease of about 1.2 percent from 1966. The electric utility industry continued to be the largest consumer, utilizing 272 million tons of coal in 1967, or about 2.9 percent more than in 1966. Industrial uses accounted for 186 million tons, of which, 92 million tons were used to make coke; 17 million tons were used for retail delivery; 9 million tons for cement mills; and 6 million tons for steel and rolling mills. Development of mine-mouth generating stations, which use high-voltage transmission lines to transport power, has been an important factor in the increased use of coal by electric utilities.

Nuclear energy continued as a major competitor in the utility market in 1967, comprising about 45 percent of the orders for steam generating equipment. TVA, in 1967, approved a contract for a record capacity generator—1,300 milliwatt—for coal firing.

While nuclear and water power are small fractions of total energy consumption, they showed the greatest proportional increase in 1967, 31.0 percent and 12.8 percent, respectively. Total net generation at electric utilities in 1967 was 1,211.7 billion kilowatt-hours, an increase of 5.9 percent over the previous year.

The household and commercial sector accounted for 22 percent of total energy resources consumed in 1967. With the exception of coal, energy resource inputs into this sector continued to increase. Sector inputs of electricity increased 4.8 percent in 1967 and the sector absorbed 7.9 percent of the total generation of utility electricity. Fossil fuels consumed directly remained the principal source of energy in the household and commercial sector.

The industrial sector remained the major energy market in 1967, using 32 percent of the total energy consumption. Sector energy use increased 1.4 percent over the previous year. While electric use and the direct fuel uses, petroleum and natural gas, continued to grow in 1967, bituminous coal showed a decline of 4.9 percent.

In 1967, the transportation sector accounted for 24 percent of total energy consumption. The demand in this sector for energy was 5 percent over that for 1966. The bulk of demand continued to be met by petroleum products.

The electric utility sector again accounted for approximately 21 percent of the total energy resource inputs in 1967 as it did in 1966. Sector inputs, including both fossil fuels and primary electricity, increased 6.2 percent over 1966.

Fossil fuels consumed at conventional fuel-burning plants accounted for 81 percent of sector inputs; the remaining 19 percent represented theoretical inputs (based on coal equivalent of electricity generated) for hydropower and nuclear-powered plants. Hydropower continued to supply the bulk of the primary utility electricity generated. Coal accounted for 63 percent of the total inputs of fossil fuels consumed at conventional fuel-burning plants in 1967. Natural gas accounted for 27 percent and residual fuel oil for 10 percent of utility inputs.

Shipments and Orders.—In 1967, shipments of primary metals and blast furnace industries each declined about 6 percent. Monthly figures for 1967 show that shipments of primary metals declined moderately in the first and second quarters. Annual net new orders for primary metals were down 10 percent, and for blast furnace industries, down 8 percent. Monthly figures show that net new orders for primary metals and blast furnace industries rose substantially in the fourth quarter from the low level set in the first quarter. Unfilled orders in 1967 for primary metals declined 6 percent compared with those of 1966, while for blast furnace industries they increased by a like amount. Unfilled orders recorded by months declined for primary metals in the first two quarters, while for blast furnace industries they tended to rise from the first to the last quarter.

Stocks.—The Bureau of Mines index of stocks of crude minerals at mines was unchanged at 107 (1957–59=100) in 1967. The total metals index increased with both ferrous and nonferrous metals contributing to the increase. Stocks of nonmetals declined 10 index points, largely the result of a drawdown in sulfur stocks.

Seasonally adjusted book values of inventories in the mineral processing industries were up slightly for petroleum and coal products and approximately unchanged for stone, clay, and glass products at 1967 yearend. However, book values of inventories for blast furnace and steel mills and other primary metals were up moderately.

Foreign Trade.—Total value of exports of minerals and mineral fuels for the year was $3,554 million. Value of imports exceeded value of exports by $3,175 million, representing a deficit item in the U.S. balance of payments trade account. The value of nonfuel minerals imported during 1967 was $4,487 million or 59.5 percent of the value of domestic production of all non-fuel minerals.

The percentage distribution of exports of selected minerals in 1967, by origin, shows that iron and steel scrap was exported chiefly to Asia, North America, and Europe. Nonferrous metal scrap was exported chiefly to Europe and Asia. Aluminum and aluminum products were exported to North America, Europe, and Asia. Crude fertilizers also were exported chiefly to the areas just mentioned. Crude petroleum was exported chiefly to Europe.

The 1967 value of imports for selected minerals and mineral products, at $6,730 million, was virtually unchanged from the $6,723 million of imports of these items in 1966 (table 17).

The percentage distribution of imports of minerals and mineral fuels in

1967, by origin, shows that ores and concentrates where chiefly imported from North America (Canada); South America (Venezuela, Chile, and Peru); and Asia (Philippines). Among the nonmetallic crude minerals group, phosphate and potassic fertilizers were mainly imported from North America (Canada). Among the mineral fuels, crude petroleum and petroleum products were imported mainly from North America (Canada, Trinidad, and Netherlands Antilles); South America (Venezuela); and Asia (Saudi Arabia, Iran, and Indonesia).

EMPLOYMENT AND PRODUCTIVITY

Employment.—Employment gains in the mineral industries were spotty in 1967, due in part to the copper strike, with some gains and declines over the previous year in both the metal mining and mineral fuels industries (table 24). The small gain in employment in the nonmetal mining and quarrying category was more than offset by the loss in metal mining and mineral fuels. As a result, employment in total mining showed the greatest decline since 1964.

Percentage change in employment in 1967 compared with 1966 by groupings are shown below:

	Percent
All industries	+3.1
Mining (including fuels)	−2.0
Metal mining	−8.6
Nonmetal mining and quarrying	+.1
Coal mining	+3.1
Crude petroleum and natural gas	−1.7
Oil and gas field services	−5.3
Manufacturing	
Minerals [1]	−3.1
Fuels	+1.8

[1] Based on selected items given in table 24.

Employment in minerals manufacturing industries was universally down in 1967 from the previous year's level. Employment in blast furnaces, steel works, and rolling mills and in nonferrous smelting and refining industries showed declines of more than 3 percent. Employment in fuels manufacturing showed a gain of almost 2 percent. Employment in all industries, U.S. total, showed slightly less gain in 1967 compared with the two previous years.

Hours and Earnings.—Average hours worked in the nonfuel mining industries declined slightly in 1967, while hourly and weekly earnings increased 2.5 and 2.3 percent, respectively. Because of fewer hours worked, the percentage increase for weekly earnings was lower compared with hourly earnings. For the mineral fuels group, average hours worked increased slightly compared with the previous year, with the highest increase reflected in coal mining. Weekly earnings in coal mining increased 3.4 percent.

Average hours worked increased 0.7 percent in 1967 for workers in petroleum refining and related products. For all other minerals and mineral fuels manufacturing industries average hours worked declined. Increase in hourly earnings in various categories of minerals and fuels manufacturing ranged from 1 to 5 percent. Increases in weekly earnings in this group ranged from less than 0.5 percent to around 6 percent. The average increase in weekly earnings for selected categories studied in minerals and mineral fuels manufacturing industries was 2.6 percent.

Labor Turnover Rates.—Accession rates for metal mining remained stable in 1967 compared with manufacturing, in which they declined moderately from the previous year. A sizeable increase occurred in the accession rate for iron ore mining but this was offset by a decline in copper ore and other mining. Separation rates increased in all metal mining, with the largest increase in the copper ore category. The layoff rates in all metal mining increased almost 30 percent from 1966. Accession, separation, and layoff rates for 1967 for the mineral manufacturing industries were mixed. Blast furnaces, steel and rolling mills, and nonferrous smelting and refining industries had generally similar accession and separation rates but different layoff rates. Hydraulic cement, blast furnaces, and steel and rolling mills had generally similar separation and layoff rates. In mineral fuels manufacturing, increases in 1967 accession and separation rates in petroleum refining and related industries were matched by decreases and no change, respectively, in these rates in coal mining. Layoff rates remained stable for petroleum refining and related industries while for coal mining they were 45 percent lower.

Wages and Salaries.—Wages and salaries in the mining industry in 1967, including fuels, continued the upward trend set several years before. The percent increase in 1967 in the mineral industries was slightly lower compared to 7.3 and 4.8 percent gains reported for all industries and manufacturing, respectively. Average earnings per full-time employee, in 1967, continued to be higher for mining employees, at $7,545 annually, compared with an average of $6.879 in manufacturing industries and $6,209 in all industries. Wages and salaries in mining comprised 3.5 percent of that in manufacturing and 1 percent of that in all industries.

Productivity.—The 1966 productivity indexes (most recent data available) indicate the generally rising trend of production per man-hour in important sectors of mining. Increases in production per man-hour are the result of improved mechanization, automation, and training programs for workers. Production per man-hour for copper ore and recoverable copper mined increased, while that for usable iron ore mined remained the same. For iron ore, the overall production per man-hour declined slightly due to declines in productivity of hematite and magnetite ores which more than offset gains in taconite ore mining. Productivity showed a marked increase in the bituminous coal and lignite group and in the petroleum refining sector. In the instances where labor productivity declined, the explanation generally was that average weekly hours worked increased more rapidly than output.

PRICES AND COSTS

Index of Average Unit Mine Value.—During 1967 the index of average unit value for all minerals increased about 1 percent over the previous year. This index has shown no appreciable change since 1958. The most noticeable changes in the components occurred in the unit mine value of ferrous and nonferrous metals, particularly in the monetary metals. Of the nonmetals, the unit mine value of chemicals showed a greater rise than the other subcategories (table 29).

Index of Implicit Unit Value.—The index of implicit unit value, which measures price change from aggregate value and volume relationships, showed in 1967 a moderate increase of slightly less than 1 percent for all minerals compared with 1966 figures. The components within both the metals and nonmetals groups, however, showed slight to major price changes. For monetary metals, the index increased more than 7 points, while for the ferrous group the increase was only slightly more than 3 points. Within the nonmetals group the index for nonmetals used in construction was down a little less than 1 index point. The sharp increase in the index of implicit value for monetary metals in 1967 was mainly due to the rapid increase in value of production of silver with a moderately lesser increase in production. The index of implicit value for gold remained virtually the same.

Prices.—Prices of most major metals, nonmetals, and mineral fuels rose only slightly in 1967. In the metals group, electrolytic copper ingot and aluminum ingot increased 5.9 and 1.8 percent, respectively. By contrast, prices of lead, zinc, and nonferrous scrap showed moderate to marked declines. In the mineral fuels group, the price of bituminous coal went up about 5 percent, while price of electric power was up less than 1 percent. Interesting differences were shown in the change in wholesale prices for fertilizers: Prices for potash were down 9 percent and those for phosphates were up 4 percent. Prices paid by farmers for fertilizers in 1967 (generally retail prices) showed the following changes: For potash (muriate of potash) up 4 percent; for nitrogen (ammonium nitrate) down 2 percent; and for phosphates (superphosphate) up 2 percent. It has been generally thought that fertilizer ingredients were strongly complementary. Given ample supplies, this would tend toward equivalent price increases. Plausible explanations for the varying price changes may be a gradually differing demand for the individual ingredients, and new, unanticipated, respective sources of supply.

Prices for fuels in 1967 generally increased over those of the previous year. The 1-percent increase in price for crude petroleum probably resulted from the combined effects of the Arab-Israeli conflict and increased demand. Comparatively higher price—3 percent—changes occurred in gasoline. Residual fuel oil prices for Gulf Ports, Bunker C, showed a drop of 12 cents to $1.98 per barrel. Dry natural gas prices were largely unchanged from the previous year.

Average cost of coal in steam-electrical power generation rose 0.3 cent to 24.7 cents per million Btu in 1966 (the latest year for which data are available). Cost of oil decreased 0.7 cent to 32.4 cents in 1966 while gas remained at the 1965 average of 25.0 cents per million Btu. Coal remained the cheapest fossil fuel in 1966 for power generation. Among all regions, the East had the lowest average cost expended for coal, 19.3 cents per million Btu.

Average cost of electrical energy remained at 1.6 cents per kilowatt-hour in 1966. Within the regional breakdown, small declines in cost were shown for the New England and Pacific regions. The East South Central region had the lowest average cost for power, 0.9 cent per kilowatt-hour in 1966, as it did in the two previous years. Cost of electrical energy remained lowest in the commercial and industrial markets—1.3 cents per kilowatt-hour, and highest in the residential market—2.2 cents per kilowatt-hour.

Index of Principal Metal Mining Expenses.—Higher index values for principal metal mining expenses in 1966 were principally due to an increase of 9 index points in the labor component, together with nominal increases in prices of supplies, fuels, and electrical energy. Labor costs increased faster than in any year since 1963. The indexes of major input expenses for bituminous coal and crude petroleum and natural gas mining showed no appreciable change in 1966.

Costs.—The indexes of relative labor costs and productivity in mineral and mineral fuels industries in 1967 generally continued to increase over those of 1966. The index of labor costs per unit of output for recoverable iron ore and copper increased moderately to markedly, while for bituminous coal and petroleum there was no appreciable change. Changes in the index of value of product per man-period were mixed for the mineral industries. Productivity was down markedly in the iron ore industry and up moderately for recoverable copper. As a result labor costs in the iron ore industry were up sharply, while for recoverable copper, they were moderately down.

Indexes of prices of mining construction and material handling machinery were up in every category in 1967. Prices of construction machinery and mining machinery showed about equivalent increases of 3.1 points each. Tractors other than farm showed the largest price increase, while portable air compressors showed the smallest increase.

INCOME AND INVESTMENT

Income generated by mining declined in 1967, the first year of decline since 1964 (table 40). In contrast, income generated in manufacturing increased slightly above 2 percent and for all industries, it rose above 5 percent. The decline in metal mining was primarily responsible for the drop in total mining. Other categories in mining rose slightly but the rise was not great enough to offset the sharp drop in metal mining.

Direct private investment of United States companies shows Europe, Canada, and Latin American Republics as the chief areas of foreign investment (book value) in petroleum industries in 1966, the latest year for which data are available. Total book value at the end of the year for the petroleum group was $16.3 billion. This was 30 percent of end-of-the-year book value for all industries.

Direct private investment of the United States in foreign mining and smelting industries in 1966 was valued at $4.1 billion or 9 percent above that in 1965. Canada and the Latin American countries accounted for 74 percent of foreign investment in mining and smelting. The

1966 earnings of affiliates in mining rose by $89 million over those of the previous year, reaching $660 million. Of this total, $524 million was returned to the United States as income compared with $443 million in 1965.

Expenditures for new plant and equipment by firms in mining totaled $1.42 billion in 1967, down 3.4 percent from 1966. Of the five manufacturing categories, expenditures for stone, clay, and glass products and chemical and allied products were down slightly to moderately. This was the first time in several years that expenditures for major items associated with new plant and equipment showed a decline. A bright note was registered for primary iron and steel in which new plant and equipment increased $14 million to $2.31 billion. Other categories in which expenditures increased were primary nonferrous metals and petroleum and coal products. Expenditures in the all-manufacturing category declined 1 percent to $26.7 billion.

In 1965, the latest year for which data are available, funds from all sources for direct foreign investment by United States mining and smelting industries increased $323 million to $1.4 billion. Canada and Latin America continued to account for more than two-thirds of the total. The affiliates relied principally on net income generated within the industries. There was a continued increase in funds obtained from other countries relative to funds obtained from the United States.

Uses of funds for direct foreign investments by United States mining and smelting industries in 1965 (latest data available) were chiefly expended for property, plant, and equipment (48 percent). About two-fifths was income paid out, and the remainder was distributed to inventories, receivables, and other assets.

Annual profit rates in 1967 on shareholders' equity in selected mineral manufacturing corporations showed decreases from 1966 in all categories except petroleum refining and related industries. Primary nonferrous metals showed the biggest decline, 3.8 percent, followed by primary iron and steel, 2.6 percent. Profit rates for 1967 for petroleum refining and related industries increased very slightly, 0.1 percent, compared with a 0.5-percent increase in 1966. Dividends in mineral manufacturing in 1967 showed relatively small increases compared with 1966. Primary iron and steel and primary nonferrous metals reflected dividend increases of around 2 percent while other mineral manufacturing industries showed lesser increases. Dividends in 1967 in petroleum refining and related industries fared better than profit rates compared with 1966 figures, with an 8.9-percent increase recorded.

The number of industrial and commercial failures in mining, including fuels, was 71 in 1967, or 2 lower than reported in 1966. However, the liabilities reported by these firms were substantially higher in 1967 than in 1966. Manufacturing firms, which comprised a larger category of firms than mining, showed 18 (1.0 percent) less failures in 1967 than in 1966; but liabilities of manufacturing firms were about 10 percent less compared with 1966.

Estimated gross proceeds of new corporate securities offered for the extractive industries in 1967 was $588 million compared with $24.8 billion for all corporate securities. Slightly more than two-thirds of the proceeds in extractive industry offerings during the year came from bonds, less than one-third was in common stock issues, and only about 1 percent was in preferred stock issues.

Plant and equipment expenditures in 1967 by direct investment in mining and smelting in other countries rose $141 million to $948 million. This 17-percent increase in outlays compares favorably with the 9-percent increase reported for manufacturing. Petroleum outlays increased $823 million to a total of $3.4 billion, or 32 percent. Canada dropped slightly in outlays for manufacturing in 1967. Except for mining and smelting in Europe, which remained the same, increased investment in all mining and smelting and petroleum categories was reflected for Canada, the Latin American Countries, and Europe.

TRANSPORTATION

In 1966 (the latest year for which data are available) the greater quantity, 66 percent of the metals and metal products transported, moved by rail. The remainder was transported by water (table 51). Some of the important metals and nonmetallic minerals which showed higher rail transport as compared with water in 1967 were: Iron ore and concentrates, iron and steel scrap, iron and steel ingots and other shapes, nonferrous ores, cement, and fertilizer and fertilizer materials. Items that showed higher water transport were gypsum and plaster rock, liquid sulfur, and limestone flux and calcareous stone. Mineral commodity tonnages transported by rail were 2 percent greater in 1966 compared with those in 1965, while those transported by water were almost 6 percent greater.

Mineral fuels and related products in 1966 moved in greater quantities by water, 55 percent, as compared with rail, 45 percent, based on water and rail transport data. Coal, gasoline, and crude petroleum were the most important items moving by water. Bituminous coal was by far the most important item moving by rail. Total mineral fuels and related product tonnage moving by water increased almost 3 percent in 1966 over 1965 production. Crude petroleum and coal, in that order, were primarily responsible for the gain. Mineral fuels tonnage moving by rail increased slightly over 3 percent in 1966 above the previous year. Among the important items, bituminous coal dominated all others in contributing to the increase. Increased shipments of bituminous coal by rail in recent years stem principally from lower freight rates.

Gas pipeline mileage totaled 800 thousand miles in 1966 (the latest year for which data are available) or 4 percent more than the 768 thousand miles in use in 1965. Natural gas lines comprised almost 99 percent of the total, with the remaining 1 percent divided among manufactured, mixed, and liquefied petroleum gases.

Total petroleum mileage recorded at the beginning of 1965 (latest data available) was 210.9 thousand miles or 5 percent greater than the 200.5 thousand miles of pipelines in use in 1962. Total pipeline fill at the beginning of 1965, at 100.7 million barrels, was 15 percent greater than that reported for 1962. Of the total petroleum pipeline mileage in 1965, 34 percent was in crude gathering systems in oilfields; 29 percent was in the larger size crude trunklines; and 37 percent was in petroleum product pipelines that extend from refineries to distribution terminals.

RESEARCH ACTIVITIES

Bureau of Mines.—Research relating to problems of mineral resources and production is necessary to assure an adequate and dependable flow of minerals. Funds alloted and expended by both the Government and private sectors were used to advance knowledge and capabilities in the physical and economic sciences, and mining and metallurgical technology to help solve these problems.

National expenditures data for research and development activities in selected industries in 1966 (latest year for which data are available) showed that chemicals and allied products accounted for 9.7 percent of total funds expended, or about the same as in 1965 (table 55). Petroleum refining and extraction accounted for about 2.8 percent of the total, slightly smaller than in 1965. Federal funds accounted for slightly more than 50 percent of total research and development program expenditures in 1966. Only about 3 percent of Federal funds was related to minerals and mineral fuels. Of this amount, about 1 percent was expended for petroleum refining and extraction and about 2 percent for chemicals and allied products.

During 1967, the Bureau of Mines continued work under established programs for minerals and mineral fuels research and resources development. New emphasis was placed on problem areas relating to supply and demand. Techniques employing simple econometric models were used to determine existing economic relationships for major mineral commodities, competitive relationships with respect to substitutes, and to forecast short- and long-run estimates of production, consumption, and prices. By developing relatively accurate supply and demand forecasts, research efforts can be more meaningfully directed to those areas where existing and future supply and demand are most critical. Emphasis was also placed on determination of input-output relationships of the United States mining industries, using 1963 data. The findings of a research study on the interindustry structure of the U.S. mining industries, using 1958 purchase and sales data, was published in 1967.[4]

Obligations of funds by the Bureau of Mines for mining and mineral research and development totaled $34.5 million during fiscal year 1968. Of this amount, $20.0 million consisted of obligations to research and resource development work for minerals, excluding fuels, and $14.5 million for work on mineral fuels. Obligations for basic and applied research for fiscal year 1968 were $4.9 and $24.4 million, respectively. The Bureau's expenditures obligated for applied research in the field of metallurgy and materials in 1967 were $6.1 million. Total research funds of $29.3 million obligated by the Bureau of Mines for fiscal year 1968 were divided as follows: Engineering science, $20.1 million; physical sciences, $7.1 million; mathematical sciences, $0.6 million; and environmental sciences, $1.5 million.

Research on technological and economic problems was designed to continually advance the process of extracting raw materials at reasonable cost without environmental degradation. Noteworthy accomplishments of the Bureau in research programs, including work in progress, follow.

Mining Research.—Studies were made of various forms of energy best adapted to break rock. A system was developed to determine the difficulty of rupture of certain types of rock as a function of temperature. A method of applying high-frequency dielectric heating was developed that may be competitive with conventional cyclic methods based on energy required for fracture. In a full-scale mining demonstration, new design criteria permitted greater slope inclination. Laboratory and field studies of methane drainage revealed the possibility of eliminating losses of 4 to 6 man-hours per shift involving high gas concentration. Results of tests for improving the supporting abilities of hydraulic fill materials showed that the addition of varying amounts of Portland cement increased the strength significantly.

The first phase of the Marine Heavy Metals Research Program, which was to assess the possibilities for commercial exploitation of marine minerals, was completed at location off the coast of Nome, Alaska. Gold was found in all drillings in the sea floor sediments, but there were no immediately commercial deposits delineated. Subbottom profiles covering 200 square miles of area were examined and recorded for the purpose of defining prime targets for future delineation work.

Land and Air Pollution.—During 1967, Solid Waste Disposal Program research centered on technical and educational programs to give greater insight into recovery of mineral values from automobiles. Examination of municipal wastes channeled into incinerators revealed substantial quantities of ferrous and nonferrous metals could be recovered from this source. Incinerator fly ash contained relatively high amounts of gold and silver, comparable in grade to ores now being processed. Further research dealt with methods of recovery of this gold and silver so that the materials could be recycled into the economy. Research trials indicated that mine wastes can be of benefit to man. Demonstrations showed that bricks, ceramic tiles, and small magnets can be produced from mill tailings.

In the area of air pollution, the Bureau was concerned with two methods of attack to reduce sulfur dioxide emissions from the burning of high sulfur coal. One method involved taking out the sulfur in such coals before burning, and the other method was aimed at removing sulfur dioxide from stack gases before they were emitted. Pilot-plant studies have succeeded in removing up to 90 percent of sulfur dioxide from relatively high sulfur coal. Studies were also directed to reduction of air pollution by alleviating internal combustion engine emissions.

Water pollution resulting from high acidity mine water discharges has also been investigated.

Work on the Appalachian Region Mining Area Restoration program continued in 1967. The greater portion of this program was directed toward sealing and

[4] Wang, Kung-Lee and Robert G. Kokat. The Interindustry Structure of the U.S. Mining Industries–1958. BuMines Inf. Circ. 8338, 1967, 190 pp.

filling voids in abandoned coal mines and extinguishing mine fires. A troublesome problem now being attacked by the Bureau involves the Wilkes-Barre-Scranton region, where the land is honeycombed by old mine workings and there are uncontrolled seam and culm bank coal fires burning. Research was continued on the problem of extinguishing dump fires which contribute to air pollution. Reclamation and rehabilitation of strip and service mines on public lands in Appalachia were implemented by public safety and water pollution control programs.

Coal Research.—In coal research the problem of sodium fouling of superheaters was solved, and the investigation of the nature of corrosion of boiler tube surfaces began. In carbonization studies of coals and blends, a poor coking coal yielded a coke of metallurgical grade. It was also learned that, regardless of the coal from which it is prepared, char can be used to achieve an increase in coke strength.

Coal liquefication and gasification research was continued to develop more efficient processes for converting coal to various gaseous and liquid fuels and to improve their economic status. Research demonstrated that coal can now be made soluble in a relatively cheap solvent by treatment with an alkali metal and electron transfer agent at ambient temperature and pressure. A two-zone small-scale steam-air coal gasifier yielded a gas suitable for synthesis of gasoline or ammonia. By eliminating the need for oxygen, such a gasifier could reduce significantly the cost of making gasoline and ammonia from coal. In the production of high Btu gas, material progress was made in the development of a pilot plant for the two-step coal-char hydrogasification process. Data also were obtained indicating the feasibility of a relatively simple single step process eliminating the char-hydrogenation phase. In the field of chemical conversion, organometallic complexes (phosphines) were found to be very effective in the conversion of crude coal acids into high-priced phthalic acids much in demand in the plastics industry.

Petroleum Research.—In petroleum and natural gas research the Bureau successfully completed the first test for enlarging the wellbore of oil and gas wells by a new liquid chemical injection method. More intriguing was Project Gasbuggy, the December 10 nuclear explosion in New Mexico, having a yield equivalent to 26,000 tons of TNT and detonated 4,240 feet below the ground. This experiment conducted in cooperation with the U.S. Atomic Energy Commission, the U.S. Department of the Interior, and industry, was expected to release natural gas trapped in low permeable rock. Heretofore, only limited quantities of this gas could be produced economically.

Other petroleum research included secondary recovery methods to bring into production oil already discovered but not now economically producible. The Bureau also conducted research aimed at increasing the service life of asphalt. A cooperative program with industry was continued concerning the analysis and characterization of the heavier materials found in petroleum.

Oil Shale Research.—The Bureau continued its research on the feasibility of retorting oil shale in situ to avoid mining costs and alleviate the problem of disposal of spent shale which results from above ground retorting operations. These problems were approached by conducting studies of crushing tendencies of oil shale while being heated under simulated overburden pressure, methods for fracturing oil shale in place, and by retorting random-sized oil shale to simulate in situ retorting. Coreholes were studied in Colorado and Wyoming in a search for a suitable location for a nuclear fracturing experiment in oil shale. Other research included characterization of paraffin and olefin fractions upon retorting Colorado oil shale and investigations of the minerals associated with oil shale.

Legislation has been directed toward a five-point oil shale research and development program involving both private enterprise and the Government, representing slightly over $1.3 million in government funds. Investigations have been conducted on rich deposits of oil shale in Colorado, Utah, and Wyoming. It has been estimated that known oil shales of the area contain the equivalent of about 70 times the present domestic proved reserves of crude petroleum.

Economic Studies.—New emphasis was placed by the Bureau on supply and demand analysis of minerals and mineral-fuel commodities. Iron ore, steel, copper, aluminum, and the mineral fertilizers were the main areas of investigation. Measurements of existing demand relationships were derived. Techniques were also developed to yield more accurate forecasts of production, consumption, and prices of minerals and mineral fuels. Work was continued on input-output studies, linking all mining sectors with all other manufacturing, services, and final demand sectors of the U.S. economy, using 1963 data. Work also was continued on an integrated study of state and regional energy balances for the years 1960 and 1965. Four contracts were let for needed economic studies relating to nonfuels mineral policy. The subject areas were price stability and instability for domestic minerals, sources of investment funds for mineral industries, exploration as an economic and industrial process, and impact of mineral industry flows on U.S. balance of payments.

Health and Safety.—The Health and Safety Activity in 1967 continued its ongoing programs of mine inspection; health and safety education and training; research and statistical analyses; and coalbed fire control. All of these have as their principal objective the conservation of human and natural resources in the mineral extractive industries. Work on control of radiation hazards in underground uranium mines led to substantial reductions in worker exposure to radiation. Work was performed on development and revision of several complex Bureau of Mines testing and aproval schedules that detail physical features, performance requirements, and methods and standards by which the effectiveness and safety of diverse types of mining and personal-protective equipment are approved for use in the mineral industries. A testing and approval schedule was issued for a machine-mounted, continuous methane monitor that had been researched and developed in prototype form at the Health and Safety Research and Testing Center to warn the machine operator of the presence of significant concentrations of flammable methane gas in the atmosphere. The monitor is designed to cut off power to the machine if the methane concentration should rise to incipient ignition-danger levels through neglect of the operator to take appropriate corrective action upon receiving the warning signal. Commercial methane monitors approved under the testing and approval schedule are now affording added protection to personnel of a number of the Nation's underground coal mines.

Explosives and Explosions Research.—The Bureau's explosives and explosions research continued to promote safety in handling and using highly flammable and explosive materials. In producing standards for industry, the Bureau of Mines and Stanford Research Institute collaborated on an information guide, "Safe Handling of High Energy Liquids," published by the Office of Naval Research. Other developments included research on a low-strength explosive which substitutes for outlawed black powder in underground coal mines where lump coal commands a premium price; examination of a stable, jelled ammonium nitrate-water slurry composition which should find application in underground noncoal mines subject to hazardous concentration of flammable gases; and research leading to the discovery of materials which will stabilize reactions of ammonium nitrate fuel oil used in sulfide-ore, high-temperature mines. Importantly, in line with its help in the investigation of the NASA Apollo fire, the Bureau, cooperating with the Kennedy Space Center, found Freon 1301 to be a useful inerting agent for certain propellants used in the space program.

Helium Conservation.—The national helium conservation program continued in 1967 to obtain the maximum beneficial use of the helium resources of the United States. The program stresses the production and sale of helium for present use, the acquisition and storage of helium that would otherwise be wasted in the consumption of helium-bearing natural gas, and the continuance of fundamental and applied research that will contribute to more effective utilization of our helium resources. Continued emphasis was placed on process development studies for helium purification and "enrichment" of the conserved helium, the production and analysis of ultrapure helium, and investigation of the thermodynamic properties of helium.

LEGISLATIVE AND GOVERNMENT PROGRAMS

Much of the Government's activities with respect to minerals and mineral-fuels industries in 1967 were concerned with the introduction of remedial fiscal and montary policies. Because business spending on plant and equipment declined during the first half of 1967 and severe inventory adjustments were underway, the investment tax credit was restored in the spring of 1967. Fiscal policy was exerted to attempt to influence expansion for a sluggish economy in the first half of 1967. This occurred despite the unusually high level of long-term interest rates. At midyear both short-term and long-term interest rates began to move upward and continued to do so throughout the year, but several factors, including the ready availability of credit, caused the economy, on balance, to turn expansionary in the second half.

Monetary conditions—as measured by changes in bank reserves, money supply, and bank credit—remained flexible to mineral and mineral fuel companies up until the 1967 yearend. The changed monetary environment from 1966 was marked by a step-up in acquisitions of mortgages during the second and third quarters of 1967, thus contributing greatly to the recovery of total construction activity. The changed fiscal and monetary environments, despite inflationary pressures, enabled certain sectors of the mineral and mineral fuel economies to advance at a healthy rate.

With regard to the national stockpile program, strategic materials held in government inventories amounted to $6.9 billion at acquisition cost and $6.6 billion at estimated market value. Of the total materials in government inventories, $3.8 billion at cost and $3.4 billion at market value were considered to be in excess of conventional stockpile objectives in 1967. About 83 percent of the market value of the total current excess was made up of 11 materials: Aluminum, bauxite (from Jamaica and Surinam), metallurgical grade chromite, cobalt, industrial diamond stones, lead, metallurgical grade manganese, nickel, tin, tungsten, and zinc. Major mineral stockpile items sold in 1967 were aluminum, copper, metallurgical chromite, nickel, and tin. During 1967, legislation was enacted by Congress authorizing the disposal of bismuth, molybdenum, and rate earths, valued at $32.5 million. Total stockpile disposal of mineral commodities during 1967 was valued at $293 million.

Continued exploration for new domestic sources of strategic and critical mineral commodities was encouraged during 1967 by government assistance under the Office of Minerals Exploration (OME) program. During fiscal year 1968, 37 contracts representing a government participation of $1.7 million were executed. Small mine operators have been an important factor in maintaining adequate supplies of vital minerals, and the OME program enables them to continue their contribution.

WORLD REVIEW

World Economy.—The world economy in 1967 continued to grow, but as in the immediately preceding years, at a slightly declining rate. For most countries available data on 1967 GNP indicate a general increase in economic activity. Overall gains in world industrial production continued at the modest rate exhibited in the most recent years.

World Production.—Net gains in the extractive industries in 1967 were generally at a slightly lower rate than in 1966 (table 62). Only slight increases in extractive output were registered in the United States and Canada. Other industrialized countries showed generally larger extractive output increases in 1967 compared with North America. Production of metals was down appreciably for the United States and Canada but up slightly for the total of all non-communist countries. World coal production was down 4 index points in 1967, while world crude petroleum production was up 6 index points. Major mineral processing sectors, such as base metals, chemicals, petroleum products, coal and nonmetallic mineral products showed moderate gains for the non-Communits countries. However, gains in chemicals, petroleum products and coal exceeded gains made in other categories. East Asia, principally Japan, tended to dominate world production increases in mineral-oriented manufacturing, while gains in the United States and Canada were only moderate.

For a number of metals, there were major changes in United States-rest-of-the-world supply and demand positions in 1967. While domestic production of copper declined precipitously from 1.4 to 0.8 million tons, due to the copper strike, rest-of-the-world production increased slightly, from 2.5 to 2.6 million tons. Rising world demand for copper was strong compared with available supply, causing a disruption in the supply-demand balance. Contributing factors in the disruption were political problems, especially in the Congo and in South America—highly variable prices, heavy demand for imports by the U. S., and labor problems in the United States and elsewhere.

Non-Communist consumption of silver in 1967 exceeded production by 194 million ounces. A production deficit continued to be balanced by withdrawals from world stocks, chiefly U.S. treasury bullion stocks. Gains in production of silver were registered by Canada and other industrial nations in 1967, while losses were recorded in the United States and South American countries. A fall-off in coinage consumption in 1967 was registered in the United States and Canada as well as in the rest of the world. Further, the fall-off in this item during 1967 in the rest of the world was greater than in North America compared with 1966. Industrial consumption of silver in the United States in 1967 was down slightly.

Lower gold production in the United States in 1967 was matched by lower output in other important gold-producing countries. Because of drains upon the gold supply, due to a big increase in demand for gold for speculative purposes preceding and following devaluation of the British pound in November 1967, U.S. official holdings of gold declined appreciably. The U.S. price of gold in 1967 could not go above $35 per ounce, but buying of gold in the world private market continued, and the U.S. Treasury was the principal supplier. Unsettled conditions in foreign exchange markets added to the problem of depletion of monetary gold reserves.

Among the nonmetals, world production of recovered sulfur increased in 1967, but the increased supplies were an insignificant quantity in alleviating the U.S. and rest-of-the-world sulfur shortage. Again, as in 1966, producers' stocks were withdrawn. In the United States about half of the sulfur consumed in 1967 was used in acidulation of phosphate rock for fertilizer use. Lack of sulfur supplies was responsible for a curtailment in the expansion of production of phosphates for fertilizer. Frasch sulfur output was up slightly in the United States though insufficient to balance demand, while in Europe and South America it was down moderately. Recovered sulphur production was up in most areas of the world.

In mineral fuels, petroleum and natural gas continued in 1967 to increase in relative importance as world sources of energy. Production of crude petroleum in the United States and other North American countries increased at about the same rate as in previous years. Production in some of the important Middle East countries declined slightly, while in others production was up moderately to sharply. Venezuela, which showed a drop in production of crude oil in 1966, registered a record production in 1967. Substitution of oil for coal in Japan and in some parts of Europe continued to be restrained by government controls, foreign exchange shortages, and considerations of energy self-sufficiency.

World Trade.—Fragmentary data from trade reports indicated a rising trend of world mineral trade in 1966 (the latest year for which data are available). Total exports of metal ores and scrap, metals, and mineral fuels from the United States in 1966 increased slightly. Total exports in 1966 from Europe of the above categories increased more percentagewise compared with the United States. Increases in exports of these items from the European Free Trade Association were moderately higher, percentagewise, compared with exports of the same items from the European Economic Community. The net value of world trade in minerals and mineral fuels in 1966 was $204 billion, or 9 percent higher than in 1965.

World Consumption.—Changes in world minerals and mineral fuels consumption were mixed in 1967. Increases were recorded in world consumption of individual nonferrous metals as follows: Aluminum, up 4 percent; copper, down 6 percent; lead, up 3 percent; tin, no change; and zinc, down 2 percent. Although no data were available on world consumption of mineral fuels and electricity, supply and trade figures suggested that demand continued to increase during 1967.

Ocean Freight Rates.—World ocean freight rates in 1967 moved slightly to sharply higher, depending upon the method of shipment. Dry cargo rates in general showed a modest rise while tanker rates tended to be markedly higher. Both dry cargo and tanker rates rose appreciably by quarters throughout the year. Merchant shipbuilding activity was up moderately in 1967 in every major shipbuilding country. Japan led shipbuilding activity, with 43 million gross tons of carrier tonnage delivered, followed by Panama, Sweden, and West Germany. A major part of the increase in carrier tonnage built in 1967 was in tankers constructed. During the Suez Canal closing of several months in 1967 more ships were needed to carry the going tonnage of ores and fuels, since the distances traveled were longer and more time was taken up in negotiating the markedly greater mileage.

World Prices.—World export price indexes for the total of metal ores and fuels in 1967 were slightly lower than the annual average in 1966. The quarterly indexes for 1967 indicated a slight rise in prices for metal ores in the fourth quarter, but the more important component, fuels, showed no material change throughout the four quarters. Export prices of total mineral and nonferrous base metals were down slightly more in the developed nations than in the less-developed nations category. On the other hand, prices for nonferrous base metals were down considerably more in the less developed nations than in the developed nations. Smaller individual and collective markets in the less developed countries, with more uncertainty in their respective supply and demand positions, probably contributed to the higher price fluctuation in those countries. Quoted U.S. copper prices in the U.S. ranged from $0.36 to $0.38 during 1967. After July 15, the date of the general 1967 U.S. copper strike, copper prices on the London spot market climbed slowly upward in anticipation that the strike would be settled in a matter of weeks. After the strike had lasted 3 months, London spot market prices began rising moderately to sharply until the end of the year. London copper spot prices in 1967 ranged from $0.60 at the beginning of the year down to $0.45 per pound at midyear, and then climbed again to $0.60 by yearend. Production of copper in the United States was sharply off and no sales were authorized from government stockpiles in 1967. Thus, reduction in supplies resulted in a rise in spot prices which prevailed in the last half of the year.

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

(Million dollars)

Mineral group [1]	1963			1964			1965			1966			1967		
	Production	Imports	Exports	Production	Imports	Exports	Production	Imports	Exports	Production [r]	Imports	Exports	Production	Imports	Exports
Metals and nonmetals except fuels:															
Nonmetals	$4,316	$286	$115	$4,623	$323	$141	$4,933	$354	$185	$5,176	$412	$228	$5,205	$414	$241
Metals	2,002	695	137	[r] 2,366	917	151	[r] 2,544	973	154	2,703	1,192	158	2,333	1,126	171
Total	6,318	981	252	[r] 6,989	1,240	292	[r] 7,477	1,327	339	7,879	1,604	386	7,538	1,540	412
Mineral fuels	13,317	1,165	483	13,623	1,250	471	14,047	1,295	487	15,112	1,311	490	16,198	1,289	600
Grand total	19,635	2,146	735	[r] 20,612	2,490	763	[r] 21,524	2,622	826	22,991	2,915	876	23,736	2,829	1,012

[r] Revised.
[1] For details, see the "Statistical Summary" chapter of this volume.

Table 2.—Value of mineral production by group 1957–59 constant dollars [1]

(Million dollars)

Mineral group	1963	1964	1965	1966	1967
Metals and nonmetals except fuels:					
Nonmetals	$4,266	$4,537	r $4,836	$4,972	$4,962
Metals	1,978	r 2,098	r 2,132	2,258	1,944
Total	6,244	r 6,635	r 6,968	7,230	6,906
Mineral fuels	13,424	13,831	14,232	15,082	15,803
Grand total	19,668	r 20,466	r 21,200	22,312	22,709

r Revised.
[1] Values deflated by the index of implicit unit value.

Table 3.—Indexes of the physical volume of mineral production by group and subgroup

(1957–59 = 100)

	1963	1964	1965	1966	1967
Metals:					
Ferrous	95.8	108.3	110.4	119.1	109.0
Nonferrous:					
Base	120.8	125.8	135.8	142.2	102.5
Monetary	90.8	92.0	105.0	112.5	92.7
Other	112.2	114.3	98.2	98.1	111.4
Total	115.5	119.4	124.1	129.2	103.3
Total metals	105.7	113.9	117.3	124.2	106.1
Nonmetals:					
Construction	119.6	126.2	129.9	136.5	132.4
Chemical	120.5	132.1	151.8	167.1	172.6
Other	111.6	119.0	127.9	136.0	129.7
Total	119.4	126.9	133.5	141.7	139.1
Fuels:					
Coal	102.8	108.2	112.6	116.4	119.8
Crude oil and natural gas [1]	111.6	113.8	116.6	124.0	131.6
Total	110.8	114.0	117.3	124.1	131.1
Total all minerals	112.2	116.7	120.7	127.8	130.5

[1] Does not cover isopentane, LP gases, and other natural gas liquids.

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

(1957–59 = 100)

	1963	1964	1965	1966	1967 p
Mining:					
Coal	102.5	107.1	113.3	117.0	118.1
Crude oil and natural gas:					
Crude oil	108.1	109.9	111.9	119.3	126.4
Gas and gas liquids	128.7	136.1	143.0	152.0	163.3
Total [1]	107.9	110.4	112.3	118.0	123.2
Total coal, oil, and gas	107.0	109.8	112.5	117.8	122.4
Metal	112.3	117.4	124.2	133.4	119.9
Stone and earth minerals	112.1	118.7	126.5	133.5	135.4
Total metal, stone and earth minerals	112.2	118.1	125.5	133.5	128.8
Total mining	107.9	111.3	114.8	120.5	123.5
Industrial production:					
Primary metals	113.3	129.1	137.6	142.7	132.5
Iron and steel	109.6	126.5	133.6	136.2	126.8
Nonferrous metals and products	126.7	138.3	152.2	166.2	153.1
Clay, glass, and stone products	117.5	126.0	133.5	140.7	138.7
Total industrial production	124.3	132.3	143.4	156.3	158.0

p Preliminary.
[1] Total includes oil and gas drilling.
Source: Board of Governors of the Federal Reserve System. Federal Reserve Bulletin, monthly issues February–June 1968. A description and historical data are available in Business indexes, Industrial Production, 1957–1959 Base, published by Federal Reserve Board, monthly.

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

(1957–59 = 100)

Month	Total mining [1]		Coal, oil, and gas		Coal		Crude oil and natural gas: Total [2]		Crude oil and natural gas: Crude oil		Crude oil and natural gas: Gas and gas liquids		Metal, stone and earth minerals		Metal mining		Stone and earth materials	
	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967
January	117.3	123.2	113.6	119.8	114.4	120.7	113.5	119.7	114.1	121.0	143.8	158.4	134.6	139.4	133.4	140.3	135.5	138.7
February	117.7	122.4	114.3	119.0	111.2	115.7	115.0	119.6	115.1	120.0	149.0	160.0	133.6	138.9	130.8	142.1	135.6	136.6
March	120.0	121.5	116.7	117.6	117.7	115.1	116.5	118.1	117.0	120.1	148.1	156.7	136.0	140.0	134.5	143.7	137.1	137.2
April	115.6	122.0	111.6	118.5	85.3	125.5	117.0	117.1	117.2	119.6	152.2	161.5	134.6	138.7	139.7	149.5	130.9	130.6
May	120.7	120.2	118.8	118.0	116.9	120.1	119.1	117.5	121.3	119.6	152.2	161.3	130.1	130.8	133.6	132.9	127.5	129.2
June	122.0	123.8	119.5	121.7	120.7	122.5	119.3	121.6	121.4	123.6	154.4	167.3	133.7	133.6	134.2	133.9	133.3	133.3
July	122.0	128.0	119.5	128.0	120.8	122.6	119.2	129.1	120.9	133.9	155.1	NA	133.8	127.7	134.0	119.7	133.7	133.7
August	122.1	127.8	119.7	128.8	120.7	117.2	119.6	131.2	121.2	138.0	155.5	NA	133.1	123.4	132.1	105.7	133.8	136.6
September	121.1	124.3	118.3	125.4	122.9	115.5	117.4	127.5	118.9	133.1	145.8	NA	145.5	119.1	145.5	95.6	145.5	136.5
October	121.9	122.4	121.1	123.7	133.7	112.3	118.5	126.1	119.9	130.3	151.4	NA	141.1	116.2	138.9	93.8	142.7	132.9
November	121.6	123.6	120.2	124.5	121.8	115.3	119.9	126.4	120.8	128.7	159.0	NA	130.2	119.5	124.3	93.2	134.7	139.0
December	123.8	122.3	122.0	122.2	125.3	116.1	121.4	123.5	122.0	126.4	164.9	NA	125.0	122.7	122.5	95.7	126.8	142.7
Average annual	120.5	p 123.5	117.8	p 122.4	117.0	p 118.1	118.0	p 123.2	119.3	p 126.4	152.0	p 163.3	133.5	p 128.8	133.4	p 119.9	133.5	p 135.4

p Preliminary. NA Not Available.
[1] Including fuels.
[2] Total includes oil and gas drilling.
Source: Board of Governors of Federal Reserve System. Federal Reserve Bulletin, monthly issues February–April 1968.

duction of mineral energy resources and electricity from hydropower and nuclear power

(Trillion Btu)[1]

Year	Anthracite	Bituminous coal and lignite	Natural gas, wet (unprocessed)	Crude petroleum	Electricity: Hydropower	Electricity: Nuclear power	Total
1963	464	12,024	16,271	15,741	1,741	33	46,274
1964	436	12,759	17,056	15,690	1,861	34	47,836
1965	378	13,417	17,652	15,930	2,051	39	49,467
1966	329	13,988	18,894	16,925	2,062	58	52,256
1967 p	311	14,436	20,121	17,994	2,338	76	55,276

p Preliminary.
[1] 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 coal equivalent at the prevailing average pounds of coal per kilowatt-hour produced at central electric plants, using 12,000 Btu per pound.

Table 7.—Consumption of major mineral products, mineral fuels, and electricity, 1966, 1967, and projections

Commodity	1966	1967 [p]	Projection [1]	Average annual growth rate 1947–65 (percent)	Projected average annual growth rate [1] (percent)
Mineral products:					
Ferrous metals:					
Iron ore ... thousand long tons	134,047	127,424	176,000	+0.8	+1.5
Raw steel [2] ... thousand short tons	134,101	127,213	162,000	+1.5	+1.0
Chromite ores (gross weight):					
Metallurgical grade ... do	828	866	2,100	+4.0	+5.0
Refractory grade ... do	439	310	260	+0.8	−2.8
Chemical grade ... do	194	179	280	+2.0	+2.0
Manganese ore (35 percent or more Mn) ... do	2,371	2,239	3,250	+1.9	+1.7
Molybdenum (Mo content) ... thousand pounds	52,324	49,506	132,000	[3] +5.2	+5.0
Tungsten (W content) ... do	18,058	13,860	36,800	+3.6	+3.8
Nonferrous metals:					
Aluminum [4] ... thousand short tons	4,002	4,009	12,300	+7.4	+6.1
Antimony, primary ... short tons	19,681	17,350	23,000	−1.5	+0.8
Copper, refined [5] ... thousand short tons	2,360	1,936	3,750	+1.0	+2.5
Lead, primary and secondary ... do	1,324	1,261	1,430	0.0	+0.5
Zinc, all classes ... do	1,807	1,592	3,000	+1.3	+2.7
Mercury, primary ... 76-pound flasks	55,633	47,367	67,000	+3.4	+1.0
Platinum group metals ... thousand troy ounces	1,676	1,334	4,013	+6.9	+4.7
Silver, industrial consumption ... do	183,696	171,031	332,000	NA	+3.2
Ilmenite and Ti slag (est. TiO_2 content) ... short tons	601,062	575,181	1,500,000	+4.8	+4.9
Uranium (U_3O_8 content) [2] ... do	9,487	8,425	46,000–74,000	+4.9	+8.7 to +11.4
Nonmetals:					
Asbestos [4] ... thousand short tons	805	721	1,314	+0.8	+2.6
Cement [2] ... million barrels	394	378	890	+3.7	+4.4
Clays [4] ... thousand short tons	55,780	53,623	79,700	+2.1	+[illegible]
Lime [6] ... do	18,057	17,974	52,000	+5.3	
Phosphate rock [4] ... do	27,373	27,902	47,000	+4.9	
Potash (K_2O content) [4] ... do	4,003	4,139	7,600	+6.4	
Salt [4] ... do	38,280	41,111	88,000	+4.6	
Sand and gravel ... million short tons	[6] 934	[6] 905	1,510	[7] +4.2	
Stone, crushed ... do	[6] 811	[6] 784	1,310	+8.1	
Sulfur, all forms [4] ... thousand long tons	9,160	9,316	17,648	+3.0	

Mineral energy resources and electricity: [8]					
Bituminous coal .... million short tons	486	480	675–737	−1.1	+2.3 to +3.0
(Coal carbonized for coke) .... do	(96)	(92)	(97)	(−0.6)	+0.1
Anthracite .... do	11	11	10	−7.1	−.9
Petroleum, including natural gas liquids .... million barrels	4,411	4,584	6,665	+4.3	+3.0
Natural gas, dry [9] .... billion cubic feet	16,854	17,685	24,594	+7.3	+2.8
Electricity generation, net .... million kilowatt-hours	1,249,444	1,314,299	NA	+7.6	NA
Utilities .... do	1,144,350	1,211,749	2,737,000	+8.2	+6.4
Hydropower [10] .... do	195,848	220,043	338,000	+1.9	+4.0
Nuclear power .... do	5,520	7,147	458,000–723,000	[11] +54.0	+37.0 to +42.0
Conventional fuel burning plants .... do	944,074	984,559	1,676,000–1,941,000	+9.2	+4.2 to +5.3
Industrial .... do	105,094	102,549	NA	+3.9	NA
Total energy resources inputs .... trillion Btu	56,948	58,853	88,075	+2.7	+3.2

p Preliminary. NA Not Available.
[1] Mineral products projections are for 1985. Projected average annual growth rates are from 1966 to 1985. Mineral energy resources and electricity projections are for 1980. Projected average annual growth rates are from 1966 to 1980.
[2] Production.
[3] Growth rate 1956–65.
[4] Apparent consumption.
[5] Changed from withdrawals from total supply to refined copper consumption.
[6] Sold or used.
[7] Growth rate 1954–65.
[8] See: Morrison, Warren E. and Charles L. Readling. An Energy Model for the United States, Featuring Energy Balances for the Years 1947 to 1965 and Projections and Forecasts to the Years 1980 and 2000. Bureau of Mines Information Circular 8384, 1968, 127 pp.
[9] Residue gas excludes extraction loss but includes transmission loss.
[10] Net generation, adjusted for net imports or exports. The bulk of net trade is hydropower with an undetermined portion of steam plant power.
[11] Growth rate 1957–65.

Table 8.—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				
1963	361	10,722	14,843	20,247	1,703	1,740	33	49,649
1964	365	11,295	15,562	20,590	1,796	1,873	34	51,515
1965	328	12,030	16,098	21,364	1,877	2,049	39	53,785
1966	290	12,740	17,393	22,405	1,989	2,073	58	56,948
1967 p	274	12,583	18,251	23,153	2,178	2,338	76	58,853
				Percent				
1963	0.7	21.6	29.9	40.7	3.5	3.5	0.1	100.0
1964	.7	21.9	30.2	40.0	3.5	3.6	.1	100.0
1965	.6	22.4	29.9	39.7	3.5	3.8	.1	100.0
1966	.5	22.4	30.5	39.4	3.5	3.6	.1	100.0
1967 p	.5	21.4	31.0	39.3	3.7	4.0	.1	100.0

p Preliminary.

[1] Heat values employed are anthracite, 12,700 Btu per pound; bituminous coal and lignite, 13,100 Btu per pound; crude oil 1963, 5,718,300 Btu; 1964, 5,630,254 Btu; 1965, 5,531,000 Btu; 1966, 5,257,440 Btu; and 1967 5,181,633 Btu; weighted average British thermal units for petroleum products obtained by using 5,248,000 gasoline, 5,670,000 kerosine, 5,825,000 distillate, 6,287,000 residual, 6,064,800 lubricants, 5,537,280 wax, 6,636,000 asphalt, and 5,796,000 miscellaneous; natural gas dry, 1,032 Btu per cubic foot; natural gas liquids weighted average British thermal unit based on production of natural gasoline at 110,000 Btu per gallon, and LP gas at 95,000 Btu per gallon. Hydropower and nuclear power converted to coal equivalent at the prevailing rate of pounds of coal per kilowatt-hour each year at central electric stations using 12,000 Btu per pound.

Table 9.—Gross consumption of energy resources by major sources and consuming sectors

(Trillion Btu)

Consuming sectors	Anthracite	Bituminous and lignite	Natural gas dry [1]	Petroleum [2]	Hydropower [3]	Nuclear power [3]	Total gross energy inputs [4]	Utility electricity purchased [5]	Total sector energy inputs [6]
Household and commercial:									
1963	103	671	5,027	5,258	--------	--------	11,059	1,645	12,704
1964	85	560	5,314	5,190	--------	--------	11,149	1,795	12,944
1965	168	546	5,518	5,635	--------	--------	11,867	1,948	13,815
1966	[7] 143	575	5,945	5,766	--------	--------	12,429	2,101	14,530
1967 p	[7] 128	495	6,223	6,179	--------	--------	13,025	2,224	15,249
Industrial:									
1963	57	5,015	7,159	3,994	--------	--------	16,225	1,464	17,689
1964	46	5,362	7,397	4,184	--------	--------	16,989	1,544	18,533
1965	[7] 101	5,640	7,671	4,138	--------	--------	17,550	1,634	19,184
1966	[7] 88	5,806	8,203	4,352	--------	--------	18,449	1,788	20,237
1967 p	[7] 90	5,521	8,603	4,420	--------	--------	18,634	1,893	20,527
Transportation: [8]									
1963	---	19	439	11,506	--------	--------	11,964	19	11,983
1964	---	20	448	11,791	--------	--------	12,259	17	12,276
1965	---	19	517	12,179	--------	--------	12,715	18	12,733
1966	---	18	553	12,777	--------	--------	13,348	16	13,364
1967 p	---	14	594	13,413	--------	--------	14,021	17	14,038
Electrical generation, utilities: [3]									
1963	55	5,017	2,218	600	1,740	33	9,663	3,128	--------
1964	57	5,353	2,403	636	1,873	34	10,356	3,356	--------
1965	55	5,825	2,392	744	2,049	39	11,104	3,600	--------
1966	56	6,341	2,692	905	2,073	58	12,125	3,905	--------
1967 p	55	6,553	2,831	1,022	2,338	76	12,875	4,134	--------
Miscellaneous and unaccounted for:									
1963	146	--------	--------	592	--------	--------	738	--------	--------
1964	177	--------	--------	585	--------	--------	762	--------	--------
1965	[7] 4	--------	--------	545	--------	--------	549	--------	--------
1966	[7] 3	--------	--------	594	--------	--------	597	--------	--------
1967 p	[7] 1	--------	--------	297	--------	--------	298	--------	--------
Total gross energy inputs:									
1963	361	10,722	14,843	21,950	1,740	33	49,649	--------	--------
1964	365	11,295	15,562	22,386	1,873	34	51,515	--------	--------
1965	328	12,030	16,098	23,241	2,049	39	53,785	--------	--------
1966	290	12,740	17,393	24,394	2,073	58	56,948	--------	--------
1967 p	274	12,583	18,251	25,331	2,338	76	58,853	--------	--------

p Preliminary.

1 Excludes natural gas liquids.

2 Petroleum products including still gas, liquefied refinery gas, and natural gas liquids.

3 Represents outputs of hydropower and nuclear power converted to theoretical energy inputs at prevailing rate of pounds of coal per kilowatt-hour at central electric stations, using 12,000 Btu per pound coal. 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 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 The household and commercial and industrial sectors include an estimated breakdown of undistributed energy formerly included under miscellaneous and unaccounted for.

8 Includes bunkers and military transportation.

Table 10.—Domestic supply and demand for coal

	1966		1967 [p]	
	Thousand short tons	Trillion Btu	Thousand short tons	Trillion Btu
Anthracite:				
Supply:				
Production [1]	12,941.2	328.7	12,256.1	311.3
Imports	-----	-----	-----	-----
Exports [2]	−1,531.0	−38.9	−1,421.8	−36.1
Stock changes	-----	-----	-----	-----
Losses, gains, and unaccounted for	−10.2	−.2	−34.3	−.9
Total	11,400.0	289.6	10,800.0	274.3
Demand by major consuming sectors: [3]				
Household and commercial [4]	5,622.0	142.8	5,035.0	127.9
Industrial [5]	3,455.0	87.8	3,529.0	89.6
Transportation [6]	(7)	(7)	(7)	(7)
Electricity generation, utilities	2,192.0	55.7	2,186.0	55.5
Miscellaneous and unaccounted for	131.0	3.3	50.0	1.3
Total	11,400.0	289.6	10,800.0	274.3
Bituminous coal and lignite:				
Supply:				
Production [1]	533,881.2	13,987.7	551,000.0	14,436.2
Imports	178.0	4.7	212.0	5.6
Exports	−49,302.4	−1,291.7	−49,510.0	−1,297.2
Stock changes	+2,931.5	+76.8	−18,600.0	−487.3
Losses, gains, and unaccounted for	−1,422.3	−37.3	−2,847.0	−74.6
Total	486,266.0	12,740.2	480,255.0	12,582.7
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial [4]	19,965.0	575.3	17,099.0	494.6
Industrial [5]	196,342.6	5,658.2	185,901.3	5,377.1
(Coal carbonized for coke)	(95,891.8)	(2,512.4)	(92,272.1)	(2,417.5)
Transportation [6]	609.0	17.5	467.0	13.5
Electricity generation, utilities	264,202.0	6,340.8	271,784.0	6,552.8
Total	481,118.6	12,591.8	475,251.3	12,438.0
Raw material: [8]				
Industrial:				
Crude light oil	1,303.2	37.6	1,260.8	36.4
Crude coal tar	3,844.2	110.8	3,742.9	108.3
Total	5,147.4	148.4	5,003.7	144.7
Total	486,266.0	12,740.2	480,255.0	12,582.7

[p] Preliminary.
[1] Includes use by producers for power and heat.
[2] Includes shipments to U.S. Armed Forces in West Germany.
[3] With the exception of small quantities used as raw material for coal chemicals, all anthracite is used for fuel and power.
[4] Data represents "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] Coal equivalent based on British thermal unit value of raw materials for coal chemicals.

Table 11.—Domestic supply and demand for natural gas

	1966		1967 p	
	Million cubic feet	Trillion Btu	Million cubic feet	Trillion Btu
Supply:				
Production [1]	17,206,628.0	18,983.5	18,171,325.0	20,121.0
Imports	479,780.0	495.1	564,226.0	582.3
Exports	−24,639.0	−25.4	−81,614.0	−84.2
Stock changes	−68,855.0	−71.1	−184,829.0	−190.7
Transfers out, extraction loss [2]	−739,308.0	−1,989.2	−784,535.0	−2,177.9
Losses, gains, and unaccounted for	-----------	--------	-----------	--------
Total	16,853,606.0	17,392.9	17,684,573.0	18,250.5
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial	5,760,999.0	5,945.4	6,029,855.0	6,222.8
Industrial [3]	7,662,332.0	7,907.5	8,046,647.0	8,304.1
Transportation	535,353.0	552.5	575,752.0	594.2
Electricity generation, utilities	2,608,768.0	2,692.2	2,743,251.0	2,831.0
Total	16,567,452.0	17,097.6	17,395,505.0	17,952.1
Raw material: [4]				
Industrial:				
Carbon black	91,154.0	94.1	84,068.0	86.8
Other chemicals [5]	195,000.0	201.2	205,000.0	211.6
Total	286,154.0	295.3	289,068.0	298.4
Total	16,853,606.0	17,392.9	17,684,573.0	18,250.5

p Preliminary.
[1] Marketed production includes wet gas sold or consumed by producers, losses in transmission, producers' additions to storage, and increases in gas pipeline fill; excludes repressuring and vented and wasted. British thermal unit value of production is for wet gas prior to extraction of natural gas liquids. Higher values assigned to extraction loss are reflected in value of production for each year.
[2] Extraction loss from cycling plants represents offtake of natural gas for natural gas liquids as reported to 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 and annual outputs of liquefied petroleum gases at 95,500 Btu per gallon.
[3] Includes transmission losses of 401,203 million cubic feet in 1966 and 296,214 million cubic feet in 1967.
[4] Includes some fuel and power use by raw materials industries.
[5] Estimated from partial data.

Table 12.—Domestic supply and demand for petroleum [1]

	1966		1967 p	
	Million bbl	Trillion Btu	Million bbl	Trillion Btu
Supply:				
Crude oil: [2]				
Production	3,027.8	16,925.1	3,215.7	17,994.3
Imports	447.1	2,499.2	411.6	2,303.2
Exports	−1.5	−8.4	−26.5	−148.3
Stock changes	−18.1	−101.2	−10.6	−59.3
Losses and transfers for use as crude	−8.1	−45.3	−7.6	−42.5
Total	3,447.2	19,269.4	3,582.6	20,047.4
Petroleum input run to stills:				
Crude oil [2]	3,447.2	19,269.4	3,582.6	20,047.4
Transfers in, natural gas liquids [3]	235.6	1,088.5	244.7	1,130.5
Total	3,682.8	20,357.9	3,827.3	21,177.9
Output:				
Refined products	3,682.8	20,357.9	3,827.3	21,177.9
Unfinished oils, net	34.6	217.5	34.2	215.0
Overage or loss	89.5	494.8	106.6	589.9
Total	3,806.9	21,070.2	3,968.1	21,982.8
Imports [4]	492.0	3,093.2	514.2	3,232.8
Exports	−70.9	−392.1	−85.4	−472.3
Stock change, including natural gas liquids	−20.0	−110.6	−53.4	−295.3
Transfers in, natural gas liquids [3] [5]	233.0	900.7	269.8	1,047.4
Losses, gains, and unaccounted for	−30.2	−167.0	−29.8	−164.8
Total	4,410.8	24,394.4	4,583.5	25,330.6
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial	859.1	4,830.2	933.8	5,260.9
Industrial	484.6	2,882.5	490.3	2,920.7
Transportation [6]	2,382.6	12,777.0	2,499.0	13,413.4
Electricity generation, utilities	144.2	904.9	163.6	1,022.0
Other, not specified	85.2	496.2	35.0	203.7
Total	3,955.7	21,890.8	4,121.7	22,820.7
Raw material: [7]				
Petrochemical feedstock offtake	212.7	965.9	235.1	1,067.9
Other nonfuel use	224.7	1,439.8	209.8	1,348.6
Total	437.4	2,405.7	444.9	2,416.5
Miscellaneous and unaccounted for	17.7	97.9	16.9	93.4
Total	4,410.8	24,394.4	4,583.5	25,330.6

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 liquefied refinery gas; also natural gas liquids transferred from natural gas.
[2] Btu value for crude oil for each year shown is based on average British thermal unit 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] Btu values for natural gas liquids for each year shown are implicitly derived from weighted averages of major natural gas liquids, with natural gasoline and associated products converted at 110,000 Btu per gallon and liquefied petroleum gases at 95,500 Btu per gallon.
[4] Btu value for imported refined products for each year shown is based on the value of residual fuel and unfinished oils. The value for exports of refined products is based on the average value of domestic petroleum products output.
[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 use by raw materials industries.

Table 13.—Petroleum consumption by major products and by major consuming groups [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
1966												
Fuel and power:												
Liquefied gases	135.3	542.7	18.0	72.2	28.9	115.9	----	----	2.7	10.8	184.9	741.6
Jet fuels (kerosine and naphtha types)	----	----	----	----	244.4	1,353.6	----	----	----	----	244.4	1,353.6
Gasoline	----	----	----	----	1,793.4	9,412.3	----	----	----	----	1,793.4	9,412.3
Special naphtha	----	----	30.3	159.0	----	----	----	----	----	----	30.3	159.0
Kerosine	76.4	433.2	24.1	136.6	----	----	----	----	----	----	100.5	569.8
Distillate fuel	467.4	2,722.6	57.6	335.5	196.6	1,145.2	3.6	21.0	72.2	420.6	797.4	4,644.9
Residual fuel	180.0	1,131.7	176.2	1,107.8	119.3	750.0	140.6	883.9	10.3	64.8	626.4	3,938.2
Still gas	----	----	135.5	813.0	----	----	----	----	----	----	135.5	813.0
Petroleum coke	----	----	42.9	258.4	----	----	----	----	----	----	42.9	258.4
Total	859.1	4,830.2	484.6	2,882.5	2,382.6	12,777.0	144.2	904.9	85.2	496.2	3,955.7	21,890.8
Raw material: [3]												
Lubes and waxes	----	----	52.9	318.6	----	----	----	----	----	----	52.9	318.6
Petroleum coke [4]	----	----	30.8	185.5	----	----	----	----	----	----	30.8	185.5
Asphalt and road oil	141.0	935.7	----	----	----	----	----	----	----	----	141.0	935.7
Petrochemical feedstock offtake: [5]												
Liquefied refinery gas	----	----	46.8	187.7	----	----	----	----	----	----	46.8	187.7
Liquefied petroleum gas [6]	----	----	92.0	369.0	----	----	----	----	----	----	92.0	369.0
Naphtha (−400 degrees)	----	----	39.9	209.4	----	----	----	----	----	----	39.9	209.4
Still gas	----	----	10.1	60.6	----	----	----	----	----	----	10.1	60.6
Miscellaneous (+400 degrees)	----	----	23.9	139.2	----	----	----	----	----	----	23.9	139.2
Total	141.0	935.7	296.4	1,470.0	----	----	----	----	----	----	437.4	2,405.7
Miscellaneous and unaccounted for	----	----	----	----	----	----	----	----	17.7	97.9	17.7	97.9
Total domestic product demand	1,000.1	5,765.9	781.0	4,352.5	2,382.6	12,777.0	144.2	904.9	102.9	594.1	4,410.8	24,394.4
1967 p												
Fuel and power:												
Liquefied gases	141.5	567.6	16.0	64.2	30.6	122.7	2.3	9.2	2.0	8.0	192.4	771.7
Jet fuels (kerosine and naphtha types)	----	----	----	----	300.8	1,670.2	----	----	----	----	300.8	1,670.2
Gasoline	----	----	----	----	1,842.7	9,670.5	----	----	----	----	1,842.7	9,670.5
Special naphtha	----	----	25.2	132.2	----	----	----	----	----	----	25.2	132.2
Kerosine	68.5	388.4	31.6	179.2	----	----	----	----	----	----	100.1	567.6
Distillate fuel	531.7	3,097.2	56.0	326.2	200.7	1,169.1	2.9	16.9	25.4	147.9	816.7	4,757.3
Residual fuel	192.1	1,207.7	169.8	1,067.5	124.2	780.9	158.4	995.9	7.6	47.8	652.1	4,099.8
Still gas	----	----	140.0	840.0	----	----	----	----	----	----	140.0	840.0
Petroleum coke	----	----	51.7	311.4	----	----	----	----	----	----	51.7	311.4
Total	933.8	5,260.9	490.3	2,920.7	2,499.0	13,413.4	163.6	1,022.0	35.0	203.7	4,121.7	22,820.7

See footnotes at end of table.

Table 13.—Petroleum consumption by major products and by major consuming groups [1]—Continued

	1967p											
	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
Raw materials: [3]												
Lubes and waxes	-----	-----	48.1	289.8	-----	-----	-----	-----	-----	-----	48.1	289.8
Petroleum coke [4]	-----	-----	23.4	141.0	-----	-----	-----	-----	-----	-----	23.4	141.0
Asphalt and road oil	138.3	917.8	-----	-----	-----	-----	-----	-----	-----	-----	138.3	917.8
Petrochemical feedstock offtake: [5]												
Liquefied refinery gas	-----	-----	44.0	176.5	-----	-----	-----	-----	-----	-----	44.0	176.5
Liquefied petroleum gas [6]	-----	-----	107.2	430.0	-----	-----	-----	-----	-----	-----	107.2	430.0
Naphtha (−400 degrees)	-----	-----	50.3	264.0	-----	-----	-----	-----	-----	-----	50.3	264.0
Still gas	-----	-----	9.5	57.0	-----	-----	-----	-----	-----	-----	9.5	57.0
Miscellaneous (+400 degrees)	-----	-----	24.1	140.4	-----	-----	-----	-----	-----	-----	24.1	140.4
Total	138.3	917.8	306.6	1,498.7	-----	-----	-----	-----	-----	-----	444.9	2,416.5
Miscellaneous and unaccounted for	-----	-----	-----	-----	-----	-----	-----	-----	16.9	93.4	16.9	93.4
Total domestic product demand	1,072.1	6,178.7	796.9	4,419.4	2,499.0	13,413.4	163.6	1,022.0	51.9	297.1	4,583.5	25,330.6

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 material industries.
4 Includes portions of petroleum coke estimated to be consumed in nonfuel uses.
5 Partly estimated.
6 Includes LP gas for synthetic rubber.

Table 14.—Electrical energy sales to ultimate consumers

(Million kilowatt-hours)

Region	Total consumption	Residential	Industrial and commercial	Total consumption	Residential	Industrial and commercial
	1963			1964		
New England	32,086	11,263	19,596	34,207	12,013	20,889
Middle Atlantic	126,287	33,978	83,466	135,255	36,152	89,898
East North Central	172,816	45,914	120,037	182,871	49,058	126,920
West North Central	54,005	20,985	31,076	57,500	22,570	32,973
South Atlantic	110,782	37,653	68,885	120,891	41,482	75,004
East South Central	98,883	23,061	74,580	102,776	25,489	75,988
West South Central	76,946	22,969	49,993	83,938	25,100	54,574
Mountain	38,225	9,985	26,573	41,045	10,957	28,332
Pacific	118,187	34,920	79,140	129,026	38,150	86,576
Alaska and Hawaii	2,594	964	1,569	2,847	1,039	1,741
Total United States	830,811	241,692	554,915	890,356	262,010	592,895
	1965			1966		
New England	36,984	12,813	22,806	40,184	13,883	24,877
Middle Atlantic	145,248	38,850	96,783	156,302	42,088	104,153
East North Central	193,539	52,544	133,919	207,521	57,005	142,858
West North Central	61,335	23,864	35,458	66,030	25,303	38,579
South Atlantic	132,883	45,178	82,932	148,757	50,920	92,723
East South Central	106,314	26,811	78,118	112,594	29,589	81,463
West South Central	92,586	27,396	60,602	102,760	29,753	68,071
Mountain	43,086	11,445	29,913	47,198	12,313	33,100
Pacific	138,376	40,939	93,085	154,302	44,502	103,093
Alaska and Hawaii	3,063	1,130	1,861	3,334	1,216	2,038
Total United States	953,414	280,970	635,477	1,038,982	306,572	690,955

Source: Edison Electric Institute. Statistical Year Book of the Electric Utility Industry. Annually 1963 through 1966.

Table 15.—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			Components as percent of total, before subtracting exports							
				Primary shipments		Old scrap		Imports		Exports	
	1966	1967	Percent increase	1966	1967	1966	1967	1966	1967	1966	1967
Ferrous metals:											
Iron ore	r 101,126	95,940	−5	53	51	---	----	47	49	r 8	6
Pig iron	92,462	87,397	−6	99	99	----	----	1	1	----	----
Steel ingot	133,935	127,211	−5	100	100	----	----	----	----	1	1
Chromite (Cr_2O_3)	754	494	−35	----	----	----	----	100	100	10	15
Cobalt	10	7	−30	4	42	----	----	96	58	----	----
Manganese	1,380	1,422	3	13	32	----	----	87	68	1	1
Molybdenum	37	27	−27	100	100	----	----	----	----	30	37
Nickel	265	173	−35	43	14	6	7	51	79	4	5
Tungsten	11	8	−27	77	89	----	----	23	11	----	6
Other metals:											
Aluminum	3,780	3,617	−4	80	83	3	3	17	14	8	9
Antimony	47	43	−9	5	4	52	55	43	41	----	----
Beryl ore (BeO) ... tons	236	1,046	343	W	W	----	----	100	100	----	----
Cadmium	7	5	−29	29	31	----	----	71	69	3	7
Copper	2,556	2,034	−20	66	50	19	21	15	29	10	10
Lead	1,316	1,380	5	30	24	43	39	27	37	----	----
Magnesium	104	110	6	84	81	13	11	3	8	13	10
Mercury ... 76-pound flasks	r 68,939	67,080	−3	32	34	23	32	45	34	1	4
Platinum-group ... thousand troy ounces	1,704	1,324	−22	20	1	5	23	75	76	11	17
Tin ... thousand long tons	75	71	−5	21	8	20	18	59	74	4	3
Titanium concentrate (TiO_2):											
Ilmenite and slag	577	603	5	78	77	----	----	22	23	----	----
Rutile	135	148	10	W	W	----	----	r 100	100	1	2
Uranium concentrate (U_3O_8)	12	10	−17	82	87	----	----	18	13	----	----
Zinc	1,389	1,293	−7	45	44	6	6	49	50	----	1
Nonmetals:											
Asbestos	805	721	−11	15	16	----	----	85	84	6	6
Barite, crude	1,646	1,494	−9	58	64	----	----	42	36	----	----
Bromine	138	146	6	100	100	----	----	----	----	----	----
Clays	r 55,780	53,623	−4	100	100	----	----	----	----	2	2
Fluorspar, finished	1,129	1,197	6	22	24	----	----	78	76	1	1
Gypsum	r 15,088	14,076	−7	64	67	----	----	36	33	----	----
Mica (except scrap)	5	3	−40	----	----	----	----	100	100	10	20
Phosphate rock (P_2O_5)	9,368	9,220	−2	100	100	----	----	----	----	23	26
Potash (K_2O equivalent)	r 4,003	4,139	3	68	65	----	----	32	35	13	14
Salt, common	38,280	41,111	7	94	93	----	----	6	7	2	2
Sand and gravel ... million tons	935	906	−3	100	100	----	----	----	----	----	----
Stone, crushed ... million tons	813	785	−3	100	100	----	----	----	----	----	----
Sulfur, all forms	r 9,470	9,628	2	85	85	----	----	15	15	22	20
Talc and allied minerals	846	852	1	98	98	----	----	2	2	8	7

r Revised.

W Withheld to avoid disclosing individual 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.

Table 16.—Shipments, net new orders, and yearend unfilled orders for selected mineral processing industries

(Millions)

Year and month	Shipments [1]			Net new orders [1]			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 [2]	Blast furnaces	All other primary metals [2]
1963	$35,325	$19,033	$16,292	$35,508	$19,104	$16,404	$3,930	$2,120	$1,810
1964	38,832	21,236	17,596	41,308	23,303	18,005	6,559	4,311	2,248
1965	41,910	22,916	18,994	41,017	21,378	19,639	5,646	2,730	2,916
1966	45,651	23,707	21,944	46,879	24,285	22,594	6,909	3,305	3,604
1967	42,607	22,237	20,370	42,216	22,403	19,813	6,527	3,497	3,030
1967:									
January	3,758	1,920	1,838	3,315	1,495	1,820	6,466	2,880	3,586
February	3,618	1,802	1,816	3,427	1,805	1,622	6,274	2,882	3,392
March	3,517	1,787	1,730	3,013	1,434	1,579	5,771	2,529	3,242
April	3,439	1,742	1,697	3,236	1,701	1,535	5,569	2,487	3,082
May	3,434	1,791	1,643	3,606	2,020	1,586	5,741	2,716	3,025
June	3,462	1,755	1,707	3,591	1,886	1,705	5,870	2,847	3,023
July	3,581	1,905	1,676	3,646	1,994	1,652	5,935	2,936	2,999
August	3,519	1,839	1,680	3,470	1,794	1,676	5,886	2,890	2,996
September	3,419	1,780	1,639	3,612	1,971	1,641	6,078	3,082	2,996
October	3,475	1,885	1,590	3,467	1,905	1,562	6,070	3,102	2,968
November	3,620	1,992	1,628	3,783	2,091	1,692	6,233	3,201	3,032
December	3,826	2,097	1,729	4,120	2,394	1,726	6,527	3,497	3,030

[1] Monthly figures are seasonally adjusted and do 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. 44–48, No. 3, March 1964–1968, pp. S-5, S-6.

Table 17.—Value of selected minerals and mineral products imported and exported by the United States in 1967, by commodity groups and commodities [1]

(Thousands)

SITC Code [2]	Commodity	Imports	Exports
	Minerals, nonmetallic (crude):		
271	Fertilizers, crude	$10,590	$95,600
273	Stone, sand and gravel	15,749	17,138
274	Sulfur and unroasted iron pyrites	47,663	90,974
275	Natural abrasives (including industrial diamonds)	64,914	26,984
276	Other crude minerals	132,347	86,980
	Total	271,263	317,676
	Metals (crude and scrap):		
281	Iron ores and concentrates	444,079	71,585
282	Iron and steel scrap	11,614	250,929
283	Ores and concentrates of nonferrous base metals	437,357	85,333
284	Nonferrous metal scrap	62,750	108,398
286	Ores and concentrates of uranium and thorium	270	--------
	Total	956,070	516,245
	Mineral energy resources and related products:		
321	Coal, coke, and briquets (including peat)	16,233	501,260
331	Petroleum, crude and partly refined	1,157,095	92,019
332	Petroleum products, except chemicals	923,844	446,870
341	Gas, natural and manufactured	145,789	64,226
	Total	2,242,961	1,104,375
	Chemicals:		
	Inorganic chemicals:		
513	Elements, oxides, and halogen salts	167,000	191,215
514	Other inorganic chemicals	48,780	107,671
515	Radioactive and associated materials except uranium and thorium	15,992	50,640
521	Mineral tar, crude chemicals from coal, petroleum, and natural gas	8,781	28,912
	Total	240,553	378,438
	Minerals, nonmetallic (manufactured):		
661	Lime, cement, and fabricated building materials, except glass and clay	34,204	14,980
662	Clay and refractory construction materials	30,338	48,395
663	Mineral manufactures, not elsewhere specified	19,023	66,260
	Total	83,565	129,635
	Metals (manufactured):		
671	Pig iron, spiegeleisen sponge iron, iron and steel powder and shot, and ferroalloys	83,706	22,482
672	Ingots and other primary forms of iron or steel	31,391	61,725
673	Iron and steel bars, rods, angles, shapes, and sections	385,049	49,149
674	Universals, plates and sheets of iron or steel	564,976	149,774
675	Hoops and strips of iron or steel	29,625	28,072
676	Rails and railway track construction material of iron or steel	1,853	6,336
677	Iron and steel wire (excluding wire rod)	84,296	10,082
678	Tubes, pipes, and fittings of iron or steel	180,503	180,658
679	Iron and steel castings or forgings, unworked, not elsewhere specified	9,730	52,885
681	Silver, platinum, and platinum group metals	85,389	30,144
682	Copper and copper alloys	659,869	208,994
683	Nickel and nickel alloys	204,567	41,012
684	Aluminum and aluminum alloys	243,303	197,181
685	Lead and lead alloys	89,462	4,767
686	Zinc and zinc alloys	59,083	8,173
687	Tin and tin alloys	166,988	7,495
688	Uranium and thorium and their alloys	1	22
689	Miscellaneous nonferrous base metals	55,404	49,195
	Total	2,935,195	1,108,146
	Grand total	6,729,607	3,554,515

[1] Data in this table are for the indicated SITC numbers only and, therefore, may not correspond to the figures classified by commodity in the "Statistical Summary" Chapter of this volume.
[2] Standard International Trade Classification.

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Imports General and Consumption, FT 135, December 1967, table 1. United States Exports, Commodity and Country, FT 410, December 1967, table 1.

Table 18.—Percentage distribution of exports of selected minerals and mineral fuels and related products by area of destination, 1967

SITC Code [1]	Group	North America [2]	South America	Europe	Asia	Africa	Oceania	Soviet bloc [3]	Undesignated area [4]
271	Fertilizers, crude	31	3	30	23	-----	7	(5)	(5)
273	Stone, sand and gravel	86	3	5	2	(5)	1	-----	3
274	Sulfur and unroasted iron pyrites	7	12	42	21	6	12	(5)	(5)
275	Natural abrasives, including industrial diamonds	14	3	58	18	2	4	-----	1
276	Crude minerals, n.e.c	35	6	37	16	1	3	(5)	2
281	Iron ore and concentrates	41	-----	(5)	59	-----	-----	-----	(5)
282	Iron and steel scrap	16	1	5	77	1	(5)	-----	(5)
283	Ores and concentrates of nonferrous base metal	11	1	67	20	1	(5)	(5)	(5)
284	Nonferrous metal scrap	24	1	38	36	(5)	(5)	1	(5)
286	Ores and concentrates of uranium and thorium	---	-----	-----	-----	-----	-----	-----	-----
321	Coke, coal, and briquets, including peat	30	6	37	26	(5)	(5)	1	(5)
331	Petroleum, crude and partly refined	19	-----	79	2	-----	-----	---	(5)
332	Petroleum products, except chemicals	23	10	27	31	5	3	(5)	1
341	Gas, natural and manufactured	91	1	8	(5)	(5)	(5)	-----	(5)
513	Inorganic chemical elements, oxides and halogen salts	41	9	26	10	6	3	3	2
514	Other inorganic chemicals	34	14	24	16	4	5	1	2
515	Radioactive and associated materials	4	(5)	77	18	(5)	(5)	(5)	1
521	Mineral tar and crude chemicals from coal, petroleum and natural gas	14	4	33	44	1	3	-----	1
661	Lime, cement, and fabricated building materials, except glass and clay	48	2	23	11	9	1	-----	6
662	Clay and refractory construction materials	56	11	16	8	2	3	(5)	4
663	Mineral manufactures, n.e.c	41	7	31	11	3	3	(5)	4
671	Pig iron, sponge iron, iron or steel powders and shot, and ferroalloys	36	4	42	13	2	2	-----	1
672	Iron and steel ingots and other primary forms	36	4	31	29	(5)	(5)	-----	(5)
673	Iron and steel bars, rods, angles, shapes, and sections	61	9	8	15	2	2	-----	3
674	Iron and steel plates and sheets	29	12	14	41	2	1	(5)	1
675	Iron and steel hoop and strip	50	4	25	12	2	4	1	2
676	Iron and steel rails and railway track construction material	36	46	1	2	4	6	-----	5
677	Iron and steel wire (except insulated electric)	55	10	8	10	9	2	-----	6
678	Iron and steel tubes, pipes, and fittings	39	12	13	19	12	2	1	2
679	Iron and steel castings and forgings (rough)	75	3	12	7	2	(5)	-----	6
681	Silver, platinum, and platinum group metals	6	1	77	16	-----	(5)	-----	(5)
682	Copper and copper alloys	11	5	57	26	(5)	(5)	-----	1
683	Nickel and nickel alloys	31	3	48	15	(5)	2	-----	1
684	Aluminum and aluminum alloys	33	9	30	25	1	1	(5)	1
685	Lead and lead alloys	14	14	50	15	-----	-----	-----	7
686	Zinc and zinc alloys	38	7	6	44	1	1	-----	3
687	Tin and tin alloys	12	3	29	54	-----	-----	-----	2
688	Uranium and thorium and their alloys	57	-----	-----	-----	-----	-----	-----	43
689	Base metals and alloys, n.e.c	41	3	45	9	(5)	1	(5)	1

[1] Standard International Trade Classification.
[2] Includes Trinidad and Netherlands Antilles.
[3] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Poland, Rumania, mainland China, North Korea, North Viet-Nam, and Yugoslavia.
[4] Special category exports.
[5] Less than ½ unit.

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Exports Schedule B Commodity and Country, FT 410, December 1967.

Table 19.—Percentage distribution of imports of principal minerals and related products consumed by area of origin in 1967

SITC Code	Commodity	North America	South America	Europe	Asia	Africa	Oceania	Soviet bloc [1]
2713000	Phosphates, crude and apatite	97	-----	3	-----	-----	-----	-----
2732100	Gypsum	98	(2)	1	(2)	-----	1	-----
2743000	Sulfur	100	-----	(2)	(2)	-----	-----	-----
2752400	Natural abrasives	3	-----	91	2	4	(2)	-----
2762200	Graphite, natural	39	-----	20	21	20	-----	-----
2762500	Magnesia, refractory, and caustic calcined and crude magnesite	1	-----	67	31	-----	1	-----
2763000	Salt	89	3	(2)	-----	8	-----	-----
2764000	Asbestos	90	(2)	1	-----	9	-----	-----
2765200	Mica, including scrap	(2)	32	1	58	9	-----	-----
2765420	Fluorspar	65	(2)	34	(2)	1	-----	-----
2768300	Barite, crude	47	15	19	5	14	-----	-----
2768500	Talc	10	-----	69	21	-----	(2)	-----
2810000	Iron ore and concentrates	62	31	1	(2)	6	(2)	-----
2820000	Iron and steel scrap	77	-----	17	3	(2)	(2)	3
2831110	Copper ores and concentrates	17	19	-----	64	-----	(2)	-----
2833000	Bauxite	75	25	(2)	-----	-----	(2)	-----
2834000	Lead ores and concentrates	35	39	1	(2)	(2)	25	-----
2835000	Zinc ores and concentrates	83	10	(2)	(2)	6	1	-----
2836000	Tin ores and concentrates	-----	100	(2)	-----	-----	-----	-----
2837000	Manganese ores and concentrates	3	14	1	8	74	(2)	-----
2839100	Chrome ore	-----	-----	-----	26	42	-----	32
2839200	Tungsten ores and concentrates	23	28	31	1	4	13	-----
2839310	Tantalum, molybdenum, and vanadium ores and concentrates	1	30	11	6	48	4	-----
2839320 / 2839330	Titanium ores	3	-----	-----	-----	7	90	-----
2839340	Zirconium ores	1	-----	-----	(2)	-----	99	-----
2839810	Antimony ores and needles	14	35	(2)	(2)	51	-----	-----
2839820	Beryllium ores and concentrates	-----	16	15	57	7	5	-----
2839830	Columbium ores and concentrates	9	38	7	5	41	(2)	-----
2840200	Copper waste and scrap	97	1	2	(2)	-----	(2)	-----
2840300	Nickel waste and scrap	66	-----	34	-----	(2)	(2)	-----
2840400	Aluminum waste and scrap	96	1	3	-----	-----	-----	-----
2840500	Magnesium waste and scrap	41	53	1	2	2	1	-----
2840600	Lead waste and scrap	76	1	22	(2)	-----	1	-----
2840700	Zinc waste and scrap	100	-----	-----	-----	-----	-----	-----
2840900	Tin waste and scrap	4	74	-----	22	-----	-----	-----
2850000	Platinum group metals, ores, concentrates and waste	47	3	25	3	5	17	-----
2860000	Thorium ores and concentrates	-----	-----	1	21	5	73	-----
3213000 / 3218000	Coal, coke, and briquets	79	-----	21	-----	-----	-----	-----
3310000	Petroleum, crude and partly refined	39	41	(2)	16	4	-----	-----
3320000	Petroleum products, except chemicals	48	46	4	1	1	(2)	(2)
3410000	Gases, natural and manufactured	100	(2)	(2)	(2)	-----	-----	-----
5132500	Mercury, including waste and scrap	6	4	88	2	-----	-----	-----
5136500	Alumina	15	42	5	6	2	30	-----
5210000	Mineral tar and crude chemicals from coal, petroleum, and natural gas	14	-----	82	(2)	-----	3	1
5613000	Potassic fertilizers and fertilizer materials	81	(2)	16	1	-----	-----	-----

[1] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Poland, Rumania, mainland China, North Korea, North Viet-Nam.
[2] Less than ½ unit.
Source: United States Department of Commerce, Bureau of the Cenus. U.S. Imports for Consumption, FT 135, December 1967, table 2.

Table 20.—Physical stocks of mineral energy resources and related products at yearend

(Producers' stocks, unless otherwise indicated)

Fuels	1963	1964	1965	1966	1967 p
Coal and related products: [1]					
Bituminous and lignite [2] short tons	73,028,665	77,939,559	79,739,516	76,808,024	95,408,000
Coke do	2,884,931	1,971,892	2,702,946	3,078,768	5,467,532
Petroleum and related products:					
Carbon black thousand pounds	254,216	231,171	237,704	233,145	264,247
Crude petroleum and petroleum products thousand barrels	835,559	839,235	836,344	r 881,105	944,111
Crude petroleum do	237,361	230,057	220,289	238,391	248,970
Natural gas liquids do	33,747	35,679	35,867	40,423	65,742
Gasoline do	186,860	193,633	183,058	194,177	207,715
Special naphthas do	4,077	5,879	6,209	5,583	5,742
Distillate fuel oil do	156,677	155,846	155,407	r 158,076	159,674
Residual fuel oil do	47,538	40,403	56,214	r 63,856	65,597
Petroleum asphalt do	14,354	14,231	16,178	17,309	19,939
Other refined products do	154,945	163,507	163,122	163,290	170,732
Natural gas [3] billion cubic feet	2,745	2,313	2,458	2,506	2,648

r Revised.
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 d ocks.
[3] American Gas Association.

Table 21.—Index of stocks of mineral manufacturers, consumers, and dealers at yearend

(1957-59=100)

Yearend	Metals and nonmetals [1]	Metals					Nonmetals
		Total	Iron	Other ferrous	Base nonferrous	Other nonferrous	
1963	96	94	91	85	96	96	128
1964	90	88	85	72	88	97	130
1965	90	89	84	72	92	99	116
1966	100	99	90	81	106	106	133
1967	100	98	89	103	95	128	138

[1] Excludes fuels.

Table 22.—Index of stocks of crude minerals at mines or in hands of primary producers at yearend

(1957-59=100)

Yearend	Metals and nonmetals [1]	Metals				Nonmetals [1]
		Total	Iron ore	Other ferrous	Nonferrous	
1963	121	141	157	69	153	112
1964	113	133	153	44	147	104
1965	110	149	180	41	128	92
1966	107	r 148	r 172	34	172	88
1967	107	169	186	96	177	78

r Revised.
[1] Excludes fuels.

Table 23.—Seasonally adjusted book value of product inventories for selected mineral processing industries

(Million dollars)

End of year or month	Petroleum and coal products	Stone, clay and glass products	Primary metals: Blast furnace and steel mills	Primary metals: Other primary metals [1]	Primary metals: Total
1963: December	$1,736	$1,544	$3,533	$2,385	$5,918
1964: December	1,745	1,587	3,707	2,404	6,111
1965: December	1,756	1,626	3,678	2,671	6,349
1966: December	1,869	1,746	4,043	3,066	7,109
1967:					
December	1,980	1,789	4,318	3,201	7,519
January	1,930	1,772	4,088	3,052	7,140
February	1,925	1,787	4,137	3,037	7,174
March	1,915	1,794	4,128	3,085	7,213
April	1,950	1,819	4,204	3,134	7,338
May	1,960	1,842	4,243	3,208	7,451
June	1,918	1,847	4,242	3,236	7,478
July	1,935	1,835	4,257	3,238	7,495
August	1,923	1,813	4,265	3,217	7,482
September	1,920	1,769	4,248	3,192	7,440
October	1,925	1,792	4,273	3,191	7,464
November	1,930	1,785	4,282	3,194	7,476

[1] "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. 44–48, No. 3, March 1964–1968, pp. S–5 to S–6.

Table 24.—Total employment in selected mineral industries

(Thousands)

	1963	1964	1965	1966	1967
Mining:					
Metal:					
Iron	24.1	24.6	[r] 25.9	[r] 26.3	27.5
Copper	27.7	27.1	[r] 30.0	[r] 31.7	23.8
Total [1]	79.7	79.5	[r] 83.8	[r] 86.5	79.1
Nonmetal mining and quarrying	117.0	116.2	[r] 119.6	[r] 120.8	120.9
Fuels:					
Bituminous	137.7	136.1	[r] 131.8	[r] 129.9	135.0
Other coal	11.3	11.2	[r] 9.6	[r] 7.8	7.0
Crude petroleum and natural gas fields	163.8	160.4	[r] 156.6	[r] 152.4	149.8
Oil and gas field services	125.4	130.7	[r] 130.5	[r] 127.4	120.7
Total	438.2	438.4	[r] 428.5	[r] 417.5	412.5
Total mining	634.9	634.1	[r] 631.9	[r] 624.8	612.5
Manufacturing:					
Minerals:					
Fertilizers complete and mixing only	38.2	38.0	[r] 39.7	[r] 40.7	40.6
Cement, hydraulic	38.9	38.6	38.0	[r] 38.0	36.5
Blast furnaces, steel works and rolling mills	520.0	556.7	[r] 580.2	[r] 571.3	553.1
Nonferrous smelting and refining	68.4	69.7	[r] 73.9	[r] 78.1	75.5
Fuels:					
Petroleum refining	153.7	149.6	[r] 148.1	[r] 149.6	152.8
Other petroleum and coal products	35.1	34.2	[r] 34.8	[r] 36.4	36.6
Total [2]	188.8	183.8	[r] 182.9	[r] 186.0	189.4
Total manufacturing	854.3	886.8	[r] 914.7	[r] 914.1	895.1

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

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings Statistics for the United States 1909–1967. Bul.. 1312–5, October 1967, 851 pp. Employment and Earnings, v. 14, No. 9, March 1968, table B–2.

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

	1963	1964	1965	1966	1967
Mining:					
Metal:					
Iron ores:					
Weekly earnings	$120.04	$125.83	$129.24	$138.09	$138.60
Weekly hours	39.1	40.2	40.9	42.1	42.0
Hourly earnings	$3.07	$3.13	$3.16	$3.28	$3.30
Copper ores:					
Weekly earnings	$124.56	$130.42	$136.71	$140.07	$140.51
Weekly hours	43.1	42.9	43.4	43.5	43.1
Hourly earnings	$2.89	$3.04	$3.15	$3.22	$3.26
Total: [1]					
Weekly earnings	$118.66	$122.54	$127.30	$133.77	$136.83
Weekly hours	41.2	41.4	41.6	42.2	42.1
Hourly earnings	$2.88	$2.96	$3.06	$3.17	$3.25
Nonmetallic mining and quarrying:					
Weekly earnings	$108.38	$111.85	$117.45	[r] $123.39	$128.65
Weekly hours	44.6	45.1	45.7	45.7	45.3
Hourly earnings	$2.43	$2.48	$2.57	[r] $2.70	$2.84
Fuels:					
Total coal mining:					
Weekly earnings	$119.89	$126.88	[r] $137.51	[r] $145.95	$150.93
Weekly hours	[2] 38.8	[2] 39.0	[2] 39.9	[2] 40.3	[2] 40.5
Hourly earnings	[2] $3.12	[2] $3.26	[r 2] $3.46	[r 2] $3.62	[2] $3.72
Bituminous coal:					
Weekly earnings	$121.43	$128.91	[r] $140.26	[r] $148.44	$153.09
Weekly hours	[2] 38.9	[2] 39.2	[2] 40.2	[2] 40.6	[2] 40.7
Hourly earnings	[2] $3.15	[2] $3.30	[2] $3.49	[2] $3.65	[2] $3.75
Crude petroleum and natural gas:					
Weekly earnings	$112.52	$112.63	$116.18	[r] $122.69	$120.66
Weekly hours	42.3	42.5	42.4	42.6	42.7
Hourly earnings	$2.66	$2.65	$2.74	[r] $2.88	$3.06
Total fuels: [3]					
Weekly earnings	$115.40	$118.15	[r] $124.29	[r] $131.55	$138.83
Weekly hours	40.9	41.1	41.5	[r] 41.7	41.8
Hourly earnings	$2.84	$2.89	$3.01	$3.16	$3.33
Total mining: [3]					
Weekly earnings	$112.55	$116.19	[r] $121.52	[r] $127.73	$131.85
Weekly hours	43.2	43.6	44.0	44.2	44.0
Hourly earnings	$2.61	$2.67	$2.77	[r] $2.90	$3.00
Manufacturing:					
Fertilizers, complete and mixing only:					
Weekly earnings	$90.67	$93.74	$96.57	[r] $101.38	$104.98
Weekly hours	43.8	43.4	43.5	[r] 43.7	43.2
Hourly earnings	$2.07	$2.16	$2.22	[r] $2.32	$2.43
Cement, hydraulic:					
Weekly earnings	$116.60	$121.30	$124.42	$132.61	$133.40
Weekly hours	41.2	41.4	41.2	41.7	41.3
Hourly earnings	$2.83	$2.93	$3.02	$3.18	$3.23
Blast furnaces, steel, and rolling mills:					
Weekly earnings	$134.40	$140.15	$141.86	$145.71	$145.16
Weekly hours	40.0	41.4	41.0	40.7	40.1
Hourly earnings	$3.36	$3.41	$3.46	$3.58	$3.62
Nonferrous smelting and refining:					
Weekly earnings	$118.14	$120.22	$124.44	$129.98	$134.30
Weekly hours	41.6	41.6	41.9	42.2	42.1
Hourly earnings	$2.84	$2.89	$2.97	$3.08	$3.19
Petroleum refining and related industries:					
Weekly earnings	$131.77	$133.76	$138.42	$144.58	$152.87
Weekly hours	41.7	41.8	42.2	42.4	42.7
Hourly earnings	$3.16	$3.20	$3.28	$3.41	$3.58
Petroleum refining:					
Weekly earnings	$137.45	$139.52	$145.05	$151.56	$159.09
Weekly hours	41.4	41.4	41.8	42.1	42.2
Hourly earnings	$3.32	$3.37	$3.47	$3.60	$3.77
Other petroleum and coal products:					
Weekly earnings	$108.28	$112.49	$115.90	$120.22	$129.51
Weekly hours	42.8	43.6	43.9	43.4	44.2
Hourly earnings	$2.53	$2.58	$2.64	$2.77	$2.93
Total manufacturing: [3]					
Weekly earnings	$129.54	$134.43	[r] $137.35	[r] $141.83	$142.96
Weekly hours	40.6	41.3	[r] 41.3	[r] 41.2	40.9
Hourly earnings	$3.19	$3.25	[r] $3.32	[r] $3.44	$3.51

[r] Revised.
[1] Includes other metal mining not shown separately.
[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 pages. Employment and Earnings, v. 14, No. 9, March 1968, Table C-2

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

(Per thousand employees)

Rates and year	Manufacturing	Cement hydraulic	Blast furnaces, steel and rolling mills	Nonferrous smelting and refining	Metal mining	Iron ore	Copper ore	Petroleum refining and related industries [2]	Petroleum refining	Coal mining
Total accession rate:										
1965	43	26	23	25	32	27	28	18	12	17
1966	50	23	29	32	35	26	30	21	16	17
1967	44	28	25	29	35	33	28	23	17	16
Total separation rate:										
1965	41	27	30	22	31	25	25	19	13	19
1966	46	28	24	27	35	r 30	26	21	r 15	18
1967	46	31	25	27	38	35	35	22	16	18
Layoff rate:										
1965	14	16	13	4	7	13	4	r 7	4	9
1966	12	13	5	3	7	15	2	6	5	r 9
1967	14	17	9	3	9	17	5	6	5	5

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

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment anc Earnings Statistics for the United States' 1909–1967, Bull. 1312-5, October 1967, 852 pp. Employment and Earnings, v. 14, No. 9, March 1968, table D-2

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

	1965 r	1966 r	1967 p	Percent change 1965–66	Percent change 1966–67
Wages and salaries:					
All industries, total .... millions	$358,885	$394,560	$423,382	9.9	7.3
Mining .... do	4,322	4,517	4,648	4.5	2.9
Manufacturing .... do	115,561	126,036	134,127	10.8	4.8
Average earnings per full-time employee:					
All industries, total	$5,710	$5,959	$6,209	4.4	4.2
Mining	6,785	7,125	7,545	5.0	5.9
Manufacturing	6,389	6,643	6,879	4.0	3.6

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business, v. 48, No. 7, July 1968, pp. 41–42.

Table 28.—Labor-productivity indexes for selected minerals

(1957–59 = 100)

Year	Copper, crude ore mined per—			Iron, crude ore mined per—		
	Employee	Production worker	Production worker man-hour	Employee	Production worker	Production worker man-hour
1962	131.6	125.1	120.3	151.2	150.6	142.3
1963	r 133.6	125.3	119.7	168.6	163.5	157.3
1964	145.0	136.7	131.1	187.5	180.8	169.1
1965	146.0	136.1	129.1	183.0	176.9	162.6
1966 p	149.2	139.2	131.7	184.5	180.2	161.1
	Copper, recoverable metal per—			Iron, usable ore mined per—		
	Employee	Production worker	Production worker man-hour	Employee	Production worker	Production worker man-hour
1962	128.2	121.9	117.2	120.8	120.3	113.7
1963	r 131.3	123.0	117.5	129.3	125.4	120.6
1964	138.4	130.5	125.2	145.5	140.3	131.2
1965	135.3	126.2	119.6	143.8	139.1	127.8
1966 p	135.6	126.5	119.7	146.3	143.0	127.8
	Petroleum, refined per—			Bituminous coal and lignite mined per—		
	Employee	Production worker	Production worker man-hour	Employee	Production worker	Production worker man-hour
1962	135.2	138.5	137.3	r 137.3	r 137.5	r 130.8
1963	142.9	145.0	146.8	r 151.5	r 150.1	r 135.7
1964 r	153.4	156.4	154.2	162.6	161.5	144.4
1965	p 163.0	p 165.9	p 166.5	r 176.7	r 176.5	r 154.2
1966 p	NA	NA	NA	186.7	188.2	162.9

r Revised.
p Preliminary.
NA Not available.
Source: U.S. Department of Labor, Bureau of Labor Statistics. Index of Output per Man-hour Selected Industries 1939 and 1947–66. BLS Bull. No. 1572, October 1967, 99 pages.

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

(1957–59 = 100)

	1963	1964	1965	1966	1967
Metals:					
Ferrous	107.6	110.9	112.1	112.2	116.7
Nonferrous:					
Base	103.7	112.5	123.2	124.8	128.7
Monetary	120.0	120.5	120.5	124.7	136.9
Other	95.7	98.6	99.5	92.3	85.9
Total	103.2	109.7	117.7	r 117.6	120.2
Total metals	105.4	110.3	114.9	114.9	118.5
Nonmetals:					
Construction	101.7	101.9	101.5	r 101.9	104.1
Chemical	98.1	101.2	104.5	r 105.6	111.1
Other	102.8	103.5	103.3	r 103.5	108.4
Total	101.2	101.9	102.1	r 102.6	105.5
Fuels:					
Coal	90.1	91.4	90.8	r 92.0	96.4
Crude oil and natural gas [1]	101.6	100.8	100.4	r 101.1	102.6
Total	98.4	98.0	97.8	r 99.1	101.3
Total all minerals	99.6	99.9	100.3	101.3	103.7

r Revised.
[1] Does not cover isopentane, LP gases, and other natural gas liquids.

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

(1957–59=100)

	1963	1964	1965	1966	1967 [p]
Metals:					
Ferrous	108.8	112.2	[r] 113.8	114.6	118.1
Nonferrous:					
Base	104.4	113.2	123.5	124.6	129.2
Monetary	116.0	116.9	116.2	116.6	125.1
Other	95.7	97.3	[r] 97.3	91.7	92.1
Total	104.8	112.1	[r] 121.8	122.3	122.8
Total metals	101.2	112.8	119.4	119.7	120.0
Nonmetals:					
Construction	101.5	101.8	[r] 101.6	103.2	102.5
Chemical	98.8	101.6	[r] 103.0	107.0	112.8
Other	104.7	105.2	[r] 104.2	105.8	107.5
Total	101.2	101.9	[r] 102.0	104.1	104.9
Fuels:					
Coal	89.7	90.9	90.6	92.1	96.7
Crude oil and natural gas	102.4	101.6	101.5	103.1	103.9
Total	99.2	98.5	98.7	100.7	102.5
Total all minerals	100.3	100.7	[r] 101.5	103.3	104.2

[r] Revised. [p] Preliminary.

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

(1957–59=100 unless otherwise indicated)

Commodity	Annual average		Percent change from 1966
	1966	1967	
Metals and metal products	108.3	109.5	+1.1
Iron and steel	102.3	103.6	+1.3
Iron ore	90.5	89.9	−0.7
Iron and steel scrap	77.3	72.5	−6.2
Semifinished steel products	103.7	105.0	+1.3
Finished steel products	104.7	106.1	+1.3
Foundry and forge shop products	108.0	111.6	+3.3
Pig iron and ferroalloys	80.2	80.0	−0.3
Nonferrous metals	120.9	120.6	−0.3
Primary metal refinery shapes	118.8	122.2	+2.9
Aluminum ingot	97.7	99.5	+1.8
Copper, ingot, electrolytic	123.2	130.5	+5.9
Lead, pig, common	116.1	107.8	−7.1
Zinc, slab, prime western	130.0	124.4	−4.3
Nonferrous scrap	162.7	134.8	−17.1
Nonmetallic mineral products	102.6	104.3	+1.7
Concrete ingredients	103.9	106.0	+2.0
Sand, gravel, and crushed stone	106.6	109.0	+2.3
Concrete products	103.0	105.3	+2.2
Structural clay products	[r] 108.4	110.1	+1.6
Gypsum products	102.4	102.4	----------
Other nonmetallic minerals	101.7	101.9	+0.2
Building lime	114.6	117.6	+2.6
Insulation materials	89.8	90.7	+1.0
Asbestos cement shingles	115.1	117.8	+2.3
Bituminous binders	99.2	98.1	−1.1
Fertilizer materials	104.4	106.9	+1.5
Nitrogenates	96.9	98.2	+1.3
Phosphates	120.9	125.6	+3.9
Phosphate rock	145.1	147.4	+1.6
Potash	112.5	102.7	−8.7
Muriate, domestic	109.3	97.9	−10.4
Sulfate	119.2	120.9	+1.4
Fuels and related products and power	101.3	103.6	+2.3
Coal	98.6	103.2	+4.7
Anthracite	92.5	92.9	+0.4
Bituminous	99.3	104.2	+5.0
Coke	109.8	112.0	+2.0
Gas fuels [1]	129.3	133.6	+3.3
Electric power [1]	100.3	100.7	+0.4
Petroleum products, refined	99.5	102.2	+2.7
Crude petroleum	97.5	98.6	+1.1
All commodities other than farm and food	104.7	106.3	+1.5
All commodities	105.9	106.1	+0.2

[r] Revised.
[1] January 1958=100.
Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes, January 1967–February 1968, tables 2, 2–A, and 2–B.

Table 32.—Comparative mineral energy resource prices

Fuel	1966	1967
Bituminous coal: Average prices:		
Cost of coal at merchant coke ovens……dollars per net ton	9,81	10.50
Anthracite, average sales realization per net ton at preparation plants, excluding dredge coal:		
Chestnut……dollars	11.59	12.03
Pea……do	9.35	9.75
Buckwheat No. 1……do	8.74	6.35
Petroleum and petroleum products:		
Crude petroleum, average price per barrel at well……do	2.88	2.92
Gasoline, average dealers net price (excluding taxes) of gasoline in 55 U.S. cities [1] cents per gallon	15.83	16.31
Residual fuel oil:		
No. 6 fuel, average of high and low prices in Philadelphia [1] dollars per barrel (refinery)	3.10	3.10
Bunker C, average price for all Gulf Ports……do	2.10	1.98
Distillate fuel oil:		
No. 2 distillate, average of high and low prices at Philadelphia [1] cents per gallon (refinery)	10.02	10.57
No. 2 distillate, average price for all Gulf ports [1]……do	8.74	9.48
Natural gas:		
Average U.S. value at well……cents per thousand cubic feet	15.7	16.0
Average U.S. value at point of consumption……do	52.3	51.9

[1] Platt's Oil Price Handbook.

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

(Cents per million Btu)

Region	1964			1965			1966		
	Coal	Oil	Gas	Coal	Oil	Gas	Coal	Oil	Gas
New England	33.4	34.4	34.2	33.4	34.4	34.2	33.6	32.9	33.8
Middle Atlantic	26.0	31.7	33.5	26.2	32.3	33.8	26.5	31.9	34.4
East North Central	24.6	68.2	24.8	24.3	66.2	25.9	24.4	59.8	25.9
West North Central	26.0	50.4	24.3	26.2	50.8	24.2	26.4	49.9	24.2
South Atlantic	25.4	33.9	32.2	25.1	33.7	32.3	25.6	33.6	31.8
East South Central	19.3	50.1	24.6	18.9	62.8	23.8	19.3	52.1	22.7
West South Central	14.9	42.6	19.6	17.7	50.4	19.8	------	40.7	19.8
Mountain	19.2	25.7	26.6	19.3	26.2	27.1	20.4	25.4	26.7
Pacific	----	30.7	32.2	------	32.0	31.4	------	31.5	31.5
Average	24.6	32.6	25.3	24.4	33.1	25.0	24.7	32.4	25.0

Source: National Coal Association. Steam-Electric Plant Factors. Annually, 1964 through 1966, table 2.

Table 34.—Cost of electrical energy

(Cents per kilowatt hour)

Region	1964			1965			1966		
	Total	Residential	Commercial and industrial	Total	Residential	Commercial and industrial	Total	Residential	Commercial and industrial
New England	2.4	3.0	2.0	2.4	3.0	2.0	2.3	2.9	1.9
Middle Atlantic	1.9	2.8	1.6	1.9	2.7	1.6	1.9	2.7	1.5
East North Central	1.7	2.5	1.4	1.7	2.5	1.3	1.7	2.4	1.3
West North Central	2.1	2.6	1.7	2.0	2.6	1.7	2.0	2.5	1.7
South Atlantic	1.7	2.2	1.4	1.6	2.1	1.3	1.6	2.1	1.3
East South Central	0.9	1.4	0.7	0.9	1.4	0.7	0.9	1.3	0.7
West South Central	1.7	2.5	1.3	1.6	2.4	1.3	1.6	2.3	1.2
Mountain	1.5	2.3	1.2	1.5	2.2	1.2	1.5	2.2	1.2
Pacific	1.3	1.8	1.1	1.3	1.8	1.1	1.2	1.7	1.0
Alaska and Hawaii	2.5	3.0	2.2	2.5	2.9	2.2	2.5	2.9	2.2
Total	1.6	2.3	1.3	1.6	2.3	1.3	1.6	2.2	1.3

Source: Edison Electric Institute. Statistical Year Book of the Electric Utilities Industry. Annually 1964 through 1966.

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

(1957–59 = 100)

Year	Total[2]	Labor[2]	Supplies	Fuels	Electrical energy
1963	99	96	102	100	102
1964	98	95	102	97	101
1965	102	101	103	99	101
1966	104	103	105	102	100
1967 p	109	112	107	104	101

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.
[2] Revised because of the change in weight values.

Table 36.—Indexes 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
1963	85	99
1964	85	100
1965	86	100
1966	86	100
1967 p	87	100

p Preliminary.
[1] Index based on weights derived from the 1963 Census of Mineral Industries and data from U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Prices and Price Indexes. Annual and monthly releases.

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

(1957–59 = 100)

Year	Index of labor costs per unit of output				Index of value of product per man-period				Index of labor costs per dollar of product			
	Iron ore [2]	Copper [2]	Bituminous coal	Petroleum	Iron ore [2]	Copper [2]	Bituminous coal	Petroleum	Iron ore [2]	Copper [2]	Bituminous coal	Petroleum
1963	92	100	76	98	115	127	125	118	97	94	86	101
1964	87	101	75	98	123	139	134	120	93	91	84	102
1965	r 91	r 110	76	98	r 119	r 145	140	124	r 97	r 90	85	102
1966	94	112	75	94	110	148	151	136	101	91	82	98
1967 p	106	117	77	93	106	153	163	147	114	89	79	95

p Preliminary. r Revised.

[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 values 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 mineral and mineral fuels production

(1957–59 = 100, unless otherwise specified)

Commodity	1967 January	1967 December	Change from January (percent)	Annual average 1966	Annual average 1967	Change from 1966 (percent)
Coal	102.3	104.9	+2.5	98.6	103.2	+4.7
Coke	112.0	112.0	-------	109.8	112.0	+2.0
Gas fuels (Jan. 1958 = 100)	134.6	133.1	−1.1	129.3	133.6	+3.3
Petroleum products, refined	100.3	99.9	−0.4	99.5	102.2	+2.7
Industrial chemicals	96.6	98.3	+1.8	95.7	97.4	+1.8
Lumber	104.5	111.8	+7.0	108.5	108.4	−0.1
Explosives	109.4	112.0	+2.4	109.7	112.4	+2.5
Construction machinery and equipment	121.3	126.3	+4.1	118.9	122.7	+3.2

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes January–February 1967, tables 2 and 2B, and January 1968, tables 2 and 2A. Monthly issues, January–December 1967, table 2, used to figure annual average for explosives.

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

(1957–59 = 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
1963	109.6	109.1	102.6	108.8	108.1	115.1	108.5	112.1	110.8
1964	112.4	110.5	104.3	111.8	108.5	117.6	110.8	116.3	114.7
1965	115.3	113.3	104.7	113.7	110.3	128.7	114.2	119.6	117.6
1966	118.9	116.8	106.2	118.3	114.5	133.8	117.1	123.7	120.8
1967	122.7	120.3	109.8	122.4	117.0	134.7	120.1	127.8	125.2

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes, January 1968, table 2A, and previous years.

Table 40.—National income originated in the mineral industries

Industry	Income millions 1965 [r]	Income millions 1966 [r]	Income millions 1967 [p]	Change from 1966 (percent)
Mining	$6,116	$6,511	$6,435	−1.2
Metal mining	908	1,183	912	−22.9
Coal mining	1,332	1,391	1,443	+3.7
Crude petroleum and natural gas	2,754	2,744	2,824	+2.9
Mining and quarrying of nonmetallic metals	1,122	1,193	1,256	+5.3
Manufacturing	172,725	191,798	196,613	+2.5
Chemicals and allied products	12,648	13,752	14,511	+5.5
Petroleum refining and related industries	5,381	5,839	6,028	+3.2
Stone, clay, and glass products	5,713	5,965	5,857	−1.8
Primary metal industries	14,735	16,148	15,194	−5.9
All industries	564,336	620,760	652,867	+5.2

[r] Revised. [p] Preliminary.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business, v. 48, No. 7, July 1968, p. 23.

Table 41.—Direct private investment of U.S. companies in foreign petroleum industries, 1966 p

(Million dollars; net inflows to the United States (−)

	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
Canada	3,356	155	89	3,606	15,223	1,087	539	16,840
Latin American Republics, all	3,034	−67	−5	2,959	9,391	162	299	9,854
Other Western Hemisphere	512	32	8	579	1,445	114	41	1,619
Europe	3,427	634	−77	3,977	13,985	1,805	434	16,200
Africa	1,029	70	17	1,108	1,918	89	75	2,078
Middle East	1,436	112	12	1,560	1,536	121	13	1,671
Far East	904	−8	18	907	2,033	85	98	2,219
Oceania	498	12	10	521	1,813	150	97	2,064
International [1]	1,101	−64	28	1,047	1,985	−71	121	2,016
Total [2]	15,298	876	100	16,264	49,328	3,543	1,716	54,562

p Preliminary
[1] Comprised of international trading and shipping companies.
[2] Data may not add to total due to rounding.
Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business, v. 47, No. 9, September 1967, pp. 42–43.

Table 42.—Direct private investments of the United States in foreign mining and smelting industries in 1966 p

(Millions)

	Mining and smelting				
	Value	Net capital outflow	Undistributed earnings of subsidiaries	Earnings [1]	Income [2]
Canada	$1,942	$121	$67	$191	$120
Latin America, total	1,117	−24	28	263	234
Mexico	108	−6	11	19	7
Panama	19	-------	-------	-------	-------
Brazil	58	(3)	(3)	(3)	(3)
Chile	494	−14	−1	98	98
Peru	262	−9	8	99	92
Europe	54	1	−1	10	11
Africa, total	369	−4	19	78	58
South Africa, Republic of	73	(4)	9	45	33
Far East	37	(4)	3	4	1
Oceania, total	249	75	12	18	6
Australia	249	76	12	18	6
All other countries [5]	367	52	3	96	93
Total, all areas [6] [7]	4,135	220	130	660	524

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] Combined with other industries in source reference.
[4] Less than ½ unit.
[5] "All other countries" includes other Western Hemisphere, Middle East, and International.
[6] Excludes Communist countries.
[7] Data may not add to total due to rounding.
Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business, v. 47, No. 9, September 1967, pp. 42–43.

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

(Billions)

Industry	1965	1966	1967
Mining [1]	$1.30	$1.47	$1.42
Manufacturing:			
Primary iron and steel	1.93	2.17	2.31
Primary nonferrous metals	.68	.86	.90
Stone, clay and glass products	.78	.91	.73
Chemical and allied products	2.59	2.99	2.88
Petroleum and coal products	3.82	4.42	4.65
All manufacturing	22.45	26.99	26.69

[1] Including fuels.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business, June 1967, v. 47, No. 6, p. 10; June 1968, v. 48, No. 6, p. 10.

Table 44.—Sources of funds of direct foreign investment by United States mining and smelting industries

(Millions)

Area	Net income			Funds from United States			Funds obtained abroad [1]			Depreciation and depletion			Total sources		
	1963	1964	1965	1963	1964	1965	1963	1964	1965	1963	1964	1965	1963	1964	1965
Canada	$187	$308	$320	$−24	$14	$32	$70	$66	$90	$114	$116	$122	$347	$504	$564
Latin America	234	278	301	14	−72	−31	15	33	22	101	98	107	364	337	399
Europe	4	3	7	7	2	1	−1	([2])	6	2	5	5	12	10	19
Other areas	68	71	110	44	32	122	18	89	158	22	50	44	152	242	434
Total	493	660	738	41	−24	124	102	188	276	239	269	278	875	1,093	1,416

[1] Includes miscellaneous sources.
[2] Less than ½ unit.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business, v. 47, No. 1, January 1967, p. 28.

Table 45.—Uses of funds for direct foreign investment by United States mining and smelting industries

(Millions)

Area	Property, plant and equipment			Inventories			Receivables		
	1963	1964	1965	1963	1964	1965	1963	1964	1965
Canada	$195	$220	$265	$−12	$−15	$54	$19	$39	$24
Latin America	109	123	160	5	9	30	10	11	12
Europe	5	3	5	−1	1	3	1	2	2
Other areas	89	117	252	5	18	13	15	21	15
Total	398	463	682	−3	13	100	45	73	53
	Other assets [1]			Income paid out			Total uses		
	1963	1964	1965	1963	1964	1965	1963	1964	1965
Canada	$60	$96	$57	$85	$164	$164	$347	$504	$564
Latin America	16	24	22	224	170	175	364	337	399
Europe	(2)	(2)	1	7	4	8	12	10	19
Other areas	5	36	64	38	50	90	152	242	434
Total	81	156	144	354	388	437	875	1,093	1,416

[1] Includes miscellaneous uses.
[2] Less than ½ unit.
Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business, v. 47, No. 1, January 1967, p. 28.

Table 46.—Annual average profit rates on shareholders equity, after taxes, and total dividends, selected mineral manufacturing corporations

Industry	Annual profit rate (percent)			Total dividends (millions)		
	1966	1967	Change from 1966	1966	1967	Change from 1966 (percent)
All manufacturing [1]	13.5	11.7	−1.8	$12,958	$13,262	+2.3
Primary metals	12.0	9.0	−3.0	1,114	1,137	+2.1
Primary iron and steel	10.3	7.7	−2.6	602	616	+2.3
Primary nonferrous metals	14.8	11.0	−3.8	511	520	+1.8
Stone, clay and glass products	9.9	8.2	−1.7	363	354	−2.5
Chemicals and allied products	15.1	13.1	−2.0	1,717	1,733	+0.9
Petroleum refining and related industries	12.4	12.5	+0.1	[2] 2,442	2,660	+8.9
Petroleum refining	12.4	12.5	+0.1	[2] 2,430	2,654	+9.2

[1] Except newspapers.
[2] Corrected figure.
Source: Federal Trade Commission, Securities and Exchange Commission. Quarterly Financial Report for Manufacturing Corporations, 1st Quarter and 4th Quarter 1967, tables 4, 8.

Table 47.—Industrial and commercial failures and liabilities in mining and manufacturing

Industry	1965	1966	1967
Mining: [1]			
Number of failures	84	73	71
Current liabilities thousands	$14,556	$15,740	$24,576
Manufacturing:			
Number of failures	2,013	1,779	1,761
Current liabilities thousands	$335,768	$337,121	$301,293
All industrial and commercial industries:			
Number of failures	13,514	13,061	12,364
Current liabilities thousands	$1,321,666	$1,385,659	$1,265,227

[1] Including fuels.
Source: Dun and Bradstreet, Inc., Business Economics Department. Quarterly Failure Report, Detailed Divisions of Industry, Fourth Quarter 1967, February 9, 1968, 4 pp. Business Economics, Monthly Failures, K-9, No. 12, January 20, 1968, 4 pp.

Table 48.—Estimated gross proceeds of new corporate securities offered for cash in 1967 [1]

Type of security	Total corporate		Manufacturing		Extractive [2]	
	Millions	Percent	Millions	Percent	Millions	Percent
Bonds	$21,954	88.5	$9,894	89.5	$406	69.0
Preferred stock	885	3.5	231	2.1	7	1.2
Common stock	1,960	8.0	933	8.4	175	29.8
Total	24,799	100.0	11,058	100.0	588	100.0

[1] Substantially all new issues of securities 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. 17, No. 4, p. 12.

Table 49.—Plant and equipment expenditures of foreign affiliates of U.S. companies by area and industry

(Millions)

Area and country	1965 [r]			1966 [r]			1967 [1]		
	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing
Canada	$228	$503	$952	$315	$611	$1,203	$363	$650	$1,142
Latin America	160	307	448	229	268	438	284	380	586
Europe	4	603	1,877	6	778	2,260	6	1,140	2,574
All other areas	252	857	622	257	901	725	295	1,210	766
Total [2]	645	2,270	3,899	807	2,558	4,626	948	3,381	5,067

[r] Revised.
[1] Estimated on the basis of company projections.
[2] Details may not add to total because of rounding.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business, v. 47, No. 10, October 1967, p. 17.

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

(Millions)

Industry	1962	1963	1964	1965	1966 [p]
Total	$7,612	$7,944	$8,363	$8,797	$9,054
Petroleum	1,419	1,513	1,612	1,710	1,740

[p] Preliminary.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business, v. 46, No. 9, September 1967, p. 51.

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

(Thousand short tons)

Products	Rail [1]			Water [2]		
	1965	1966	Change from 1965 (percent)	1965	1966	Change from 1965 (percent)
Metals and minerals except fuels:						
Iron ore and concentrates	97,029	107,335	+10.6	66,247	72,364	+9.2
Iron and steel scrap	26,991	27,396	+1.5	1,365	1,499	+9.8
Pig iron	3,943	4,095	+3.9	850	880	+3.5
Iron and steel ingot, plate, bars, rods, tubing, and other primary products	53,729	53,671	−0.1	8,377	7,800	−6.9
Bauxite and other aluminum ores and concentrates	3,978	4,490	+12.9	2,518	825	−67.2
Other nonferrous ores and concentrates	17,592	17,221	−2.1	872	1,541	+76.7
Nonferrous metals and alloys	8,470	9,920	+17.1	800	870	+8.8
Nonferrous metal scrap	2,296	2,368	+3.1	54	47	−13.0
Slag	2,462	2,295	−6.8	484	639	+32.0
Sand and gravel	62,094	60,002	−3.4	58,721	58,670	−0.1
Stone, crushed and broken	67,699	65,217	−3.7	10,359	11,384	+9.9
Limestone flux, and calcareous stone	-------	-------	------	30,299	34,463	+13.7
Cement, building	26,001	26,383	+1.5	8,950	9,124	+1.9
Phosphate rock	31,265	31,601	+1.1	3,732	4,144	+11.0
Clays, ceramic and refractory materials	4,411	3,648	−17.3	2,132	2,257	+5.9
Sulfur, dry } Sulfur, liquid }	4,004	3,511	−12.3	294	488	+66.0
				7,061	7,939	+12.4
Gypsum and plaster rock	730	707	−3.2	844	907	+7.5
Other nonmetallic minerals except fuels	5,875	5,474	−6.8	4,877	4,393	−9.9
Fertilizer and fertilizer materials	12,530	15,289	+22.0	2,319	3,018	+30.1
Total	431,099	440,623	+2.2	211,155	223,252	+5.7
Mineral energy resources and related products:						
Coal:						
Anthracite	10,423	8,815	−15.4	339	181	−46.6
Bituminous and lignite	352,597	367,506	+4.2	156,645	161,894	+3.4
Coke	366	382	+4.4	465	528	+13.5
Crude petroleum	648	631	−2.6	82,083	92,851	+13.1
Gasoline } Jet fuel }	3,853	3,458	−10.3	90,440	86,443	−4.4
				10,025	10,784	+7.6
Kerosine	239	291	+21.8	8,655	7,971	−7.9
Distillate fuel oil	2,257	1,910	−15.4	71,581	72,399	+1.1
Residual fuel oil	3,929	4,041	+2.9	42,932	43,323	+0.9
Asphalt, tar, and pitches	3,259	3,205	−1.7	7,657	7,202	−6.0
Liquefied petroleum gases and coal gases	5,312	5,774	+8.7	1,179	1,029	−12.7
Other petroleum and coal products [3]	9,476	9,515	+0.4	9,034	10,809	+19.6
Total	392,359	405,528	+3.4	481,035	495,414	+3.0
Total mineral products	823,458	846,151	+2.7	692,190	718,666	+3.8
Grand total, all commodities	1,386,090	1,447,852	+4.5	829,169	862,725	+4.0
Mineral products, percent of grand total:						
Metals and minerals, except fuels	31.1	30.4	−0.7	25.5	25.9	+0.4
Mineral energy resources and related products	28.3	28,0	−0.3	58.0	57.4	−0.6
Total mineral products	59.4	58.4	−1.0	83.5	83.3	−0.2

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

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

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

Source: Interstate Commerce Commission, Bureau of Accounts. Freight Commodity Statistics, Class I Railroads in the United States for the years ended December 31, 1965 and 1966. Statements 67100 and 68100. Department of the Army Corps of Engineers. Waterborne Commerce of the United States, Part 5, National Summaries, calendar years 1965 and 1966, table 2.

Table 52.—Percentage distribution of mine shipments of bituminous coal and lignite by method of shipment and mines use

Year	Method of shipment for mines				
	Shipped by rail and trucked to rail	Shipped by water and trucked to water	Trucked to final destination	Used at mines [1]	Total production
1962	72.8	11.4	13.0	2.8	100.0
1963	72.8	11.0	13.3	2.9	100.0
1964	71.7	12.2	13.5	2.6	100.0
1965	72.6	11.8	13.3	2.3	100.0
1966	72.5	11.6	12.6	3.3	100.0

[1] Includes coal used at mine for power and heat, made into behive 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	1962	1963	1964	1965	1966
All types:					
Field and gathering	58,680	60,720	61,010	62,110	63,330
Transmission	196,380	200,940	205,400	211,360	217,100
Distribution	428,170	448,280	469,810	494,520	519,610
Total	683,230	709,940	736,220	767,990	800,040
Natural gas:					
Field and gathering	58,680	60,720	61,010	62,110	63,330
Transmission	194,970	200,020	204,730	210,780	216,530
Distribution	409,910	433,620	458,770	484,260	509,840
Total	663,560	694,360	724,510	757,150	789,700
Manufactured gas:					
Field and gathering	---	---	---	---	---
Transmission	20	[2]	[2]	10	---
Distribution	1,480	1,490	1,460	1,420	1,180
Total	1,500	1,490	1,460	1,430	1,180
Mixed gas:					
Field and gathering	---	---	---	---	---
Transmission	1,380	920	670	570	570
Distribution	15,080	11,890	8,310	7,810	7,800
Total	16,460	12,810	8,980	8,380	8,370
Liquefied petroleum gas:					
Field and gathering	---	---	---	---	---
Transmission	10	---	---	---	---
Distribution	1,700	1,280	1,270	1,030	790
Total	1,710	1,280	1,270	1,030	790

[1] Excludes service pipe. Data not adjusted to common diameter 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 1966. New York, 1967, p. 57. For earlier years see Historical Statistics of the Gas Industry.

Table 54.—Petroleum pipelines, selected years

(Miles)

Year	Trunklines		Gathering lines	Total
	Crude	Products		
1953	75,228	27,236	68,040	170,504
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

Table 55.—Research and development activity

	Funds expended (million dollars)					
	Total		Company		Federal Government	
	1965	1966 p	1965	1966 p	1965	1966 p
Petroleum refining and extraction	434	441	364	385	69	56
Percent of all industries	3.1	2.8	5.6	5.3	0.9	0.7
Chemicals and allied products	1,390	1,515	1,198	1,324	191	191
Percent of all industries	9.8	9.7	18.6	18.3	2.5	2.3
All industries	14,185	15,541	6,445	7,254	7,740	8,287

p Preliminary.
Source: National Science Foundation. Reviews of Data on Science Resources. No. 12, January 1968, table 2.

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

(Thousands)

Federal agency	Fiscal year 1967 e			Fiscal year 1968 e		
	Basic research	Applied research	Total research	Basic research	Applied research	Total research
Department of Defense	$17,334	$69,293	$86,627	$17,247	$71,254	$88,501
Atomic Energy Commission	11,623	13,674	25,297	12,179	14,022	26,201
National Aeronautics and Space Administration	13,372	5,324	18,696	14,048	7,623	21,671
Bureau of Mines	-------	6,660	6,660	-------	6,099	6,099
National Science Foundation	2,565	-------	2,565	2,619	-------	2,619
Department of Agriculture	349	1,772	2,121	371	1,660	2,031
Department of Commerce	756	895	1,651	760	942	1,702
Other	1,287	484	1,771	1,109	1,090	2,199
Total	47,286	98,102	145,388	48,333	102,690	151,023

e Estimated.
Source: National Science Foundation. Federal Funds for Research, Development, and other Scientific Activities. NSF 67–19, v. 16, August 1967, pp. 136, 137, 145, 153, 154, 165, 176, 177.

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

(Thousands)

Fiscal year	Applied research	Basic research	Development	Total
1964	$18,905	$4,138	$2,550	$25,593
1965	19,733	4,355	3,118	27,206
1966	20,836	4,636	3,390	28,862
1967	23,148	4,841	4,423	32,412
1968 e	24,356	4,945	5,175	34,476

e Estimate.

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

(Thousands)

	Fiscal year		
	1966	1967	1968 e
Engineering sciences	$16,594	$19,043	$20,147
Physical sciences	8,011	6,864	7,065
Mathematical sciences	867	597	597
Environmental sciences [1]	---------	1,485	1,491
Total research	$25,472	$27,989	$29,300

e Estimate.
[1] Included in physical sciences category prior to 1967.

Table 59.—Summary of government inventories of strategic and critical materials, December 31, 1967

	Acquisition cost	Market value [1]
Total inventories:		
National stockpile	$4,388,825,700	$4,534,725,700
Supplemental stockpile	1,449,253,200	1,416,223,200
Defense Production Act	1,009,466,200	599,668,400
Commodity Credit Corporation	11,067,300	14,182,700
Total on hand	6,858,612,400	6,564,800,000
On order	13,843,400	14,144,000
Inventories within objective:		
Total on hand	3,100,420,800	3,183,703,300
Inventories excess to objectives:		
Total on hand	3,758,191,600	3,381,096,700

[1] Market values are computed from prices at which similar materials are being traded currently; or in the absence of current trading, an estimate of the price which would prevail in commercial markets. The market values are generally unadjusted for normal premiums and discounts relating to contained qualities. The market values do not necessarily reflect the amount that would be realized at time of sale.

Source: Executive Office of the President, Office of Emergency Planning. Stockpile Report to the Congress, July–December 1967, p. 2.

Table 60.—U.S. Government stockpile disposal of mineral commodities, 1967

Commodity	Sales commitments	
	Quantity	Sales value
National and supplemental stockpile inventories:		
Aluminum short tons	36,806	$18,072,383
Antimony do	78	48,495
Asbestos, amosite do	350	60,600
Asbestos, crocidolite do	150	28,500
Bauxite, refractory long calcined tons	48,500	1,988,825
Bauxite, refractory long dry tons	16,597	700,508
Bismuth pounds	64,500	258,075
Cadmium do	825,646	2,052,345
Chromium, metallurgical short dry tons	591,744	13,868,261
Colemanite long dry tons	67,506	624,893
Copper short tons	150,000	114,890,834
Diamond stones, industrial carets	30,350	285,952
Fluorspar short dry tons	15,642	489,594
Graphite, Malagasy short tons	215	[1] (−4,993)
Graphite, other than Ceylon and Malagasy do	246	34,522
Lead do	16,725	4,740,780
Magnesium do	2,456	1,504,145
Manganese, metallurgical short dry tons	387,764	10,272,879
Mica pounds	18,696	[1] 5,291
Molybdenum do	2,886,607	3,870,978
Nickel do	18,600,283	[2] 22,981,265
Platinum group metals:		
Rhodium troy ounces	173	36,407
Rutheinum do	1,700	66,109
Quartz crystals pounds	130,220	739,597
Rare earths short dry tons	319	131,446
Talc short tons	10	1,600
Tin long tons	6,139	21,202,568
Zinc short tons	26,957	[3] 7,782,615
Total	----------	226,734,474
Defense Production Act (DPA) inventory:		
Aluminum short tons	8,946	4,662,306
Asbestos, chrysotile do	220	36,339
Cobalt pounds	6,031,978	10,131,819
Columbium do	553,841	4,141,156
Manganese, metallurgical short dry tons	28,887	524,072
Nickel pounds	----------	903,150
Titanium short tons	607	1,280,887
Tungsten pounds-tungsten content	6,444,590	15,870,301
Total	----------	37,550,030
Federal Property Act Inventory:		
Mercury flasks	7,108	3,485,135
Other:		
Mercury do	8,036	4,019,632
Silver [4] (fine) troy ounces	----------	21,510,666
Total	----------	25,530,298
Grand total	----------	293,299,937

[1] Includes credit adjustment for prior period.
[2] Includes $3,645,181 which represents a price increase between date previous sales committed and delivered.
[3] Includes AID sales of 7,337 short tons at a value of $2,115,622.
[4] Represents that portion of the total proceeds in excess of the U.S. monetary value based on $1.2929 per ounce; 43,151,860 ounces of silver were sold at an average price of $1.7913.

Source: Executive Office of the President, Office of Emergency Planning. Stockpile Report to the Congress, January–June 1967, pp. 13–14, and July–December 1967, pp. 13–14.

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

(1963 = 100)

	Canada and the United States	Latin America [2]	Asia: East and Southeast [3]	Europe [4]	Non-Communist world [5]
Extractive industries:					
Metals:					
1964	106	105	103	106	107
1965	111	108	111	108	111
1966	117	115	113	104	114
1967:					
First quarter	112	NA	112	100	110
Second quarter	127	NA	120	107	120
Third quarter	110	NA	119	99	114
Fourth quarter	97	NA	120	114	115
Annual average	112	NA	118	105	115
Coal:					
1964	106	106	97	100	101
1965	111	96	100	96	100
1966	114	106	103	90	97
1967:					
First quarter	114	NA	105	88	96
Second quarter	117	NA	103	85	95
Third quarter	111	NA	97	76	87
Fourth quarter	116	NA	99	87	95
Annual average	115	NA	102	84	93
Crude oil and natural gas:					
1964	102	105	117	110	106
1965	105	106	127	120	111
1966	111	105	136	127	119
1967:					
First quarter	115	NA	157	127	126
Second quarter	112	NA	152	136	120
Third quarter	119	NA	166	137	127
Fourth quarter	119	NA	165	147	128
Annual average	119	NA	160	137	125
Total extractives:					
1964	104	109	109	104	105
1965	107	115	116	103	109
1966	113	120	122	101	114
1967:					
First quarter	114	NA	133	99	116
Second quarter	116	NA	136	101	116
Third quarter	119	NA	138	94	117
Fourth quarter	116	NA	139	104	120
Annual average	116	NA	136	100	117
Manufacturing industries:					
Base metals:					
1964	114	112	118	112	114
1965	121	116	121	118	120
1966	126	126	137	117	124
1967:					
First quarter	121	NA	157	119	125
Second quarter	119	NA	164	121	126
Third quarter	111	NA	170	112	120
Fourth quarter	120	NA	175	124	129
Annual average	118	NA	166	119	125
Nonmetallic mineral products:					
1964	107	110	113	113	111
1965	114	115	119	115	115
1966	120	123	128	119	121
1967:					
First quarter	107	NA	136	106	110
Second quarter	119	NA	145	127	125
Third quarter	125	NA	147	124	128
Fourth quarter	121	NA	156	124	127
Annual average	118	NA	146	120	123
Chemicals, petroleum and coal products: [6]					
1964	107	106	112	113	109
1965	115	112	122	123	118
1966	127	120	136	135	130
1967:					
First quarter	130	NA	148	143	135
Second quarter	133	NA	151	145	139
Third quarter	133	NA	156	139	137
Fourth quarter	137	NA	169	152	144
Annual average	133	NA	156	145	139

See footnotes at end of table.

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

(1963=100)

	Canada and the United States	Latin America[2]	Asia: East and Southeast[3]	Europe[4]	Non-Communist world[5]
Manufacturing industries—Continued					
Total manufacturing:[7]					
1964	107	109	113	107	108
1965	116	116	119	112	115
1966	127	121	132	116	123
1967:					
First quarter	127	NA	144	115	124
Second quarter	128	NA	147	120	127
Third quarter	126	NA	152	110	123
Fourth quarter	131	NA	160	125	131
Annual average	128	NA	151	118	126
Overall industrial production:[8]					
1964	107	109	113	107	108
1965	116	115	119	112	115
1966	126	120	131	116	123
1967:					
First quarter	126	NA	144	116	124
Second quarter	128	NA	146	119	126
Third quarter	126	NA	151	109	122
Fourth quarter	130	NA	158	125	131
Annual average	127	NA	150	117	126

NA Not available.

[1] Excludes a number of countries of the Middle East and Africa for which data are not available and for which no estimate has been made, as well as all Communist countries except Mongolia.

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

[3] Afghanistan, Brunei, Burma, Ceylon, Hong Kong, India, Indonesia, Iran, Japan, South Korea, Malaysia (excluding Sabah), Mongolia, Pakistan, Philippines, Singapore, Taiwan, Thailand, and South Viet-Nam.

[4] All of Europe except Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Rumania, U.S.S.R., and Yugoslavia.

[5] Excludes European Communist countries listed in footnote 4, Asian Communist countries (mainland China, North Korea, and North Viet-Nam) and a number of Non-Communist countries in Africa and the Middle East as indicated in footnote 1. It should be noted that Mongolia, a Communist country is included.

[6] Included in this table because of the importance of coal, petroleum, and their products in the mineral industry; these data, however, take into account elements of the chemical industry not considered as a part of the mineral industry elsewhere in this volume.

[7] Aggregate of all manufacturing industries including food, beverages, tobacco, textiles, clothing, wood, wood products, paper, paper products, and metal products as well as the three mineral-based manufacturing sectors detailed above.

[8] Includes all extractives and manufacturing sectors, as well as the electric power and manufactured gas industries; excludes the construction industries.

Source: United Nations. Monthly Bulletin of Statistics. New York, May 1968, pp. x-xxi.

Table 62.—Comparisons of world and United States production and U.S. imports of principal minerals and mineral fuels in 1967

Mineral	World production (thousand short tons unless otherwise stated) p	U.S. production percentage of world production	U.S. imports (percentage of world production)	Total U.S. production and imports (percentage of world production 1967)	Total U.S production and imports (percentage of world production 1966) r
Mineral energy resources:					
Crude petroleum ... thousand barrels	12,889,705	25	7	32	33
Natural gas ... million cubic feet	NA	NA	NA	NA	NA
Bituminous and lignite	3,002,581	18	(1)	18	18
Anthracite	205,857	6	--------	6	6
Nonmetals:					
Asbestos	NA	NA	NA	NA	25
Cement [2] ... thousand barrels	2,686,749	14	(1)	14	14
Diamond ... thousand carets	42,388	--------	50	50	55
Feldspar ... thousand long tons	1,598	39	(1)	39	34
Fluorspar	2,365	13	39	52	36
Gypsum	22,084	42	21	63	30
Mica (including scrap) ... thousand pounds	NA	NA	NA	NA	73
Nitrogen, agricultural [2] [3]	31,700	31	5	36	38
Phosphate rock ... thousand long tons	86,969	46	(1)	46	45
Potash (K_2O) equivalent)	16,861	20	17	37	36
Salt [2]	111,304	35	3	38	35
Sulfur, elemental ... thousand long tons	17,247	47	8	57	59
Metallic ores and concentrates:					
Bauxite ... thousand long tons	43,612	4	27	31	34
Chromite	5,111	--------	11	11	17
Copper (content of ore and concentrate)	5,436	17	(1)	17	24
Iron ore ... thousand long tons	618,152	13	7	21	21
Lead (content or ore and concentrate)	3,133	10	5	15	12
Mercury ... thousand 76-pound flasks	242	10	10	20	20
Molybdenum (content of ore and concentrate) ... thousand pounds	125,363	71	(1)	71	72
Nickel (content of ore and concentrate)	453	3	32	35	35
Platinum group (Pt, pd, etc.) ... thousand troy ounces	3,154	(1)	39	41	46
Silver ... do	261,600	12	(2)	33	40
Titanium concentrates:					
Ilmenite [4]	2,960	32	7	39	40
Rutile [4]	318	W	53	53	54
Tungsten concentrate (60 percent tungsten dioxide) ... short tons	61,862	14	1	15	17
Zinc (content of ore and concentrate)	5,175	10	8	18	19
Metals, smelter basis:					
Aluminum	8,285	39	6	46	48
Copper	5,848	14	10	25	30
Iron, pig	NA	NA	NA	NA	25
Lead	3,068	12	12	24	24
Magnesium ... short tons	202,608	48	5	53	46
Steel ingots and castings	538,435	24	2	26	53

See footnotes at end of table.

Table 62.—Comparisons of world and United States production and U.S. imports of principal minerals and mineral fuels in 1967—Continued

Mineral	World production (thousand short tons unless otherwise stated) p	U.S. production percentage of world production	U.S. imports (percentage of world production)	Total U.S. production and imports (percentage of world production 1967)	Total U.S production and imports (percentage of world production 1966) r
Metals, smelter basis—Continued					
Tin ... thousand long tons	219,135	(1)	(1)	(1)	(1)
Uranium oxide (U_3O_8) [4] ... short tons	17,458	48	7	55	61
Zinc	4,233	17	5	22	28

r Revised. p Preliminary. W Withheld to avoid disclosing company confidential data.
NA Not available.
[1] Less than ½ unit.
[2] Including Puerto Rico.
[3] Year ended June 30 of year stated (United Nations)
[4] World total exclusive of U.S.S.R.

Table 63.—Value of world trade in major mineral commodities [1] by region [2] and major commodity group

(Million dollars)

Area and country [2]	Mineral commodtities								All commodities	
	Exports				Imports					
	Metal ores and scrap	Metals	Mineral fuels	Total	Metal ores and scrap	Metals	Mineral fuels	Total	Exports	Imports
1963 total	3,640	12,060	15,700	31,400	3,640	12,060	15,700	31,400	153,860	153,860
1964 total	4,360	14,270	17,010	35,640	4,360	14,270	17,010	35,640	172,160	172,160
1965 total	4,580	16,390	17,920	38,890	4,580	16,390	17,920	38,890	186,390	186,390
1966:										
Northern North America:										
United States	420	1,160	980	2,560	1,010	2,910	2,230	6,150	30,000	24,580
Canada	870	1,155	460	2,485	145	490	640	1,275	9,550	9,070
Total [3]	1,290	2,315	1,440	5,045	1,155	3,400	2,870	7,425	39,550	33,650
Latin America	760	921	2,700	4,381	52	785	670	1,507	11,660	10,410
Europe:										
Non-Communist:										
EEC	510	5,800	2,250	8,560	1,450	5,130	5,150	11,730	52,630	51,020
EFTA	340	2,430	540	3,310	650	2,690	2,970	6,310	27,990	30,930
Other [3]	70	300	80	450	90	840	760	1,690	5,680	9,690

Subtotal	920	8,530	2,870	12,320	2,190	8,660	8,880	19,730	86,300	91,640
Communist	455	2,130	2,300	4,885	500	1,835	1,280	3,615	20,910	19,650
Total [3]	1,375	10,660	5,170	17,205	2,690	10,495	10,160	23,345	107,210	111,290
Africa:										
Republic of South Africa	([4])	([4])	54	[5] 54	6	134	130	270	1,680	2,250
Other	395	[6] 1,030	1,980	[5] 3,405	3	434	485	922	8,380	8,150
Total [3]	[5] 395	[5] 1,030	2,034	[5] 3,459	9	568	615	1,192	10,060	10,400
Near East	([4])	([4])	5,960	[5] 5,960	1	335	375	711	7,130	5,050
South Asia and Far East:										
Japan	([4])	1,410	32	[5] 1,442	850	460	1,460	2,770	9,780	8,080
Other non-Communist	415	421	650	1,486	53	910	970	1,933	9,750	14,220
Subtotal	[5] 415	1,831	682	[5] 2,928	903	1,370	2,430	4,703	19,530	22,300
Communist	([4])	145	29	[5] 174	3	291	57	351	2,220	2,300
Total	[5] 415	1,976	711	[5] 3,102	906	1,661	2,487	5,054	21,750	24,600
Australia and New Zealand	([4])	280	115	[5] 395	4	188	295	487	4,140	3,780
Rest of world	265	--------	920	1,185	6	117	940	1,063	1,990	2,950
Not reported [3]	340	378	--------	718	17	11	638	666	--------	1,350
Grand total, 1966	4,840	17,560	19,050	41,450	4,840	17,560	19,050	41,450	203,480	203,480

[1] Commodities included are as follows: SITC (Standard International Trade Classification) categories: 1) Division 28—Metal ores and scrap; Section 3—Mineral Fuels, lubricants and related materials; Division 67—Iron and steel; Division 68—Nonferrous metals.

[2] Regional groupings generally conform to United Nations practice; modifications and special aspects of classification scheme are as follows: 1) Latin America includes Mexico, Central America and South America, but excludes Caribbean islands; 2) EEC consists of Belgium, France, West Germany, Italy, Luxembourg and The Netherlands; 3) EFTA consists of Austria, Denmark, Norway, Portugal, Sweden, Switzerland and the United Kingdom; 4) Other non-Communist Europe consists of Finland, Greece, Iceland, Ireland and Spain as well as Yugoslavia (a Communist country) and Turkey (a Near-Eastern country); 5) Communist Europe includes Albania, Bulgaria, Czechoslovakia, Hungary, Poland, Rumania and the U.S.S.R.; 6) Other Africa corresponds to the United Nations category "Developing Africa"; 7) Near East corresponds to the United Nations category "Western Asia"; 8) Other non-Communist South Asia and Far East corresponds to the United Nations category "Other developing Asia"; 9) Communist Far East consists of China (Mainland), North Korea, Mongolia and North Viet-Nam; 10) Rest of world is taken directly from source and reportedly consists mainly of Caribbean and Pacific islands; 11) Not reported is derived by subtracting all listed figures from reported totals.

[3] Data not reported in source, but derived from data therein.

[4] Not listed separately, presumably included under "Not reported."

[5] Partial total, exclusions indicated by footnotes 4 and 6 applied to detail.

[6] Nonferrous metals only; iron and steel presumably included under "Not reported."

Sources: United Nations. Monthly Bulletin of Statistics. March 1968, pp. xviii–xix and xxiv–xxv, and May 1968, pp. xxv–xxvi and xxviii–xxxiii.

Table 64.—Direction of trade in major mineral commodities [1] in 1966

(Million dollars)

Sources [2]	Destinations [2]: Northern North America: United States	Northern North America: Canada	Northern North America: Total [3]	Latin America	Non-Communist Europe: EEC	Non-Communist Europe: EFTA	Non-Communist Europe: Other [3]	Non-Communist Europe: Total	Communist Europe	Near East
Northern North America:										
United States	XX	619	619	378	573	203	70	846	6	28
Canada	1,565	XX	1,565	49	145	517	20	682	3	3
Total [3]	1,565	619	2,184	427	718	720	90	1,528	9	31
Latin America	1,622	231	1,853	343	560	509	63	1,132	45	2
Europe:										
Non-Communist:										
EEC	628	68	696	194	4,395	1,588	442	6,425	222	169
EFTA	320	72	392	72	1,065	928	257	2,250	168	67
Other [3]	34	1	35	5	180	94	21	295	75	5
Subtotal	982	139	[4] 1,121	271	5,640	2,610	720	8,970	465	241
Communist	43	8	51	158	491	417	366	1,274	2,910	46
Total [3]	1,025	147	1,172	429	6,131	3,027	1,086	10,244	3,375	287
Africa:										
Republic of South Africa [5]	1	--------	1	--------	3	1	1	5	--------	-----
Other [6]	169	30	199	28	2,020	727	108	2,855	32	5
Total [3] [7]	170	30	200	28	2,023	728	109	2,860	32	5
Near East [5]	270	90	360	105	1,780	950	260	2,990	--------	330
South Asia and Far East:										
Japan [8]	606	35	641	94	45	13	18	76	41	34
Other non-Communist	183	12	195	11	148	51	15	214	33	12
Subtotal [3] [9]	789	47	836	105	193	64	33	290	74	46
Communist Far East [8]	------	--------	--------	2	18	4	1	23	51	-----
Total [3] [10]	789	47	836	107	211	68	34	313	125	46
Australia and New Zealand [8]	43	4	47	2	30	58	7	95	1	-----
Rest of world [11]	520	110	630	61	88	159	22	269	--------	3
Not reported [3]	146	--------	146	15	189	91	19	299	28	7
Grand total [12]	6,150	[4] 1,275	[4] 7,425	1,507	11,730	6,310	1,690	19,730	3,615	711

Table 64.—Direction of trade in major mineral commodities [1] in 1966—Continued

Sources [2]	Destinations [2]: Africa: Republic of South Africa	Africa: Other	Africa: Total [3]	South Asia and non-Communist Far East: Japan	South Asia and non-Communist Far East: Other	South Asia and non-Communist Far East: Total [3]	Communist Far East	Australia and New Zealand	Rest of world	Not reported [3]	Grand total
Northern North America:											
United States	21	52	73	366	197	563	------	26	27	------	[4] 2,560
Canada	16	4	20	113	22	135	1	17	4	6	2,485
Total [3]	37	56	93	479	219	698	1	43	31	6	[4] 5,045
Latin America	1	4	5	210	13	223	9	3	760	6	4,381
Europe:											
Non-Communist:											
EEC	23	269	292	26	145	171	101	8	29	253	8,560
EFTA	42	68	110	34	85	119	30	63	34	5	3,310
Other [8]	-----	10	10	5	17	22	------	------	------	3	450
Subtotal	[4] 64	347	[4] 411	65	247	312	131	71	63	[4] 264	12,320
Communist	-----	70	70	166	90	256	93	------	------	27	4,885
Total [3]	64	417	481	231	337	568	224	71	63	291	17,205
Africa:											
Republic of South Africa [5]	XX	26	26	2	1	3	------	------	------	19	54
Other [6]	56	87	143	108	5	113	3	1	3	63	3,445
Total [3] [7]	56	113	169	110	6	116	3	1	3	82	3,499
Near East [5]	92	220	312	990	395	1,385	------	185	60	233	5,960
South Asia and Far East:											
Japan [8]	8	30	38	XX	367	367	113	39	5	------	[4] 1,442
Other non-Communist	2	14	16	417	457	874	------	83	48	------	1,486
Subtotal [3] [9]	10	44	54	417	824	1,241	113	122	53	------	[4] 2,928
Communist Far East [8]	-----	8	8	55	36	91	NA	------	------	------	[4] 174
Total [3] [10]	10	52	62	472	860	1,332	113	122	53	------	3,102
Australia and New Zealand [8]	2	2	4	94	61	155	2	62	21	6	395
Rest of world [11]	3	20	23	48	29	77	------	3	76	43	1,185
Not reported [3]	5	38	43	136	13	149	------	------	------	------	[4] 678
Grand total [12]	270	922	1,192	2,770	1,933	4,703	[4] 351	[4] 487	[4] 1,063	[4] 666	41,450

Table 64 footnotes

NA Not available. XX Not applicable.
[1] Commodities included are detailed in footnote 1, table 63.
[2] Regional groupings are defined in footnote 2, table 63.
[3] Data not reported in source, but derived from data therein.
[4] Detail adds to slightly more than reported total apparently because of rounding.
[5] Value of mineral fuel exports only; value of: 1) metal ores and scrap, 2) iron and steel, and 3) nonferrous metals presumably included under "Not reported"
[6] Value of: 1) mineral fuels, 2) metal ores and scrap, and 3) nonferrous metals; value of iron and steel presumably included under "Not reported."
[7] Total incomplete; see footnotes 4 and 5 on Republic of South Africa and Other Africa, respectively.
[8] Value of: 1) mineral fuels, 2) iron and steel, and 3) nonferrous metals; value of metal ores and scrap presumably included under "Not reported."
[9] Total incomplete; see footnote 7 on Japan.
[10] Total incomplete; see footnote 7 on Japan and Communist Far East.
[11] Value of: 1) iron and steel, and 2) nonferrous metals; value of: 1) metal ores and scrap, and 2) mineral fuels presumably included under "Not reported."
[12] Total as reported in source.
Sources: United Nations. Monthly Bulletin of Statistics. March 1968, pp. xxiv–xxv, and May 1968, pp. xxv–xxvi and xxviii–xxxiii.

Table 65.—Estimated world [1] consumption of major nonferrous metals

Metal	1963	1964	1965	1966	1967
Aluminum [2] thousand metric tons	5,319	5,834	6,496	r 7,044	7,333
Copper [3] do	5,401	r 5,921	r 6,121	r 6,442	6,072
Lead [4] do	2,658	2,783	2,794	r 2,946	3,029
Tin [5] thousand long tons	162	r 168	r 165	r 166	166
Zinc [6] thousand metric tons	3,466	3,864	3,995	4,056	3,983

r Revised.
[1] In general, major consuming countries only have been included; sum of consumption by excluding minor consumers may be significant; data included for Communist countries (excluding Yugoslavia) are listed as conjectural in source.
[2] Partial, according to source, but apparently includes secondary metal.
[3] Primary and secondary refined.
[4] Chiefly primary, may include some secondary.
[5] Primary only. As reported by the International Tin Council. Non-Communist countries excluded except for Yugoslavia.
[6] Primary and secondary slab.

Source: Yearbook of the American Bureau of Metal Statistics (Forty-Seventh Annual Issue for the year 1967) New York, 1968, 148 pp.

Table 66.—Indexes of ocean freight rates

(1963–100)

	London tanker brokers panel	Trip charter				
		West Germany		Netherlands (general)	Norway	
		Dry cargo	Tankers		Dry cargo	Tankers [1]
1964	93	101	90	114	100	92
1965	90	110	90	114	112	90
1966	89	100	84	100	97	84
1967: [2]						
First quarter	NA	91	66	[1] 83	92	67
Second quarter	NA	102	181	[1] 82	101	198
Third quarter	NA	111	246	NA	116	260
Fourth quarter	NA	117	152	NA	114	146
Annual average	78	102	154	NA	104	155

	Trip charter, United Kingdom				Time charter	
	General	Coal trade	Ore trade	Fertilizer trade	Norway (dry cargo)	United Kingdom (dry cargo)
1964	103	96	103	112	112	114
1965	116	105	120	136	126	128
1966	104	88	94	128	113	126
1967: [2]						
First quarter	97	80	72	146	102	113
Second quarter	104	92	NA	[3] 244	103	116
Third quarter	115	116	[4] 120	[4] 242	131	140
Fourth quarter	134	111	NA	239	126	132
Annual average	111	95	85	186	113	124

NA Not available.
[1] Actual quarterly average.
[2] Except as noted, quarterly figures are those for the last month in the quarter.
[3] June not available, July used instead.
[4] September not available, October used instead.

Table 67.—Mineral commodity export price indexes [1]

(1963=100)

Year and quarter	Metal ores	Fuels	Total
1964	108	100	102
1965	114	101	104
1966 [2]	115	101	104
1967:			
January to March	108	101	103
April to June	107	100	102
July to September	108	101	102
October to December	111	101	103
Annual average	109	101	103

[1] United Nations. Monthly Bulletin of Statistics. June 1968, special table C II, p. xvii.
[2] Derived from 1966 quarterly averages, Annual figures for 1966 erroneously reported.

Table 68.—Analysis of export price indexes [1]

(1963=100)

Year and quarter	Developed areas		Less-developed areas	
	Total minerals	Nonferrous base metals	Total minerals	Nonferrous base metals
1964	105	116	102	124
1965	106	129	103	146
1966	107	144	103	177
1967:				
January to March	105	138	102	162
April to June	103	130	102	146
July to September	104	131	102	148
October to December	106	143	102	168
Annual average	105	135	102	156

[1] United Nations. Monthly Bulletin of Statistics. June 1968, special table C III, p. xvii.

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

By John L. Morning[1]

Great strides have been made in mining practices, mining equipment, and mining technology in the past 20 years. Mining equipment has greatly increased in size and complexity to handle the higher volume of materials necessary to relieve the ever-increasing demand for mineral products. With the advent of the space age and the development of new technologies, such as sophisticated automation, closed-circuit television, computers, and lasers, companies have turned to these advanced technologies to reduce costs.

In 1967, larger equipment was being developed to do work more easily, faster, and more economically.[2] Interest continued in the use and development of mobile tunnel-boring and raise-boring machines. It has been predicted that in 10 years, tunnel-borers will be used for 80 percent of all tunnels driven in the United States.[3]

Nuclear mining and bacterial leaching are new techniques that hold promise for future development of low-grade deposits that cannot be mined by conventional methods.[4]

In open-pit mining the evolution of larger cost-cutting equipment continued. Improved rotary drills were no longer restricted to soft formations and were replacing jet piercers and percussion machines in some applications. Shovels of 15 to 30 cubic yards were under development as front-end loaders made a move to replace smaller shovels and may soon challenge large ones. Along with the development of large shovels, haulage units with engines of 1,000 to 1,300 horsepower, were under test.[5] Worldwide

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[1] Commodity specialist, Division of Mineral Studies.

[2] Tobic, Raymond L. Underground Mining. Min. Cong. J. V. 54, No. 2, February 1967, pp. 143–154.

[3] Robbins, R. J., and D. L. Anderson. Machine-Bored Tunnel and Raises: Their Applications to Underground Mining. Min. Eng. V. 53, No. 7, July 1967, pp. 156–160.

[4] Engineering and Mining Journal. Mining In-situ By Nature's Easy Way, V. 168, No. 10, October 1967, pp. 75–80.

Mining Engineering. Kennecott Proposes Nuclear Mining Experiments at Safford Deposit. V. 53, No. 11, November 1967, pp. 66–67.

[5] Atkins, J. T. Open-Pit Mining. Min. Cong. J. V. 53, No. 2, February 1967, pp. 127–136.

Carthew, Douglas J. Open-Pit Planners Face Complex Problems When Designing the Total Mine Operation. Eng. and Min. J. V. 168, No. 9, September 1967, pp. 93–106.

Dotson, Jacy C. Open-Pit Developments. Min. Eng., V. 53, No. 2, February 1967, pp. 85–88.

Herde, Roy S. Open-Pit Mining. Min. Cong. J. V. 54, No. 2, February 1968, pp. 181–185.

Hurlbut, Steward W. Open-Pit Stripping and Mining Moves on Rubber. World Mining, v. 3, No. 7, June 26, 1967, pp. 22–29.

Singhal, R. K. Some Recent Development Trends for Surface Mining. Mining & Minerals Engineering. V. 3, No. 3, March 1967, pp. 99–107.

new mine developments and mine expansions continued at a high level.[6]

Paralleling the technological advancements in borehole drills and earthmoving equipment, an even greater technologic trend has occurred in the use of explosives in the minerals industry since 1956.[7] The development of ammonium nitrate and fuel oil as a blasting agent has proven economical to the mining industry, particularly in open-pit mining.

Total material handled in the minerals industry decreased for the first time since 1962, principally because of the copper strike in the second half of the year. Surface mines continued to dominate the output of ore despite only a small increase in output over the past 5 years. Although metal mines decreased in number during the 5-year period, the trend was toward higher output of ore for those in operation.

The average value of principal mineral products and byproducts produced continued to increase, although the indicated annual growth rate for the past 5 years has been only 1 percent. Average value of byproducts from metal and nonmetal mines decreased from 1966 values. The ratio of ore to marketable product continued to increase for metal mines, indicating the constant decline in grade of ore mined.

Exploration and development work significantly increased for the year, primarily because of the surge in uranium activities. Rotary drilling was the most popular method employed and accounted for 53 percent of all exploration and drilling activities.

The historical data of industrial explosives consumption, with emphasis on explosives consumed by the minerals industry, indicates the shifting pattern of usage brought about by technological advances. Traditionally, the minerals industry accounts for over 70 percent of the total industrial consumption of explosives. With the development of the low cost ammonium nitrate-fuel oil (AN–FO) blasting agent, this explosive has captured an increasing share of the market.

Materials Handled.—Total ore and waste material handled at metal and nonmetal mines and quarries in the United States decreased for the first time since 1962, thereby ending a steady 5-percent growth rate. Although the quantity of material handled in 1967 decreased from that of 1966, it still exceeded that handled in 1965. The largest decrease compared with 1966 occurred in crude copper ore, and resulted from work stoppages in the copper industry during the second half of the year. Other mineral products that showed a notable decrease in material handled were placer gold, iron ore, titanium concentrate, potassium salts, sand and gravel, and crushed and broken stone. Mineral products that indicated a significant increase in material handled were molybdenum, uranium, and phosphate rock.

Reported material handled exceeded 100 million tons in eight States with two States essentially handling that amount. Florida replaced Arizona as the leading State in total material handled owing to the combination of increased activity in the phosphate rock industry in Florida and reduced output of copper ore in Arizona. Increased output occurred in three States, Florida, New Mexico, and Ohio, while output was essentially unchanged in Michigan and Pennsylvania. Decreased output, mostly in crude ore, was reported for Arizona, California, Minnesota, New York, and Utah.

Copper and iron ore mines continued to head the list of leading metal mines in total materials handled. The Anaconda Company at Twin Buttes, Ariz., became the leader when development of its open-pit copper mine was accelerated. The Hoyt Lake, Minn., open-pit iron ore mine of Pickands Mather & Co. became the leading producer in output of ore. Phosphate rock producers continued to dominate the listing of leading non-

[6] Engineering and Mining Journal. Mine Expansion Coasts on New High. V. 169, No. 3, February 1968, pp. 83–111.

[7] Garfield, A. M., and Vernonn O. Cook. Modern Open-Pit Blasting Practice, Eng. .and Min. J. V. 168, No. 9, September 1967, pp. 117–122.

metal mines with the Kingston, Fla., facility of International Minerals & Chemical Co. holding first place.

Comparison of Production From Surface and Underground Mines.—Surface mines accounted for 83 percent of the metal ore and 96 percent of the nonmetal material produced. In addition, surface mines accounted for 96 percent of total material handled. During the past 5 years the percentage of ore and material handled at metal and nonmetal mines has remained relatively stable with only a small trend indicated for increased surface mining.

Magnitude of the Mining Industry.—During the past 5 years the number of metal and nonmetal mines, excluding sand and gravel plants, reporting crude ore production increased from 7,093 to 8,284. Although the number of metal mines decreased from 1,449 to 1,372, nonmetal mines more than offset the loss by increasing from 5,644 to 6,912. The largest increase was in the crushed and broken stone category, reflecting increased activity in the construction industry. The largest loss in number of mines was in the gold mining industry where increasing costs forced closure of many smaller operations.

The number of mines that produced more than 10 million tons of crude ore decreased from 14 in 1966 to 12 in 1967. Two copper mines, two crushed and broken stone mines, and one placer operation fell from this category, while one iron ore mine and two phosphate rock mines increased output to over 10 million tons.

Although metal mines have decreased in number since 1963, the number of mines handling 100,000 tons to 1 million tons of crude ore increased from 169 to 290. Total number of mines producing over 1 million tons of crude ore more than doubled in the 5-year period, increasing to 405.

The average value of principal mineral products and byproducts mined during the past 5 years indicates a growth rate of about 1 percent per year. The ratio of average value of metals and nonmetals (including byproducts) recovered from underground operations to that of surface operations, remained at 3.6. In 1963, the ratio was 3.8. The average value of byproducts in ore from metal mines dropped to 32 cents per ton from 37 cents per ton in 1966. The average value of byproducts in nonmetal ores, sand and gravel excluded, also decreased, totaling 15 cents per ton compared with 20 cents per ton in 1966.

Ratio of Ore to Marketable Product.—The ratio of ore to marketable product for most metal mineral products was larger in 1967 than for 1963. This reflects the constant decline in grade of ore mined. The ratio of crude nonmetal materials to marketable products remained virtually unchanged from that of 1963. Although the ratio varied for particular mineral commodities, the high tonnage materials, with the exception of phosphate rock, kept the ratio constant.

The trend of the increased ratio of ore to marketable products for metal mines was outweighed by a more significant trend in the ratio of total material handled to marketable product. Almost without exception, this ratio increased during the past 5 years for both metal and nonmetal mineral products. With the ever increasing demand for mineral commodities, the ratio can be expected to further increase as lower grade deposits and deposits with increased stripping ratios are developed.

Underground Mining Methods.—Underground mining accounted for 6 percent of the total ore output in the United States and about 5 percent of the total material handled. This compares with 7 percent of the ore output and over 5 percent of the total material handled in 1963. Ore mined by open-stoping increased to nearly 78 percent of the total compared with an average of 75 percent during the preceding 4 years. The percentage of ore mined by block caving decreased to 20 percent of the total (23 percent in 1966) owing to a 5½-month work stoppage in the copper industry. All the bauxite, feldspar, tripoli, and wollastonite were mined by natural supported open-stoping. Most of the molybdenum ore was produced by the block caving method.

Colorado, Michigan, Missouri, and New Mexico were the leading States in underground mining. No underground mining was reported in 10 States.

Surface Mining.—Practically all material at surface mines was handled mechanically. Multiple bench metal mines accounted for most of the ore output of copper, lode gold, iron ore, and nickel. Most of the nonmetal ore output was recovered from open-pit or single bench mines. The major mineral commodity exceptions were, asbestos, boron minerals, diatomite, kyanite, and vermiculite, all multiple bench.

Drilling and blasting were required, prior to loading, for most high-tonnage metal ores, whereas most high-tonnage nonmetal ores required little or no blasting prior to loading.

During the past 5 years, the relationship at surface mines between total material handled that required blasting and material not requiring blasting has essentially remained unchanged, despite numerous shifts in the ratio for individual commodities.

Exploration and Development.—The reported footage for exploration and development of metal and nonmetal mines increased 40 percent compared with 1966 levels and was the highest total since 1961. All of the increase occurred at metal mines, whereas the total footage for nonmetal mines decreased to the lowest ever reported. Rotary drilling increased from 41 percent in 1966 to 53 percent of the total in 1967, at the expense of other methods reported. During the past 5 years, rotary drilling replaced percussion drilling as the leader in total footage for exploration and development activities.

Five States, Colorado, Idaho, New Mexico, Utah, and Wyoming, accounted for two-thirds of the exploration and development activity. Among the larger mineral commodities, copper and iron ore decreased in total footage, while the footage for lead, uranium and zinc significantly increased. Uranium accounted for 53 percent of all exploration and development work.

Explosives.—The historical pattern of industrial consumption of explosives, with particular emphasis on explosives consumed by the minerals industry, has been compiled from data that originally appeared in annual explosives issues of the Mineral Industry Surveys prepared by the Bureau of Mines, Division of Accident Prevention and Health.

Total domestic industrial consumption of explosives varies with the domestic economy with notable decreased usage in years of depressions or recessions. Prior to 1930, industrial consumption averaged about 500 million pounds annually. In 1932, consumption decreased to a record low of 234 million pounds, while in 1956 consumption exceeded 1 billion pounds for the first time. During the past ten years new consumption records have been set each year, except for the off year of 1958.

Of the total industrial explosive consumption, the minerals industry accounted for 75 percent of usage in 1920; 75 percent in 1930; 73 percent in 1940; 78 percent in 1950; 77 percent in 1960; and 69 percent in 1966.

Granular black-blasting powder was the principal explosive used in coal mining early in the century, but after a record high consumption in 1917—usage declined until today when consumption is insignificant in the minerals industry.

Pellet type black-blasting powder was introduced in 1925 and gained acceptance in coal mining, reaching a record high consumption in 1936. Historically only small quantities have been used in the metal mining industry; however, some acceptance was gained in quarrying and nonmetal mining until 1941, after which consumption steadily declined.

Consumption of permissible type explosives reached a peak during the period of 1946 to 1957 with coal mining the major consuming industry.

Since 1925, the most generally used explosive in the mineral industry has been high explosives, other than permissibles. This category of explosive includes ammonium nitrate, both processed and unprocessed, and since 1956 this explosive has become a major factor in the explosive industry. Ammonium nitrate accounted for 58 percent of high explosives, other than permissibles, used in the minerals industry in 1959; 63 percent in 1960; 66 percent in 1961; 70 percent in 1962; 76 percent in 1963; 76 percent in 1964; 77 percent in 1965 and 78 percent in 1966.

The historical decline in consumption of granular and pellet black-blasting powder and other type of explosives, together with the large demand for mineral products in recent years, resulted in the rapid growth in consumption of high explosives, other than permissibles. Total demand reached over 250,000 tons in 1956 and over 500,000 tons in 1963.

Data for domestic consumption of liquid oxygen explosives in the mineral industry was first collected in 1947. Consumption reached a maximum in 1953, but steadily declined during the next 10 years. Since 1963, however, use of liquid oxygen explosives in coal stripping operations resulted in consumption returning to about the 1957 level.

Table 1.—Material handled at surface and underground mines, by commodities, in 1967

(Thousand short tons)

Commodity	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Metals:									
Bauxite	[1] 2,265	[1] 4,341	[1] 6,606	W	W	W	2,265	4,341	6,606
Beryllium	3	6	9	---	---	---	3	6	9
Copper	111,969	357,462	469,431	18,413	79	18,492	130,382	357,541	487,923
Gold:									
Lode	1,328	7,047	8,375	2,122	248	2,370	3,450	7,295	10,745
Placer	12,570	1,490	14,060	---	---	---	12,570	1,490	14,060
Iron ore	190,653	186,881	377,534	15,764	2,509	18,273	206,417	189,390	395,807
Lead	11	10	21	6,731	581	7,312	6,742	591	7,333
Manganiferous ore	---	686	686	---	---	---	---	686	686
Mercury	231	859	1,090	166	33	199	397	892	1,289
Molybdenum	3,911	17,572	21,483	15,706	120	15,826	19,617	17,692	37,309
Nickel	1,084	339	1,423	---	---	---	1,084	339	1,423
Silver	201	32	233	442	280	722	643	312	955
Titanium: Concentrate	23,731	4,550	28,281	---	---	---	23,731	4,550	28,281
Tungsten	12	5	17	485	30	515	497	35	532
Uranium	1,536	35,838	37,374	3,194	1,130	4,324	4,730	36,968	41,698
Zinc	326	892	1,218	11,110	1,467	12,577	11,436	2,359	13,795
Other [2]	3,794	746	4,540	25	---	25	3,819	746	4,565
Total	353,000	619,000	972,000	74,000	7,000	81,000	427,000	626,000	1,053,000
Nonmetals:									
Abrasives [3]	153	192	345	42	---	42	195	192	387
Asbestos	2,714	3,356	6,070	23	217	240	2,737	3,573	6,310
Barite	6,464	1,376	7,840	212	3	215	6,676	1,379	8,055
Boron minerals	26,816	---	26,816	---	---	---	26,816	---	26,816
Clays	55,184	52,210	107,394	1,256	14	1,270	56,440	52,224	108,664
Diatomite	1,043	5,427	6,470	---	---	---	1,043	5,427	6,470
Feldspar	1,317	220	1,537	2	---	2	1,319	220	1,539

Fluorspar	74	24	98	797	10	807	871	34	905
Gypsum	6,988	10,233	17,221	2,419	101	2,520	9,407	10,334	19,741
Mica: Flake	863	439	1,302	19	---	19	882	439	1,321
Perlite	638	38	676	3	---	3	641	38	679
Phosphate rock	127,431	257,012	384,443	1,747	6	1,753	129,178	257,018	386,196
Potassium salts	---	---	---	18,268	1,609	19,877	18,268	1,609	19,877
Pumice	3,434	34	3,468	---	---	---	3,434	34	3,468
Salt	5,405	---	5,405	12,734	764	13,498	18,139	764	18,903
Sand and gravel	905,179	---	905,179	---	---	---	905,179	---	905,179
Sodium carbonate (natural)	---	---	---	2,551	---	2,551	2,551	---	2,551
Stone:									
Crushed and broken	747,045	60,639	807,684	36,565	352	36,917	783,610	60,991	844,601
Dimension	4,731	927	5,658	267	---	267	4,998	927	5,925
Sulfur:									
Frasch-process mines	7,015	---	7,015	---	---	---	7,015	---	7,015
Other mines	1	---	1	---	---	---	1	---	1
Talc, soapstone, and pyrophyllite	681	831	1,512	540	45	585	1,221	876	2,097
Vermiculite	1,173	3,036	4,209	---	---	---	1,173	3,036	4,209
Other [4]	3,702	3,079	6,781	75	41	116	3,777	3,120	6,897
Total	1,908,000	399,000	2,307,000	78,000	3,000	81,000	1,986,000	402,000	2,388,000
Grand total	2,261,000	1,018,000	3,279,000	152,000	10,000	162,000	2,413,000	1,028,000	3,441,000

W Withheld to avoid disclosing individual company confidential data.
[1] Includes underground
[2] Magnesium, manganese, platinum-group metals, rare-earth metals, and tin.
[3] Emery, garnet, and tripoli.
[4] Aplite, graphite, greensand marl, kyanite, lithium minerals, magnesite, olivine, sodium sulfate (natural), and wollastonite.

Table 2.—Material handled at surface and underground mines (including sand and gravel and stone), by States, in 1967

(Thousand short tons)

State	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Alabama	30,609	31,285	61,894	2,210	203	2,413	32,819	31,488	64,307
Alaska	29,840	2,139	31,979	---------	---------	---------	29,840	2,139	31,979
Arizona	88,219	254,620	342,839	8,872	343	9,215	97,091	254,963	352,054
Arkansas	34,445	4,678	39,123	1,317	3	1,320	35,762	4,681	40,443
California	210,878	60,171	271,049	1,589	93	1,682	212,467	60,264	272,731
Colorado	26,089	316	26,405	17,396	1,002	18,398	43,485	1,318	44,803
Connecticut	13,703	208	13,911	---------	---------	---------	13,703	208	13,911
Florida	171,979	222,994	394,973	---------	---------	---------	171,979	222,994	394,973
Georgia	40,923	32,325	73,248	1,044	---------	1,044	41,967	32,325	74,292
Idaho	17,853	19,907	37,760	1,989	279	2,268	19,842	20,186	40,028
Illinois	87,218	3,192	90,410	3,507	6	3,513	90,725	3,198	93,923
Indiana	54,588	1,103	55,691	1,130	43	1,173	55,718	1,146	56,864
Iowa	45,040	10,835	55,875	1,915	---------	1,915	46,955	10,835	57,790
Kansas	25,616	960	26,576	2,169	---------	2,169	27,785	960	28,745
Kentucky	27,853	1,528	29,381	7,105	6	7,111	34,958	1,534	36,492
Louisiana	33,275	----------	33,275	4,773	---------	4,773	38,048	----------	38,048
Maine	12,834	824	13,658	5	---------	5	12,839	824	13,663
Maryland	27,995	1,015	29,010	133	91	224	28,128	1,106	29,234
Massachusetts	24,595	236	24,831	---------	---------	---------	24,595	236	24,831
Michigan	121,826	17,381	139,207	14,421	571	14,992	136,247	17,952	154,199
Minnesota	175,254	90,297	265,551	450	8	458	175,704	90,305	266,009
Mississippi	17,614	1,354	18,968	---------	---------	---------	17,614	1,354	18,968
Missouri	44,903	2,557	47,460	16,587	341	16,928	61,490	2,898	64,388
Montana	26,693	2,723	29,416	2,078	13	2,091	28,771	2,736	31,507

Nebraska	16,593	1,105	17,698	119	---------	119	16,712	1,105	17,817
Nevada	26,965	40,963	67,928	314	38	352	27,279	41,001	68,280
New Hampshire	9,026	8	9,034	2	---------	2	9,028	8	9,036
New Jersey	32,374	365	32,739	154	2	156	32,528	367	32,895
New Mexico	26,137	53,341	79,478	19,085	927	20,012	45,222	54,268	99,490
New York	87,951	5,022	92,973	6,178	79	6,257	94,129	5,101	99,230
North Carolina	42,621	15,425	58,046	10	---------	10	42,631	15,425	58,056
North Dakota	9,507	---------	9,507	---------	---------	---------	9,507	---------	9,507
Ohio	91,420	7,750	99,170	5,859	491	6,350	97,279	8,241	105,520
Oklahoma	20,089	5,100	25,189	1,387	---------	1,387	21,476	5,100	26,576
Oregon	34,727	360	35,087	22	7	29	34,749	367	35,116
Pennsylvania	77,348	18,681	96,029	8,063	1,810	9,873	85,411	20,491	105,902
Rhode Island	2,818	---------	2,818	---------	---------	---------	2,818	---------	2,818
South Carolina	16,070	3,809	19,879	---------	---------	---------	16,070	3,809	19,879
South Dakota	15,752	167	15,919	1,906	199	2,105	17,658	366	18,024
Tennessee	43,440	4,253	47,693	6,666	231	6,897	50,106	4,484	54,590
Texas	95,037	7,008	102,045	382	4	386	95,419	7,012	102,431
Utah	34,799	43,156	77,955	2,446	1,585	4,031	37,245	44,741	81,986
Vermont	7,953	906	8,859	229	4	233	8,182	910	9,092
Virginia	41,183	1,995	43,178	2,683	736	3,419	43,866	2,731	46,597
Washington	43,211	122	43,333	753	68	821	43,964	190	44,154
West Virginia	13,643	1,424	15,067	2,314	15	2,329	15,957	1,439	17,396
Wisconsin	59,597	253	59,850	1,078	34	1,112	60,675	287	60,962
Wyoming	16,263	43,984	60,247	3,609	405	4,014	19,872	44,389	64,261
Other States [1]	7,035	40	7,075	---------	---------	---------	7,035	40	7,075
Total	2,261,000	1,018,000	3,279,000	152,000	10,000	162,000	2,413,000	1,028,000	3,441,000

[1] Delaware and Hawaii.

Table 3.—Value of principal mineral products and byproducts of surface and underground ores mined in the United States in 1967

(Value per ton)

Ore	Surface			Underground			All mines		
	Principal mineral product	By-products	Total	Principal mineral product	By-products	Total	Principal mineral product	By-products	Total
Metals:									
Bauxite	$7.89	------	$7.89	------	------	------	$7.89	------	$7.89
Beryllium	2.33	------	2.33	------	------	------	2.33	------	2.33
Copper	5.22	$0.29	5.51	$7.73	$0.93	$8.66	5.56	$0.38	5.94
Gold:									
Lode	12.99	.04	13.03	12.26	2.31	14.57	12.51	1.52	14.03
Placer	.17	------	.17	------	------	------	.17	------	.17
Iron ore	3.59	------	3.59	7.41	.25	7.66	3.89	.02	3.91
Lead	18.10	21.00	39.10	10.05	4.34	14.39	10.06	4.36	14.42
Mercury	18.25	------	18.25	43.12	------	43.12	28.73	------	28.73
Molybdenum	4.33	------	4.33	5.39	.19	5.58	5.19	.16	5.35
Platinum-group metals	.35	------	.35	------	------	------	.35	------	.35
Silver	1.42	.66	2.08	43.89	6.73	50.62	30.21	4.78	34.99
Titanium:									
Concentrate	.78	.26	1.04	------	------	------	.78	.26	1.04
Tungsten	19.66	------	19.66	36.48	2.94	39.42	36.37	2.92	39.29
Uranium	30.80	.04	30.84	31.48	.09	31.57	31.19	.07	31.26
Zinc	12.58	2.74	15.32	11.12	2.99	14.11	11.16	2.98	14.14
Average value [1]	4.11	.11	4.22	9.46	1.30	10.76	5.03	.32	5.35
Nonmetals:									
Abrasive stone	159.66	24.33	183.99	------	------	------	159.66	24.33	183.99
Asbestos	3.92	------	3.92	40.92	------	40.92	4.09	------	4.09
Barite	1.72	.01	1.73	3.95	------	3.95	1.80	------	1.80
Clays	3.89	.01	3.90	9.63	.04	9.67	4.01	.01	4.02
Diatomite	38.52	------	38.52	------	------	------	38.52	------	38.52
Emery	18.50	------	18.50	------	------	------	18.50	------	18.50
Feldspar	4.07	.46	4.53	2.50	------	2.50	4.07	.46	4.53
Fluorspar	19.42	2.63	22.05	13.25	5.36	18.61	13.71	5.16	18.87
Garnet	16.43	------	16.43	------	------	------	16.43	------	16.43
Graphite	283.33	------	283.33	------	------	------	283.33	------	283.33
Gypsum	3.46	------	3.46	4.69	------	4.69	3.77	------	3.77
Kyanite	7.47	.22	7.69	------	------	------	7.47	.22	7.69
Lithium minerals	6.47	.38	6.85	------	------	------	6.47	.38	6.85
Magnesite	3.08	.05	3.13	------	------	------	3.08	.05	3.13
Mica: Flake	2.62	.09	2.71	4.52	------	4.52	2.66	.08	2.74
Olivine	15.69	------	15.69	------	------	------	15.69	------	15.69
Perlite	6.61	------	6.61	8.00	------	8.00	6.62	------	6.62
Phosphate rock	1.99	------	1.99	6.34	------	6.34	2.03	------	2.03
Potassium salts	------	------	------	4.62	------	4.62	4.62	------	4.62
Pumice	1.47	------	1.47	------	------	------	1.47	------	1.47
Salt	14.83	1.29	16.12	6.08	.52	6.60	8.78	.76	9.54
Sand and gravel	1.08	------	1.08	------	------	------	1.08	------	1.08
Stone:									
Crushed and broken	1.42	------	1.42	1.95	------	1.95	1.45	------	1.45
Dimension	18.35	.65	19.00	22.51	1.31	23.82	18.57	.69	19.26
Sulfur:									
Frasch	32.75	------	32.75	------	------	------	32.75	------	32.75
Other	3.00	------	3.00	------	------	------	3.00	------	3.00
Talc, soapstone, and pyrophyllite	4.26	------	4.26	7.30	------	7.30	5.58	------	5.58
Tripoli	6.80	------	6.80	4.09	------	4.09	5.22	------	5.22
Vermiculite	4.22	------	4.22	------	------	------	4.22	------	4.22
Average value [1]	1.63	.02	1.65	3.86	.15	4.01	1.72	.02	1.74
Average value, metal and nonmetals [1]	2.02	.03	2.05	6.67	.73	7.40	2.30	.07	2.37
Average value, nonmetals (excluding stone, sand and gravel) [1]	3.99	.13	4.12	5.48	.30	5.78	4.19	.15	4.34
Average value, metals and nonmetals (excluding stone, sand and gravel) [1]	4.05	.12	4.17	8.05	.95	9.00	4.68	.25	4.93

[1] Including unpublished data.

Table 4.—Crude ore and total material handled at surface and underground mines, by commodities in 1967

(Percent)

Commodity	Crude ore		Total material	
	Surface	Underground	Surface	Underground
Metals:				
Bauxite	88	12	96	4
Beryllium	100	-----	100	-----
Copper	87	13	96	4
Gold:				
Lode	38	62	78	22
Placer	100	-----	100	-----
Iron ore	92	8	95	5
Lead	---	100	-----	100
Manganese ore	---	100	-----	100
Mercury	57	43	85	15
Molybdenum	20	80	58	42
Nickel	100	-----	100	-----
Rare-earth metals and thorium	100	-----	100	-----
Silver	4	96	24	76
Titanium:				
Concentrate	100	-----	100	-----
Tungsten	2	98	3	97
Uranium	31	69	90	10
Zinc	2	98	9	91
Total	83	17	92	8
Nonmetals:				
Abrasives:				
Emery	100	-----	100	-----
Garnet	100	-----	100	-----
Tripoli	42	58	56	44
Asbestos	99	1	96	4
Barite	97	3	97	3
Boron minerals	100	-----	100	-----
Clays	98	2	99	1
Diatomite	100	-----	100	-----
Feldspar	100	-----	100	-----
Fluorspar	6	94	11	89
Graphite	100	-----	100	-----
Gypsum	74	26	87	13
Kyanite	100	-----	100	-----
Lithium minerals	100	-----	100	-----
Magnesite	100	-----	100	-----
Marl, greensand	100	-----	100	-----
Mica: Flake	97	3	99	1
Olivine	100	-----	100	-----
Perlite	100	-----	100	-----
Phosphate rock	99	1	100	-----
Potassium salts	---	100	-----	100
Pumice	100	-----	100	-----
Salt	30	70	29	71
Sand and gravel	100	-----	100	-----
Sodium carbonate (natural)	---	100	-----	100
Sodium sulfate (natural)	100	-----	100	-----
Stone:				
Crushed and broken	95	5	96	4
Dimension	95	5	96	4
Sulfur: Frasch-process mines	100	-----	100	-----
Talc, soapstone, and pyrophyllite	42	58	72	28
Vermiculite	100	-----	100	-----
Wollastonite	---	100	-----	100
Total	96	4	96	4
Grand total	94	6	96	4

Table 5.—Crude ore and total material handled at surface and underground mines, by States, in 1967

(Percent)

State	Crude ore		Total material	
	Surface	Underground	Surface	Underground
Alabama	93	7	96	4
Alaska	100	----	100	----
Arizona	91	9	97	3
Arkansas	96	4	97	3
California	99	1	99	1
Colorado	60	40	59	41
Connecticut	100	----	100	----
Delaware	100	----	100	----
Florida	100	----	100	----
Georgia	98	2	99	1
Hawaii	100	----	100	----
Idaho	92	8	95	5
Illinois	96	4	96	4
Indiana	98	2	98	2
Iowa	96	4	97	3
Kansas	92	8	92	8
Kentucky	79	21	81	19
Louisiana	87	13	87	13
Maine	100	----	100	----
Maryland	100	----	99	1
Massachusetts	100	----	100	----
Michigan	90	10	91	9
Minnesota	100	----	100	----
Mississippi	100	----	100	----
Missouri	73	27	74	26
Montana	93	7	93	7
Nebraska	99	1	99	1
Nevada	99	1	99	1
New Hampshire	100	----	100	----
New Jersey	100	----	100	----
New Mexico	58	42	80	20
New York	93	7	94	6
North Carolina	100	----	100	----
North Dakota	100	----	100	----
Ohio	94	6	94	6
Oklahoma	94	6	95	5
Oregon	100	----	100	----
Pennsylvania	90	10	91	9
Rhode Island	100	----	100	----
South Carolina	100	----	100	----
South Dakota	89	11	88	12
Tennessee	87	13	87	13
Texas	100	----	100	----
Utah	93	7	95	5
Vermont	97	3	97	3
Virginia	94	6	93	7
Washington	98	2	98	2
West Virginia	85	15	87	13
Wisconsin	98	2	98	2
Wyoming	94	6	98	2
Total	94	6	96	4

Table 6.—Number of domestic metal and nonmetal mines in 1967, 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:							
Antimony	6	6	------	------	------	---	--
Bauxite	10	1	2	3	3	1	------
Beryllium	5	4	1	------	------	------	------
Copper	124	51	11	19	22	18	3
Gold:							
Lode	79	68	6	1	3	1	------
Placer	142	86	25	21	8	2	------
Iron ore	121	4	11	23	48	31	4
Lead	73	50	9	5	8	1	------
Manganese ore	3	1	1	1	------	------	------
Mercury	119	88	19	12	------	------	------
Molybdenum	4	1	------	------	1	1	1
Silver	74	60	8	5	1	------	------
Tin	4	2	2	------	------	------	------
Titanium: Concentrate	6	------	------	------	1	5	------
Tungsten	18	10	5	2	1	------	------
Uranium	406	153	90	57	106	------	------
Zinc	173	23	20	45	85	------	------
Other [1]	5	2	------	------	3	------	------
Total	1,372	610	210	194	290	60	8
Nonmetals:							
Abrasives [2]	18	8	6	3	1	------	------
Asbestos	9	1	2	3	1	2	------
Barite	51	10	9	15	16	1	------
Boron minerals	3	------	------	------	------	3	------
Clays	1,280	79	327	697	177	------	------
Diatomite	14	3	4	3	4	------	------
Feldspar	49	26	8	10	5	------	------
Fluorspar	23	4	11	6	2	------	------
Gypsum	75	4	8	26	37	------	------
Kyanite	4	------	------	------	4	------	------
Marl, greensand	2	1	1	------	------	------	------
Mica: Flake	20	4	4	11	1	------	------
Olivine	5	1	2	2	------	------	------
Perlite	16	4	6	4	2	------	------
Phosphate rock	48	1	1	3	20	20	3
Potassium salts	10	------	------	------	3	7	------
Pumice	150	34	46	40	30	------	------
Salt	57	1	14	10	26	6	------
Sodium carbonate (natural)	3	------	------	1	1	1	------
Stone:							
Crushed and broken	4,427	207	495	1,502	1,932	290	1
Dimension	547	214	242	83	8	------	------
Sulfur:							
Frasch-process mines	16	------	2	4	7	3	------
Other mines	1	1	------	------	------	------	------
Talc, soapstone, and pyrophyllite	65	13	30	21	1	------	------
Vermiculite	5	2	------	1	2	------	------
Wollastonite	2	1	------	1	------	------	------
Other [3]	12	------	2	3	7	------	------
Total	6,912	619	1,220	2,449	2,287	333	4
Grand total	8,284	1,229	1,430	2,643	2,577	393	12

[1] Magnesium, nickel, and rare-earth metals.
[2] Emery, garnet, and tripoli.
[3] Aplite, graphite, lithium minerals, magnesite, and sodium sulfate (natural).

Table 7.—Twenty-five leading metal and nonmetal [1] mines in the United States in 1967 in order of output of ore

Mine	State	Operator	Commodity	Mining method
Metals;				
Hoyt Lake	Minn	Pickands Mather & Co	Iron ore	Open pit.
Peter Mitchell	do	Reserve Mining Co	do	Do.
Utah Copper	Utah	Kennecott Copper Corp	Copper	Do.
Climax	Colo	American Metal Climax, Inc.	Molybdenum	Caving.
Eagle Mountain	Calif	Kaiser Steel Corp	Iron Ore	Open pit.
Pima & Northeast	Ariz	Pima Mining Co	Copper	Do.
Empire	Mich	Cleveland Cliffs Iron Co	Iron ore	Do.
Morenci	Ariz	Phelps Dodge Corp	Copper	Do.
Highland	Fla	E. I. du Pont de Nemours & Co., Inc.	Illmenite	Dredging.
Republic	Mich	Cleveland-Cliffs Iron Co	Iron ore	Open pit.
Yuba	Calif	Yuba Industries, Inc	Placer gold	Dredging.
San Manuel	Ariz	Magma Copper Co	Copper	Caving.
Trail Ridge	Fla	E. I. du Pont de Nemours & Co. Inc.	Illmenite	Dredging.
New Cornelia	Ariz	Phelps Dodge Corp	Copper	Open pit.
Butler	Minn	Hanna Minsng Co	Iron ore	Do.
Mineral Park	Ariz	Duval Corp	Copper	Do.
Thunderbird	Minn	Oglebay Norton Co	Iron ore	Do.
Sherman	do	United States Steel Corp	do	Do.
Ray Pit	Ariz	Kennecott Copper Corp	Copper	Do.
Yerington	Nev	The Anaconda Company	do	Do.
Esperanza	Ariz	Duval Corp	do	Do.
White Pine	Mich	White Pine Copper Co	do	Open stopes.
Stephens	Minn	United States Steel Corp	Iron ore	Open pit.
Rouchlea	do	do	do	Do.
Mission	Ariz	American Smelting and Refining Company.	Copper	Do.
Nonmetals:				
Kingsford	Fla	International Minerals & Chemicals Corp.	Phosphate rock	Open pit.
Noralyn	do	do	do	Do.
Payne Creek	do	Agrico Chemical Co	do	Do.
Palmetto	do	do	do	Do.
Ft. Meade	do	Mobil Chemical Co	do	Do.
Bonny Lake	do	W. R Grace & Co	do	Do.
Silver Peak	Nev	Foote Mineral Co	Lithium	Do.
Suwannee River	Fla	Occidental Corp. of Florida	Phosphate rock	Do.
Clear Springs	do	Mobil Chemical Co	do	Do.
International	N. Mex	International Minerals & Chemicals Corp.	Potassium salts	Open stopes.
Watson	Fla	Swift & Co	Phosphate rock	Open pit.
Orange Park	do	American Cyanamid Co	do	Do.
Tenoroc	do	Borden Chemical Co	do	Do.
Sydney	do	American Cyanamid Co	do	Do.
Bartow	do	Armour Agricultural Chemical Co.	do	Do.
Hancock	do	do	do	Do.
	N. Mex	Potash Company of America.	Potassium salts	Open stopes.
Shaft 1	do	Southwest Potash Co	do	Do.
Boyette	Fla	Agrico Chemical Co	Phosphate rock	Open pit.
Lee Creek	N.C	Texas Gulf Sulphur Co	do	Dredging.
Retsof	N.Y	International Salt Co	Salt	Open stopes.
Silver City	Fla	Swift & Co	Phosphate rock	Open pit.
	N. Mex	Kermac Potash Co	Potassium salts	Open stopes.
Cleveland	Ohio	International Salt Co	Salt	Do.
Chicora	Fla	American Cyanamid Co	Phosphate rock	Open pit.

[1] Sand and gravel, stone, brines and materials from wells, etc., excepted.

Table 8.—Twenty-five leading metal and nonmetal [1] mines in the United States in 1967 in order of total materials handled

Mine	State	Operator	Commodity	Mining method
Metals:				
Twin Buttes	Ariz	The Anaconda Company	Copper	Open pit.
Utah Copper	Utah	Kennecott Copper Corp	do	Do.
Eagle Mountain	Calif	Kaiser Steel Corp	Iron ore	Do.
Hoyt Lake	Minn	Pickands Mather & Co	do	Do.
Pima & Northeast	Ariz	Pima Mining Co	Copper	Do.
Peter Mitchell	Minn	Reserve Mining Co	Iron ore	Do.
Morenci	Ariz	Phelps Dodge Corp	Copper	Do.
Russellville	Ala	United States Pipe & Foundry Co.	Iron ore	Do.
Questa	N. Mex	Molybdenum Corporation of America.	Molybdenum	Do.
Mission	Ariz	American Smelting and Refining Company.	Copper	Do.
Mineral Park	do	Duval Corp	do	Do.
Tyrone	do	Phelps Dodge Corp	do	Do.
Lavender Pit	do	do	do	Do.
Chino	N. Mex	Kennecott Copper Corp	do	Do.
New Cornelia	Ariz	Phelps Dodge Corp	do	Do.
Climax	Colo	American Metal Climax, Inc.	Molybdenum	Caving.
TSG–1+Dave	Wyo	Petrotomics Co	Uranium	Open pit, Open stopes.
Ray Pit	Ariz	Kennecott Copper Corp	Copper	Open pit.
Esperanza	do	Duval Corp	do	Do.
Veteran	Nev	Kennecott Copper Corp	do	Do.
Silver Bell	Ariz	American Smelting and Refining Company.	do	Do.
Empire	Mich	Cleveland Cliffs Iron Co	Iron ore	Do.
Yerington	Nev	The Anaconda Company	Copper	Do.
Minntac	Minn	United States Steel Corp	Iron ore	Do.
Republic	Mich	Cleveland Cliffs Iron Co	do	Do.
Nonmetals:				
Kingsford	Fla	International Minerals & Chemicals Corp.	Phosphate rock	Open pit.
Noralyn	do	do	do	Do.
Payne Creek	do	Agrico Chemical Co	do	Do.
Ft. Meade	do	Mobil Chemical Co	do	Do.
Hancock	do	Armour Agricultural Chemical Co.	do	Do.
Bonny Lake	do	W. R. Grace & Co	do	Do.
Palmetto	do	Agrico Chemical Co	do	Do.
Orange Park	do	American Cyanamid Co	do	Do.
Lee Creek	N.C	Texas Gulf Sulphur Co	do	Dredging.
Tenoroc	Fla	Borden Chemical Co	do	Open pit.
DeBely	Calif	United States Borax & Chemical Corp.	Boron	Do.
Bartow	Fla	Armour Agricultural Chemical Co.	Phosphate rock	Do.
Sydney	do	American Cyanamid Co	do	Do.
Clear Springs	do	Mobil Chemical Co	do	Do.
Gay	Idaho	J. R. Simplot Co	do	Do.
Boyette	Fla	Agrico Chemical Co	do	Do.
Watson	do	Swift & Co	do	Do.
Silver Peak	Nev	Foote Mineral Co	Lithium	Do.
Suwannee River	Fla	Occidental Corporation of Florida.	Phosphate rock	Do.
Chicora	do	American Cyanamid Co	do	Do.
Tencor	do	U.S. Phosphoric Products Co.	do	Do.
Lompoc	Calif	Johns-Mansville Products Corp.	Diatomite	Do.
Silver City	Fla	Swift & Co	Phosphate rock	Do.
International	N. Mex	International Minerals & Chemicals Corp.	Potassium salts	Open stopes.
Gordon	Ga	Freeport Kaolin Co	Clay	Open pit.

[1] Sand and gravel, stone, brines and materials from wells, etc., excepted.

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

Plant	State	Operator	Commodity
Moss Landing	Calif	Kaiser Aluminum & Chemical Corp	Magnesium compounds.
Cape May	NJ	NorthwestMagnesite Co	Do.
Bonneville	Utah	Kaiser Aluminum & Chemical Corp	Potassium salts.
Port St. Joe	Fla	Michigan Chemical Corp	Magnesium compounds.
Nichols	Ala	Olin Mathieson Chemical Corp	Salt brine.
Trona	Calif	American Potash & Chemical Corp	Sodium carbonate.
South San Francisco	do	Merck & Co., Inc	Magnesium compounds.
Freeport	Texas	The Dow Chemical Co	Salt brine.
West End	Calif	Stauffer Chemical Co	Sodium carbonate.
Arkansas Chemical	Ark	Arkansas Chemicals, Inc	Bromine.
Do	do	The Dow Chemical Co	Do.
El Dorado	do	Great Lakes Chemical Corp	Do.
Wyandotte	Mich	Wyandotte Chemical Corp	Salt brine.
Iberville	La	The Dow Chemical Co	Do.
Boling Dome	Tex	Texas Gulf Sulphur Co	Frasch sulfur.
Freeport	do	Ethyl-Dow Chemical Co	Bromine.
Grand Isle	La	Freeport Sulphur Co	Frasch sulfur.
Painesville	Ohio	Diamond Shamrock Co	Salt brine.
Iberville	La	Allied Chemical Corp	Do.
Grande Ecaille	do	Freeport Sulphur Co	Frasch sulfur.

Table 10.—Ore treated or sold per unit of marketable product at surface and underground mines in the United States, by commodities, in 1967

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] 2,265	[1] 1,639	[1] 1.5:1	W	W	W	2,265	1,639	1.5:1
Copper	Thousand short tons	111,969	757	146.2:1	18,413	173	98.7:1	130,382	930	137.3:1
Gold:										
Lode	Thousand troy ounces	1,328	414	3.2:1	2,122	732	2.9:1	3,450	1,146	3.0:1
Placer	do	12,570	64	196.4:1				12,570	64	196.4:1
Iron ore	Thousand long tons	190,653	69,604	2.7:1	15,764	11,196	1.5:1	206,417	80,800	2.6:1
Lead	Thousand short tons	11			6,731	241	27.9:1	6,742	241	27.9:1
Mercury	Thousand flasks	231	8	28.1:1	166	15	10.9:1	397	23	16.9:1
Nickel	Thousand short tons	1,084	15	72.3:1				1,084	15	72.3:1
Platinum-group metals	Thousand troy ounces	2,411	7	344.4:1				2,411	7	344.4:1
Rare earth minerals	Thousand short tons	201	12	16.8:1				201	12	16.8:1
Silver	Thousand troy ounces	201	186	1.1:1	442	11,978	.03:1	643	12,164	.05:1
Titanium: Concentrate	Thousand short tons	23,731	883	26.8:1				23,731	883	26.8:1
Uranium	do	1,536	901	1.7:1	3,194	4,114	.78:1	4,730	5,015	.94:1
Zinc	do	326	15	22.2:1	11,110	449	24.8:1	11,436	464	24.7:1
Nonmetals:										
Aplite	Thousand long tons	498	135	3.6:1				498	135	3.6:1
Asbestos	Thousand short tons	2,714	120	22.5:1	23	3	4.3:1	2,737	123	22.0:1
Barite	do	6,464	861	7.2:1	212	101	2.1:1	6,676	962	6.7:1
Boron minerals	do	26,816	955	28.1:1				26,816	955	28.1:1
Clays	do	55,184	49,481	1.1:1	1,256	1,240	1.1:1	56,440	50,721	1.1:1
Emery	do	10	10	1.0:1				10	10	1.0:1
Feldspar	Thousand long tons	1,317	538	2.4:1	2	1	2.0:1	1,319	539	2.4:1
Fluorspar	Thousand short tons	74	38	1.9:1	797	255	3.5:1	871	293	3.3:1
Garnet	do	110	18	6.1:1				110	18	6.1:1
Gypsum	do	6,988	6,896	1.0:1	2,419	2,419	1.0:1	9,407	9,315	1.0:1
Kyanite	do	567	235	2.4:1				567	235	2.4:1
Magnesite	do	581	575	1.0:1				581	575	1.0:1
Mica, flake	do	863	79	10.9:1	19	8	2.4:1	882	87	10.1:1
Olivine	do	78	52	1.5:1				78	52	1.5:1
Perlite	do	638	410	1.5:1	3	3	1.0:1	641	413	1.5:1
Phosphate rock	Thousand long tons	126,591	34,094	3.7:2	1,165	782	1.5:1	127,756	34,876	3.7:1
Potassium salts	Thousand short tons				18,268	2,638	6.9:1	18,268	2,638	6.9:1
Pumice	do	3,434	3,444	1.0:1				3,434	3,444	1.0:1
Salt	do	5,405	4,956	1.1:1	12,734	10,419	1.1:1	18,139	15,375	1.1:1
Sand and gravel	do	905,179	905,179	1.0:1				905,179	905,179	1.0:1
Sodium carbonate (natural)	do				2,551	1,454	1.7:1	2,551	1,454	1.7:1
Stone:										
Dimension	do	4,731	1,776	2.7:1	267	36	7.4:1	4,998	1,812	2.8:1
Crushed and broken	do	747,045	741,625	1.0:1	36,565	35,944	1.0:1	783,610	777,569	1.0:1

Sulfur:										
Frasch	Thousand long tons	7,015	7,681	1.0:1	--------	--------	--------	7,015	7,681	1.0:1
Other	----do	1	1	1.0:1	--------	--------	--------	1	1	1.0:1
Talc, soapstone and pyrophyllite	Thousand short tons	681	427	1.6:1	540	476	1.1:1	1,221	903	1.4:1
Tripoli	----do	30	30	1.0:1	42	42	1.0:1	72	72	1.0:1
Vermiculite	----do	1,173	252	4.6:1	--------	--------	--------	1,173	252	4.6:1

W Withheld to avoid disclosing individual company confidential data.
[1] Includes underground data.

Table 11.—Material handled per unit of marketable product at surface and underground mines in the United States by commodities, in 1967

Commodity	Unit of marketable product	Surface			Underground			Total		
		Total material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable products	Total material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable products	Total material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable products
Metals:										
Bauxite	Thousand long tons	[1] 6,606	[1] 1,639	[1] 4.0:1	W	W	W	6,606	1,639	4.0:1
Copper	Thousand short tons	469,431	757	146.2:1	18,492	173	99.1:1	487,923	930	137.3:1
Gold:										
Lode	Thousand troy ounces	8,375	414	20.2:1	2,370	732	3.2:1	10,745	1,146	7.6:1
Placer	do	14,060	64	219.7:1	--------	--------	--------	14,060	64	219.7:1
Iron ore	Thousand long tons	377,534	69,604	5.4:1	18,273	11,196	1.6:1	395,807	80,800	4.9:1
Lead	Thousand short tons	21	--------	--------	7,312	241	30.3:1	7,333	241	30.4:1
Mercury	Thousand flasks	1,090	8	136.3:1	199	15	13.3:1	1,289	23	56.0:1
Nickel	Thousand short tons	1,423	15	94.9:1	--------	--------	--------	1,423	15	94.9:1
Platinum-group metals	Thousand troy ounces	3,150	7	450.0:1	--------	--------	--------	3,150	7	450.0:1
Rare-earth minerals	Thousand short tons	201	12	16.8:1	--------	--------	--------	201	12	16.8:1
Silver	Thousand troy ounces	233	186	1.3:1	722	11,978	.06:1	955	12,164	.07:1
Titanium: Concentrate	Thousand short tons	28,281	883	26.8:1	--------	--------	--------	28,281	883	26.8:1
Uranium	do	37,374	901	41.5:1	4,324	4,114	1.1:1	41,698	5,015	8.3:1
Zinc	do	1,218	15	81.2:1	12,577	449	28.0:1	13,795	464	29.7:1
Nonmetals:										
Aplite	Thousand long tons	522	135	3.9:1	--------	--------	--------	522	135	3.9:1
Asbestos	Thousand short tons	6,070	120	50.6:1	240	3	80.0:1	6,310	123	51.3:1
Barite	do	7,840	861	9.1:1	215	101	2.1:1	8,055	962	8.4:1
Boron minerals	do	26,816	955	28.1:1	--------	--------	--------	26,816	955	28.1:1
Clays	do	107,394	49,481	2.2:1	1,270	1,240	1.0:1	108,664	50,721	2.1:1
Emery	do	10	10	1.0:1	--------	--------	--------	10	10	1.0:1
Feldspar	Thousand long tons	1,537	538	2.9:1	2	1	2.0:1	1,539	539	2.9:1
Fluorspar	Thousand short tons	98	38	2.6:1	807	255	3.2:1	905	293	3.1:1
Garnet	do	266	18	14.8:1	--------	--------	--------	266	18	14.8:1
Gypsum	do	17,221	6,896	2.5:1	2,520	2,419	1.0:1	19,741	9,315	2.1:1
Kyanite	do	953	235	4.1:1	--------	--------	--------	953	235	4.1:1
Magnesite	do	1,965	575	3.4:1	--------	--------	--------	1,965	575	3.4:1
Mica, flake	do	1,302	79	16.5:1	19	8	2.4:1	1,321	87	15.2:1
Olivine	do	78	52	1.5:1	--------	--------	--------	78	52	1.5:1
Perlite	do	676	410	1.6:1	3	3	1.0:1	679	413	1.6:1
Phosphate rock	Thousand long tons	380,393	34,094	11.2:1	1,167	782	1.5:1	381,560	34,876	10.9:1
Potassium salts	Thousand short tons	--------	--------	--------	19,877	2,638	7.5:1	19,877	2,638	7.5:1
Pumice	do	3,468	3,444	1.0:1	--------	--------	--------	3,468	3,444	1.0:1
Salt	do	5,405	4,956	1.1:1	13,498	10,419	1.3:1	18,903	15,375	1.2:1
Sand and gravel	do	905,179	905,179	1.0:1	--------	--------	--------	905,179	905,179	1.0:1
Sodium carbonate (natural)	do	--------	--------	--------	2,551	1,454	1.7:1	2,551	1,454	1.7:1
Stone:										
Dimension	do	5,658	1,776	3.2:1	267	36	7.4:1	5,925	1,812	3.3:1
Crushed and broken	do	807,684	741,625	1.1:1	36,917	35,944	1.0:1	844,601	777,569	1.1:1

Sulfur:										
Frasch	Thousand long tons	7,015	7,681	.91:1	--------	--------	--------	7,015	7,681	.91:1
Other	----do	1	1	1.0:1	--------	--------	--------	1	1	1.0:1
Talc, soapstone, pyrophyllite	Thousand short tons	1,512	427	3.5:1	585	476	1.2:1	2,097	903	2.3:1
Tripoli	----do	54	30	1.8:1	42	42	1.0:1	96	72	1.3:1
Vermiculite	----do	4,209	252	16.7:1	--------	--------	--------	4,209	252	16.7:1

W Withheld to avoid disclosing individual company confidential data.
[1] Includes underground data

Table 12.—Mining methods used in underground operations, by commodities

(Percent)

	Open stoping				Block caving		Other and unspecified	
	Natural Support		Artificial Support					
	1966	1967	1966	1967	1966	1967	1966	1967
Metals:								
Bauxite	100.0	100.0	------	------	------	------	------	------
Copper	36.5	46.0	9.8	8.0	53.5	45.8	0.2	0.2
Gold: Lode	65.0	75.3	30.5	24.4	------	------	4.5	.3
Iron ore	45.5	51.4	------	------	43.2	42.7	11.3	5.9
Lead	80.5	84.3	19.5	15.7	------	------	------	------
Manganese ore	.1	.1	70.9	99.9	------	------	29.0	------
Mercury	33.8	45.0	36.0	51.5	------	------	30.2	3.5
Molybdenum	1.0	.5	------	------	99.6	99.5	------	------
Silver	9.3	24.8	82.6	70.1	------	------	8.1	5.1
Uranium	61.6	72.9	37.4	27.0	1.0	.1	------	------
Zinc	81.4	86.6	16.6	12.4	.1	------	1.9	1.0
Nonmetals:								
Asbestos	95.0	98.8	5.0	1.2	------	------	------	------
Barite	.1	1.0	53.2	49.3	------	------	46.7	49.7
Clays	95.1	94.6	4.9	5.4	------	------	------	------
Feldspar	100.0	100.0	------	------	------	------	------	------
Fluorspar	80.0	85.5	19.9	13.8	------	------	.1	.7
Gypsum	100.0	93.8	------	------	------	------	------	6.2
Phosphate rock	93.6	93.6	6.4	6.4	------	------	------	------
Potassium salts	94.4	94.0	------	------	------	------	5.6	6.0
Salt	96.5	97.1	------	------	------	------	3.5	2.9
Stone:								
Crushed and broken	99.6	99.2	.4	.8	------	------	------	------
Dimension	98.1	98.2	------	------	1.9	1.8	------	------
Talc, soapstone, and pyrophyllite	70.6	80.8	17.8	18.6	.1	------	11.5	.6
Tripoli	100.0	100.0	------	------	------	------	------	------
Wollastonite	100.0	100.0	------	------	------	------	------	------
Total	68.3	73.3	5.7	4.6	23.0	20.0	3.0	2.1

Table 13.—Mining methods used in underground operations, by States

(Percent)

State	Open stoping				Block caving		Other and unspecified	
	Natural support		Artificial support					
	1966	1967	1966	1967	1966	1967	1966	1967
Alabama	100.0	100.0	-------	-------	-------	-------	-------	-------
Arizona	2.9	6.9	8.9	7.9	88.2	85.2	-------	-------
Arkansas	84.4	84.1	8.3	7.8	-------	-------	7.3	8.1
California	79.3	81.0	14.4	16.5	-------	-------	6.3	2.5
Colorado	10.6	8.3	3.4	6.0	86.0	85.7	-------	-------
Georgia	98.4	100.0	1.6	-------	-------	-------	-------	-------
Idaho	5.3	5.7	84.3	86.4	.7	.4	9.7	7.5
Illinois	96.6	97.1	3.4	2.9	-------	-------	-------	-------
Indiana	100.0	100.0	-------	-------	-------	-------	-------	-------
Iowa	100.0	100.0	-------	-------	-------	-------	-------	-------
Kansas	100.0	100.0	-------	-------	-------	-------	-------	-------
Kentucky	99.0	97.7	.3	2.3	-------	-------	.7	-------
Louisiana	100.0	100.0	-------	-------	-------	-------	-------	-------
Maine	-------	-------	-------	-------	100.0	100.0	-------	-------
Maryland	100.0	96.5	-------	3.5	-------	-------	-------	-------
Michigan	77.4	76.7	.1	-------	16.9	18.4	5.6	4.9
Minnesota	-------	1.6	-------	-------	-------	-------	100.0	98.4
Missouri	100.0	100.0	-------	-------	-------	-------	-------	-------
Montana	33.6	56.3	66.2	43.5	-------	-------	.2	.2
Nevada	60.5	83.2	6.8	16.6	-------	-------	32.7	.2
New Jersey	38.3	1.4	50.0	73.0	-------	-------	11.7	25.6
New Mexico	89.7	90.2	4.9	3.9	-------	-------	5.4	5.9
New York	94.2	93.4	.1	-------	-------	-------	5.7	6.6
North Carolina	.1	-------	91.6	100.0	8.3	-------	-------	-------
Ohio	100.0	100.0	-------	-------	-------	-------	-------	-------
Oklahoma	100.0	100.0	-------	-------	-------	-------	-------	-------
Oregon	100.0	100.0	-------	-------	-------	-------	-------	-------
Pennsylvania	42.5	47.2	-------	-------	57.5	52.8	-------	-------
South Dakota	76.2	84.2	23.8	15.8	-------	-------	-------	-------
Tennessee	100.0	100.0	-------	-------	-------	-------	-------	-------
Texas	98.9	99.0	1.1	1.0	-------	-------	-------	-------
Utah	75.4	76.4	24.6	23.6	-------	-------	-------	-------
Vermont	67.3	79.9	11.1	20.1	-------	-------	21.6	-------
Virginia	100.0	100.0	-------	-------	-------	-------	-------	-------
Washington	80.8	88.5	8.7	10.7	-------	-------	10.5	.8
West Virginia	100.0	100.0	-------	-------	-------	-------	-------	-------
Wisconsin	98.1	100.0	-------	-------	-------	-------	1.9	-------
Wyoming	47.2	98.3	1.7	1.3	27.6	.4	23.5	-------
Total	68.3	73.3	5.7	4.6	23.0	20.0	3.0	2.1

Table 14.—Kind of surface mining operation, by commodities, in 1967

(Percent of crude ore)

Commodity	Open pit	Single bench	Multiple bench
Metals:			
Bauxite	65	2	33
Copper	34	1	65
Gold: Lode	---	-----	100
Iron ore	15	1	84
Mercury	27	43	30
Nickel	---	-----	100
Rare-earth metals and thorium	---	100	-----
Tin	100	-----	-----
Titanium: Concentrate	75	-----	25
Uranium	92	-----	8
Zinc	78	22	-----
Nonmetals:			
Abrasives:			
Emery	100	-----	-----
Garnet	61	-----	39
Tripoli	100	-----	-----
Aplite	81	-----	19
Asbestos	32	-----	68
Barite	74	2	24
Boron minerals	---	-----	100
Clays	85	7	8
Diatomite	3	6	91
Feldspar	67	3	30
Fluorspar	89	-----	11
Gypsum	52	43	5
Kyanite	16	-----	84
Lithium minerals	100	-----	-----
Marl, greensand	100	-----	-----
Mica: Flake	100	-----	-----
Olivine	46	54	-----
Perlite	84	-----	16
Phosphate rock	97	-----	3
Pumice	96	1	3
Salt	99	1	-----
Sand and gravel	100	-----	-----
Stone:			
Crushed and broken	63	8	29
Dimension	52	2	46
Talc, soapstone, and pyrophyllite	56	44	-----
Vermiculite	21	-----	79

Table 15.—Kind of surface mining operation, by States, in 1967

(Percent of crude ore)

State	Open pit	Single bench	Multiple bench
Alabama	93	-----	7
Alaska	100	-----	-----
Arizona	44	-----	56
Arkansas	89	2	9
California	56	2	42
Colorado	94	1	5
Connecticut	71	19	10
Delaware	90	-----	10
Florida	99	-----	1
Georgia	89	8	3
Hawaii	66	15	19
Idaho	66	-----	34
Illinois	73	6	21
Indiana	69	9	22
Iowa	72	14	14
Kansas	98	2	-----
Kentucky	86	4	10
Louisiana	100	-----	-----
Maine	100	-----	-----
Maryland	64	4	32
Massachusetts	83	3	14
Michigan	50	9	41
Minnesota	22	1	77
Mississippi	100	-----	-----
Missouri	85	2	13
Montana	86	-----	14
Nebraska	90	-----	10
Nevada	39	1	60
New Hampshire	99	-----	1
New Jersey	77	1	22
New Mexico	26	1	73
New York	64	3	33
North Carolina	96	2	2
North Dakota	100	-----	-----
Ohio	76	8	16
Oklahoma	76	20	4
Oregon	94	-----	6
Pennsylvania	68	5	27
Rhode Island	83	-----	17
South Carolina	91	-----	9
South Dakota	100	-----	-----
Tennessee	93	-----	7
Texas	90	3	7
Utah	21	-----	79
Vermont	90	-----	10
Virginia	56	11	33
Washington	99	-----	1
West Virginia	67	3	30
Wisconsin	88	2	10
Wyoming	80	-----	20

Table 16.—Mining methods used in open-pit mining, by commodities, in 1967

(Percent)

Commodity	Total material handled: Preceded by drilling and blasting	Total material handled: Not preceded by drilling and blasting
Metals:		
Bauxite	89	11
Beryllium	78	22
Copper	76	24
Gold:		
Lode	100	------
Placer	---	100
Iron ore	78	22
Lead	25	75
Mercury	35	65
Molybdenum	94	6
Nickel	11	89
Platinum-group metals	---	100
Rare-earth metals	100	------
Silver	31	69
Titanium: Concentrate	21	79
Uranium	---	100
Zinc	100	------
Nonmetals:		
Abrasive stone	27	73
Aplite	19	81
Asbestos	92	8
Barite	17	83
Clays	15	85
Diatomite	---	100
Emery	100	------
Feldspar	83	17
Fluorspar	61	39
Graphite	100	------
Gypsum	82	18
Kyanite	100	------
Lithium minerals	100	------
Magnesite	100	------
Mica: Flake	13	87
Olivine	62	38
Perlite	53	47
Phosphate rock	1	99
Pumice	5	95
Sand and gravel	---	100
Stone:		
Crushed and broken	92	8
Dimension	19	81
Sulfur: Other than Frasch mines	---	100
Talc, soapstone, and pyrophyllite	62	38
Vermiculite	55	45
Total	47	53

Table 17.—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
1966:						
Shaft and winze sinking	24,449	0.2	2,675	0.1	27,124	0.2
Raising	162,969	1.5	9,313	.3	172,282	1.3
Drifting and crosscutting	813,104	7.4	91,815	3.4	904,919	6.6
Diamond drilling	2,465,943	22.5	85,969	3.2	2,551,912	18.8
Churn drilling	260,996	2.4	1,900	.1	262,896	1.9
Rotary drilling	4,286,825	39.2	1,286,898	48.3	5,573,723	40.9
Percussion drilling	2,624,135	24.0	755,613	28.4	3,379,748	24.8
Trenching	52,717	.5	23,553	.9	76,270	.6
Other	256,106	2.3	406,527	15.3	662,633	4.9
Total	10,947,244	100.0	2,664,263	100.0	13,611,507	100.0
1967:						
Shaft and winze sinking	20,829	0.5	2,347	0.5	23,176	0.5
Raising	176,318	1.0	8,061	.3	184,379	.9
Drifting and crosscutting	1,065,713	6.3	60,559	2.7	1,126,272	5.9
Diamond drilling	2,514,670	14.9	123,303	5.6	2,637,973	13.8
Churn drilling	202,991	1.2	9,425	.4	212,416	1.1
Rotary drilling	8,625,263	51.3	1,383,566	62.9	10,008,829	52.7
Percussion drilling	4,009,081	23.8	280,665	12.7	4,289,746	22.5
Trenching	67,483	.4	28,824	1.3	96,307	.5
Other	111,422	.6	300,993	13.6	412,415	2.1
Total	16,793,770	100.0	2,197,743	100.0	18,991,513	100.0

Table 18.—Exploration and development by methods and selected metals and nonmetals in 1967

(feet)

Commodity	Shaft and winze sinking	Raising	Drifting and cross-cutting	Trenching	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other	Total
Metals:										
Beryllium	5	---	10	---	2,469	55	65,627	---	---	68,166
Copper	3,137	30,216	77,543	1,742	872,449	34,038	141,748	77,599	11	1,238,483
Gold	1,272	15,752	59,173	4,181	98,853	500	17,820	846,311	1,706	1,045,568
Iron ore	857	49,124	142,747	2,300	217,771	12,519	158,804	34,018	15,024	633,164
Lead	5,165	12,109	287,552	34,015	295,207	85,111	25,759	461,319	66,763	1,273,000
Mercury	438	3,604	11,111	3,850	36,069	4,322	3,596	93,621	335	156,946
Molybdenum	660	13,227	77,240	1,300	91,550	---	14,728	---	---	198,705
Silver	1,017	6,442	27,898	2,360	53,687	60	8,912	173,228	585	274,189
Tungsten	147	4,246	12,586	7,920	20,868	250	620	534	---	47,171
Uranium	5,475	16,466	245,439	2,735	609,620	10,521	8,108,098	1,097,414	6,144	10,101,912
Zinc	2,656	25,132	108,114	2,000	188,286	50,847	29,078	1,223,747	20,854	1,650,714
Other [1]	---	---	16,300	5,080	27,841	4,768	50,473	1,290	---	105,752
Total	20,829	176,318	1,065,713	67,483	2,514,670	202,991	8,625,263	4,009,081	111,422	16,793,770
Nonmetals:										
Asbestos	---	252	985	---	---	---	1,200	---	---	2,437
Barite	---	291	4,479	10	---	---	1,012	150	---	5,942
Clays	45	50	130	200	3,896	8,800	634,838	---	255,018	902,977
Fluorspar	650	1,406	14,749	30	63,104	625	---	425	---	80,989
Gypsum	---	1,200	4,505	2,000	2,384	---	79,845	---	5,500	95,434
Mica: Flake	---	---	---	1,100	1,385	---	672	---	14,700	17,857
Phosphate rock	---	45	609	800	3,300	---	246,741	---	12,000	263,495
Potassium salts	---	---	---	---	180	---	---	---	---	180
Stone	---	950	24,149	15,704	14,831	---	363,400	274,817	3,675	697,526
Talc, soapstone, and pyrophyllite	1,652	3,867	10,953	---	32,615	---	---	1,600	---	50,687
Other [2]	---	---	---	8,980	1,608	---	55,858	3,673	10,100	80,219
Total	2,347	8,061	60,559	28,824	123,303	9,425	1,383,566	280,665	300,993	2,197,743
Grand total	23,176	184,379	1,126,272	96,307	2,637,973	212,416	10,008,829	4,289,746	412,415	18,991,513

[1] Antimony, bauxite, manganese ore, nickel, tin and vanadium.
[2] Abrasives, boron minerals, diatomite, feldspar, kyanite, perlite, pumice, sodium carbonate (natural), sulfur (Frasch), and sulfur (other).

Table 19.—Exploration and development by methods and States in 1967

(Feet)

State	Shaft and winze sinking	Raising	Drifting and cross-cutting	Trenching	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other	Total
Alabama	------	--------	----------	1,000	1,320	300	30,000	----------	19,165	51,785
Arizona	2,683	29,458	70,737	1,652	371,208	41,333	153,290	46,366	14	716,741
Arkansas	------	291	20,529	4,060	36,001	--------	10,753	108,897	--------	180,531
California	1,909	7,404	26,644	4,310	137,162	--------	39,289	55,397	349	272,464
Colorado	4,696	23,211	173,368	7,203	301,584	3,581	397,412	300,750	8	1,211,813
Florida	------	--------	----------	-------	----------	--------	233,406	----------	12,000	245,406
Georgia	------	--------	----------	-------	----------	--------	615,440	----------	82,703	698,143
Idaho	2,678	12,854	38,997	3,170	79,283	--------	115,813	1,600,530	630	1,853,955
Illinois	50	716	3,569	-------	57,684	1,725	6,309	40	--------	70,093
Indiana	------	--------	----------	-------	----------	--------	80	----------	--------	80
Iowa	------	--------	----------	-------	820	--------	2,300	----------	3,500	6,620
Kansas	------	--------	----------	-------	----------	3,853	58,032	169	--------	62,054
Kentucky	163	760	6,235	-------	7,792	--------	56,994	600	--------	72,544
Michigan	615	12,790	67,992	-------	167,807	--------	54	6,923	--------	256,181
Minnesota	340	--------	----------	-------	269,968	320	523	135	7,134	278,420
Missouri	4,202	16,528	307,248	47,609	237,696	96,348	26,158	41,965	86,512	864,266
Montana	489	765	8,381	10,540	15,213	250	----------	8,485	--------	44,123
Nebraska	------	--------	----------	-------	----------	--------	500	----------	--------	500
Nevada	868	2,619	31,214	8,510	25,359	4,377	80,744	104,834	7,450	265,975
New Jersey	------	1,586	495	-------	----------	--------	----------	----------	--------	2,081
New Mexico	1,080	15,218	181,335	1,415	150,255	268	2,178,654	711,817	6,195	3,246,237
New York	414	15,957	17,495	-------	3,806	--------	----------	----------	--------	37,672
North Carolina	------	--------	----------	-------	10,646	--------	35,200	----------	3,600	49,446
Oklahoma	------	--------	----------	250	10,305	4,812	32,966	----------	--------	48,333
Oregon	50	560	1,576	3,808	786	4,768	300	4,500	9,012	25,360
Pennsylvania	------	9,415	28,533	-------	96	--------	----------	----------	--------	38,044
South Carolina	------	--------	----------	-------	1,100	--------	1,752	----------	--------	2,852
South Dakota	253	13,192	45,035	110	97,122	--------	89,260	----------	--------	244,972
Tennessee	265	1,948	30,615	-------	64,703	950	122,287	164,451	154,770	539,989
Texas	12	--------	300	-------	45,395	--------	654,240	120,000	--------	819,947
Utah	1,875	7,513	36,840	260	267,212	7,500	344,041	733,222	1	1,398,464
Vermont	490	300	1,365	-------	15,909	--------	----------	----------	--------	18,064
Virginia	------	5,662	8,657	-------	----------	--------	62,345	----------	--------	76,664
Washington	44	472	4,654	90	3,405	--------	----------	263,440	1,420	273,525
Wisconsin	------	--------	2,232	-------	3,565	40,132	1,155	1,600	--------	48,684
Wyoming	------	5,160	12,226	2,320	254,771	1,899	4,659,532	15,625	17,952	4,969,485
Total	23,176	184,379	1,126,272	96,307	2,637,973	212,416	10,008,829	4,289,746	412,415	18,991,513

Table 20.—Total material (ore and waste) produced by exploration and development in the United States, by commodities in 1967

(Thousand short tons)

Commodity	Shaft and winze sinking	Raising	Drifting and cross-cutting	Trenching	Stripping	Total
Metals:						
Bauxite	---	---	50	---	263	**313**
Beryllium	---	---	-----	---	7	**7**
Copper	17	41	218	3	121,849	**122,128**
Gold:						
Lode	4	31	95	3	84	**217**
Placer	---	---	1	3	64	**68**
Iron ore	10	56	380	2	121,166	**121,614**
Lead	36	24	2,075	78	146	**2,359**
Mercury	1	8	16	10	608	**643**
Molybdenum	10	34	248	12	-------	**304**
Siver	5	24	54	12	72	**167**
Tungsten	---	11	52	7	6	**76**
Uranium	12	18	578	5	11,260	**11,873**
Zinc	16	36	430	11	823	**1,316**
Other [1]	---	---	-----	12	2,205	**2,217**
Total	111	283	4,197	158	258,553	**263,302**
Nonmetals:						
Asbestos	---	---	1	---	56	**57**
Barite	---	---	6	---	712	**718**
Clays	---	---	-----	2	38,847	**38,849**
Feldspar	---	---	-----	1	102	**103**
Fluorspar	1	3	32	---	9	**45**
Gypsum	---	5	18	9	6,278	**6,310**
Perlite	---	---	-----	---	10	**10**
Phosphate rock	---	---	1	4	239,485	**239,490**
Stone	---	1	1,155	285	21,918	**23,359**
Talc, soapstone, pyrophyllite	7	5	27	---	84	**123**
Vermiculite	---	---	-----	---	586	**586**
Other [2]	---	---	-----	66	2,040	**2,106**
Total	8	14	1,240	367	310,127	**311,756**
Grand total	119	297	5,437	525	568,680	**575,058**

[1] Manganiferous ore, tin, and vanadium.
[2] Abrasives, boron minerals, kyanite, lithium minerals, flake mica, pumice and sulfur (other).

Table 21.—Total material (ore and waste) produced by exploration and development in the United States, by States, in 1967

(Thousand short tons)

State	Shaft and winze sinking	Raising	Drifting and cross-cutting	Trenching	Stripping	Total
Alabama	---	---	-----	1	28,188	28,189
Arizona	8	35	191	3	100,934	101,171
Arkansas	---	---	56	7	1,708	1,771
California	7	17	87	14	1,267	1,392
Colorado	18	54	427	19	114	632
Florida	---	---	-----	---	222,993	222,993
Georgia	---	---	-----	---	32,305	32,305
Idaho	16	43	100	17	2,202	2,378
Illinois	---	2	12	---	3,194	3,208
Indiana	---	---	-----	---	1,146	1,146
Iowa	---	---	-----	---	10,835	10,835
Kentucky	---	1	253	---	1,532	1,786
Maine	---	---	-----	---	823	823
Michigan	8	13	145	---	13,546	13,712
Minnesota	3	---	-----	---	89,603	89,606
Missouri	30	29	3,029	360	490	3,938
Montana	2	1	13	20	71	107
Nebraska	---	---	-----	---	120	120
Nevada	1	6	127	66	141	341
New Jersey	---	1	1	---	-------	2
New Mexico	5	16	461	6	22,960	23,448
New York	1	15	45	---	-------	61
North Carolina	---	---	-----	---	15,425	15,425
Oregon	1	1	3	7	-------	12
Pennsylvania	---	6	87	---	-------	93
South Carolina	---	---	-----	---	3,809	3,809
South Dakota	1	23	69	3	22	118
Tennessee	3	2	166	---	4,253	4,424
Texas	---	---	-----	---	4,201	4,201
Utah	14	19	79	---	339	451
Vermont	1	---	3	---	-------	4
Virginia	---	7	30	---	38	75
Washington	---	1	7	---	1	9
Wisconsin	---	---	18	---	250	268
Wyoming	---	5	28	2	6,170	6,205
Total	119	297	5,437	525	568,680	575,058

Table 22.—U.S. consumption of industrial explosives

(Thousand pounds)

Year	Black basting powder		High explosives		Liquid oxygen explosives [3]	Total
	Granular [1]	Pellets [1]	Permissible	Other than permissibles [2]		
1912	230,293	------	24,630	234,470	------	489,393
1913	229,939	------	27,686	242,387	------	500,012
1914	206,100	------	25,698	218,454	------	450,252
1915	197,722	------	27,350	235,829	------	460,901
1916	215,575	------	34,685	255,155	------	505,415
1917	277,118	------	43,041	262,316	------	582,475
1918	246,664	------	46,045	206,416	------	499,125
1919	180,511	------	38,855	198,268	------	417,634
1920	254,880	------	53,963	229,112	------	537,955
1921	160,021	------	41,134	170,952	------	372,107
1922	178,866	------	43,430	209,476	------	431,772
1923	201,952	------	60,371	267,405	------	529,728
1924	167,076	------	55,134	273,323	------	495,533
1925	156,964	------	58,353	286,435	------	501,752
1926	157,687	------	67,685	310,518	------	535,890
1927	131,696	------	63,847	303,468	------	499,011
1928	98,004	23,754	60,708	292,785	------	475,251
1929	86,818	33,227	62,670	326,993	------	509,708
1930	63,138	36,735	53,826	291,391	------	445,090
1931	46,300	33,530	41,578	216,157	------	337,565
1932	35,793	27,961	32,225	137,908	------	233,887
1933	33,887	30,323	33,928	157,849	------	255,987
1934	37,193	31,742	39,208	206,625	------	314,768
1935	34,223	34,665	39,170	200,323	------	308,381
1936	40,420	41,278	47,859	262,047	------	391,604
1937	29,837	36,404	49,579	288,924	------	404,744
1938	23,552	28,143	41,859	238,576	------	332,130
1939	28,322	29,915	49,951	278,250	------	386,438
1940	29,083	30,670	58,436	305,180	------	423,369
1941	27,882	31,576	70,612	351,857	------	481,927
1942	24,167	31,367	84,022	359,699	------	499,255
1943	19,814	26,608	92,656	338,573	------	477,651
1944	16,283	26,677	102,538	318,613	------	464,111
1945	12,303	24,644	97,407	322,957	------	457,311
1946	13,539	23,285	100,258	399,233	------	536,315
1947	9,837	26,627	122,349	476,017	16,561	651,391
1948	8,236	25,004	126,282	550,085	15,620	725,227
1949	5,853	14,224	91,630	505,601	13,922	631,230
1950	5,441	15,214	109,420	575,962	13,804	719,841
1951	3,752	10,233	108,258	611,237	20,341	753,821
1952	3,887	6,715	95,460	636,741	21,915	764,718
1953	5,186	4,329	89,879	668,952	22,465	790,811
1954	6,407	3,890	75,863	612,054	17,741	715,955
1955	3,262	3,362	93,718	687,226	19,310	806,878
1956	2,818	2,780	104,934	898,524	17,724	1,026,780
1957	1,443	2,241	104,522	912,590	13,835	1,034,631
1958	658	1,834	84,085	864,117	10,903	961,597
1959	1,114	1,219	83,520	955,915	6,808	1,048,576
1960	464	1,073	80,577	1,089,216	1,668	1,172,998
1961	647	873	73,439	1,126,427	2,235	1,203,621
1962	439	783	72,884	1,236,057	2,243	1,312,406
1963	502	636	76,319	1,376,633	1,834	1,455,924
1964	451	495	77,406	1,585,015	2,184	1,665,551
1965	464	372	76,040	1,802,426	5,598	1,884,900
1966	240	223	74,527	1,882,072	13,094	1,970,156

[1] Pellet powder was first manufactured for general use in the U.S. in 1925; included with granular powder prior to 1928.
[2] Beginning 1956 includes unprocessed ammonium nitrate as well as completely processed ammonium nitrate blasting agents.
[3] Data not collected prior to 1947.

Table 23.—U.S. consumption of pellet black blasting powder in the minerals industry [1]

(Pounds)

Year	Coal mining	Metal mining	Quarrying and nonmetal mining	Total
1928	21,968,700	41,000	329,500	22,339,200
1929	32,181,175	24,525	231,100	32,436,800
1930	36,096,225	29,625	189,300	36,315,150
1931	33,261,950	1,550	235,675	33,499,175
1932	27,782,550	16,500	118,250	27,917,300
1933	30,056,800	14,700	186,050	30,257,550
1934	31,501,000	5,275	222,000	31,728,275
1935	34,275,325	13,400	215,000	34,503,725
1936	40,933,550	5,775	295,175	41,234,500
1937	35,917,250	5,300	388,425	36,310,975
1938	27,837,000	10,775	218,025	28,065,800
1939	29,278,225	700	392,350	29,671,275
1940	29,847,725	4,600	450,225	30,302,550
1941	30,898,575	----------	656,825	31,555,400
1942	30,870,400	550	460,725	31,331,675
1943	26,031,300	450	536,325	26,568,075
1944	26,252,850	550	373,300	26,626,700
1945	24,307,650	500	315,325	24,623,475
1946	22,797,250	22,000	410,250	23,229,500
1947	26,219,575	2,500	355,925	26,578,000
1948	24,542,050	400	363,850	24,906,300
1949	13,800,200	200	323,800	14,124,200
1950	14,767,250	50	377,725	15,145,025
1951	9,799,875	2,100	334,725	10,136,700
1952	6,316,825	500	235,000	6,552,325
1953	4,163,450	100	107,150	4,270,700
1954	3,683,150	50	134,400	3,817,600
1955	3,116,200	9,675	158,175	3,284,050
1956	2,542,025	1,150	113,150	2,656,325
1957	2,078,600	----------	121,850	2,200,450
1958	1,612,200	----------	54,275	1,666,475
1959	926,750	----------	134,600	1,061,350
1960	833,275	----------	135,375	968,650
1961	692,100	----------	128,100	820,200
1962	625,750	----------	106,925	732,675
1963	496,850	900	84,800	582,550
1964	341,300	----------	47,800	389,100
1965	126,000	----------	61,000	187,000
1966	77,000	----------	25,000	102,000

[1] Prior to 1928, pellet black blasting powder was included in granular black blasting powder and shown as "black blasting powder."

Table 24.—U.S. consumption of granular black blasting powder in the minerals industry[1]

(Thousand pounds)

Year	Coal mining	Metal mining	Quarrying and nonmetal mining	Total
1912	187,091	---------	---------	187,091
1913	184,917	8,350	---------	193,267
1914	176,813	7,572	---------	184,385
1915	167,514	6,704	---------	174,218
1916	176,976	7,846	---------	184,822
1917	235,750	9,455	---------	245,205
1918	216,222	7,445	---------	223,667
1919	153,490	6,303	---------	159,793
1920	219,763	8,681	---------	228,444
1921	140,336	4,620	---------	144,956
1922	154,762	4,193	---------	158,955
1923	175,489	4,373	---------	179,862
1924	140,625	3,612	---------	144,237
1925	132,414	3,447	6,012	141,873
1926	136,112	2,849	5,909	144,870
1927	112,570	2,156	5,785	120,511
1928	78,934	2,054	4,733	85,721
1929	69,879	2,261	4,335	76,475
1930	49,589	1,359	3,636	54,584
1931	34,506	1,144	2,607	38,257
1932	28,529	435	1,369	30,333
1933	27,164	493	1,278	28,935
1934	28,915	594	1,627	31,136
1935	27,322	652	1,623	29,597
1936	30,128	478	1,937	32,543
1937	22,806	279	2,017	25,102
1938	18,531	175	1,519	20,225
1939	21,890	201	2,010	24,101
1940	23,447	236	2,353	26,036
1941	22,604	59	2,443	25,106
1942	19,878	120	1,715	21,713
1943	17,564	63	1,512	19,139
1944	13,708	69	1,216	14,993
1945	10,734	20	1,073	11,827
1946	9,786	24	1,363	11,173
1947	7,685	22	1,198	8,905
1948	6,081	45	1,354	7,480
1949	3,772	17	955	4,744
1950	2,935	[2] 54	1,057	3,992
1951	2,036	7	901	2,944
1952	1,261	14	872	2,147
1953	705	52	823	1,580
1954	591	11	536	1,138
1955	422	10	374	806
1956	375	17	341	733
1957	375	1	256	632
1958	174	2	223	399
1959	112	1	235	348
1960	103	30	183	316
1961	74	---------	428	502
1962	115	1	222	338
1963	260	---------	169	429
1964	108	6	145	259
1965	15	4	120	139
1966	[2] 245	---------	390	145

[1] Prior to 1925, explosives used for nonmetal mining were included in metal mining and classified as other mining; explosives used for quarrying were included in all other purposes (not shown in this table).
[2] Sold but later returned unused.

Table 25.—U.S. consumption of high explosives other than permissibles in the minerals industry [1]

(Thousand pounds)

Year	Coal mining	Metal mining	Quarrying and nonmetal mining	Total
1912	20,903	89,703	----------	110,606
1913	24,143	92,096	----------	116,239
1914	24,216	84,265	----------	108,481
1915	22,384	109,129	----------	131,513
1916	20,901	131,754	----------	152,655
1917	28,263	132,236	----------	160,499
1918	30,780	102,955	----------	133,735
1919	29,616	89,755	----------	119,371
1920	37,273	89,132	----------	126,405
1921	34,232	50,977	----------	85,209
1922	25,498	78,074	----------	103,572
1923	37,829	105,004	----------	142,833
1924	36,608	103,836	----------	140,444
1925	26,947	102,623	71,501	201,071
1926	35,229	110,374	76,186	221,789
1927	34,173	102,122	78,506	214,801
1928	30,077	96,088	74,820	200,985
1929	31,752	108,939	79,505	220,196
1930	28,148	91,161	68,334	187,643
1931	19,965	57,431	48,568	125,964
1932	16,173	29,409	29,263	74,845
1933	17,478	32,839	29,985	80,302
1934	22,212	45,690	34,491	102,393
1935	21,958	55,841	34,222	112,021
1936	24,053	76,657	49,779	150,489
1937	26,691	99,537	52,777	179,005
1938	23,584	75,407	40,702	139,693
1939	23,663	88,061	53,732	165,456
1940	26,686	105,995	59,634	192,315
1941	38,515	116,344	78,403	233,262
1942	42,009	119,936	85,281	247,226
1943	54,060	122,653	79,647	256,360
1944	77,493	102,164	70,531	250,188
1945	91,551	89,292	73,031	253,874
1946	108,076	82,173	101,458	291,707
1947	130,719	102,249	109,118	342,086
1948	159,258	115,909	123,135	398,302
1949	126,409	110,804	120,185	357,398
1950	156,839	127,749	138,857	423,445
1951	152,500	147,073	150,230	449,803
1952	144,996	151,148	165,511	461,655
1953	134,483	167,294	175,189	476,966
1954	108,048	145,953	169,565	423,566
1955	123,651	168,483	195,185	487,319
1956	172,730	197,190	212,189	582,109
1957	245,735	191,788	216,333	653,856
1958	259,933	144,812	210,330	615,075
1959	279,608	151,377	248,515	679,500
1960	332,395	221,097	261,980	815,472
1961	339,173	234,097	267,478	840,748
1962	363,265	245,147	286,749	895,161
1963	428,304	252,726	319,819	1,000,849
1964	470,702	318,176	360,312	1,149,190
1965	515,651	356,632	369,334	1,241,617
1966	534,141	353,236	393,911	1,281,288

[1] Prior to 1925, explosives used for nonmetal mining were included with metal mining and classified as other mining; explosives used for quarrying were included in all other purposes (not shown in this table). Includes unprocessed ammonium nitrate as well as completely processed ammonium nitrate blasting agents beginning with 1956.

Table 26.—U.S. consumption of permissible explosives in the minerals industry [1]

(Thousand pounds)

Year	Coal mining	Metal mining	Quarrying and nonmetal mining	Total
1912	18,151	4,668	---------	22,819
1913	21,804	4,735	---------	26,539
1914	19,594	4,850	---------	24,444
1915	21,842	4,688	---------	26,530
1916	26,567	6,207	---------	32,774
1917	32,910	6,102	---------	39,012
1918	37,263	4,550	---------	41,813
1919	32,840	2,498	---------	35,338
1920	45,222	3,751	---------	48,973
1921	38,056	882	---------	38,938
1922	40,198	1,453	---------	41,651
1923	56,807	783	---------	57,590
1924	52,147	515	---------	52,662
1925	52,256	3,533	838	56,627
1926	65,143	216	581	65,940
1927	60,942	191	536	61,669
1928	57,261	231	1,243	58,735
1929	60,244	165	370	60,779
1930	52,378	183	502	53,063
1931	40,611	10	230	40,851
1932	31,533	35	93	31,661
1933	33,218	26	434	33,678
1934	38,770	28	287	39,085
1935	38,665	75	329	39,069
1936	47,002	68	580	47,650
1937	48,735	50	434	49,219
1938	41,417	20	268	41,705
1939	49,401	17	387	49,805
1940	57,821	27	453	58,301
1941	69,971	19	551	70,541
1942	83,400	33	477	83,910
1943	92,135	26	421	92,582
1944	101,825	4	513	102,342
1945	96,848	15	447	97,310
1946	99,455	20	689	100,164
1947	121,432	39	703	122,174
1948	125,185	56	823	126,064
1949	90,535	35	777	91,347
1950	108,351	55	895	109,301
1951	107,182	131	815	108,128
1952	94,482	62	763	95,307
1953	88,810	73	819	89,702
1954	74,988	78	610	75,676
1955	92,657	125	754	93,536
1956	103,698	95	726	104,519
1957	103,534	55	446	104,035
1958	82,892	101	406	83,399
1959	82,573	89	528	83,190
1960	79,667	60	450	80,177
1961	72,522	58	445	73,025
1962	71,646	39	532	72,217
1963	75,150	74	560	75,784
1964	75,950	117	741	76,808
1965	73,564	79	1,520	75,163
1966	71,091	95	1,957	73,143

[1] Prior to 1925, explosives used for nonmetal mining were included in metal mining and classified as other mining; explosives used for quarrying were included in all other purposes (not shown in this table).

Statistical Summary

By Kathleen J. D'Amico [1]

This summary appears in Minerals Yearbook volumes I-II, and III, which cover mineral production in the United States, its island possessions, the Canal Zone, and the Commonwealth of Puerto Rico, as well as the principal minerals imported into and exported from the United States. The sections of this chapter and the area chapters in volume III contain further details on production. A summary table comparing world and U.S. mineral production also is included.

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 officer, 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
1963	$13,317	$4,316	$2,002	$19,635
1964	13,623	4,623	r 2,366	r 20,612
1965	14,047	4,933	r 2,544	r 21,524
1966 r	15,112	5,176	2,703	22,991
1967	16,198	5,205	2,333	23,736

r Revised.

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

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

Mineral	1964 Quantity	1964 Value (thousands)	1965 Quantity	1965 Value (thousands)	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
Mineral fuels:								
Asphalt and related bitumens (native):								
Bituminous limestone and sandstone and gilsonite short tons	1,935,344	$10,038	1,911,664	$9,461	2,041,271	$8,438	1,866,666	$8,136
Carbon dioxide, natural (estimate) thousand cubic feet	1,232,816	166	1,173,676	152	1,140,907	153	1,142,374	165
Coal:								
Bituminous and lignite [2] thousand short tons	486,998	2,165,582	512,088	2,276,022	533,881	2,421,293	552,626	2,555,377
Pennsylvania anthracite do	17,184	148,648	14,866	122,021	12,941	100,663	12,256	96,160
Helium:								
Crude thousand cubic feet	3,197,016	35,322	3,566,734	39,848	3,654,700	41,556	3,697,300	42,800
Grade A do	830,481	25,923	819,100	28,880	951,400	32,541	1,015,000	29,657
Natural gas million cubic feet	15,462,138	2,387,689	16,039,753	2,494,542	[3] 17,232,134	[3] 2,721,875	18,171,325	2,898,741
Natural gas liquids:								
Natural gasoline and cycle products thousand gallons	7,000,181	463,600	7,288,070	494,354	[3] 7,591,658	[3] 524,167	[3] 7,919,831	[3] 549,429
LP gases do	10,743,591	362,792	11,257,267	417,249	12,134,294	527,223	13,717,861	632,994
Peat short tons	639,690	6,198	603,746	6,080	605,858	6,501	619,687	6,768
Petroleum (crude) thousand 42-gallon barrels	2,786,822	8,017,078	[r] 2,848,514	[r] 8,158,299	[3] 3,028,084	[3] 8,727,387	[3] 3,216,715	[3] 9,377,516
Total mineral fuels	XX	13,623,000	XX	14,047,000	XX	[r] 15,112,000	XX	16,198,000
Nonmetals (except fuels):								
Abrasive stones [4] short tons	3,186	$292	3,603	$432	3,806	$515	2,701	$574
Asbestos do	101,092	8,143	118,275	10,162	125,928	11,056	123,189	11,102
Barite thousand short tons	830	9,796	852	10,192	947	11,259	962	11,604
Boron minerals do	776	60,871	807	64,180	866	68,209	955	74,130
Bromine thousand pounds	283,530	66,064	328,115	77,259	326,498	78,883	349,757	85,391
Calcite (optical grade) pounds	4	2	(5)	(5)	(5)	(5)	----------	----------
Calcium-magnesium chloride short tons	W	W	W	W	W	W	608,965	11,983
Cement:								
Portland thousand 376-pound barrels	358,378	1,145,108	366,802	1,154,448	373,091	1,162,984	365,570	1,148,208
Masonry thousand 280-pound barrels	22,397	63,305	23,260	65,979	22,367	63,407	21,700	62,168
Natural and slag thousand 376-pound barrels	283	1,057	279	1,027	[r] 109	[r] 415	94	360
Clays thousand short tons	52,947	192,631	55,126	204,932	[r] 56,713	[r] 221,714	54,664	223,987
Emery short tons	9,214	172	10,720	204	11,102	210	(5)	(5)
Feldspar long tons	587,194	5,389	624,598	6,263	[r] 655,452	[r] 7,020	615,397	7,086
Fluorspar short tons	217,137	9,723	240,932	10,889	253,068	10,841	295,643	13,164
Garnet (abrasive) do	16,123	1,622	19,330	1,717	21,952	2,092	20,494	1,849
Gem stones (estimate)	NA	1,474	NA	2,218	NA	2,437	NA	2,430
Gypsum thousand short tons	10,684	38,874	10,033	37,375	9,647	35,681	9,393	34,383
Lime do	16,089	223,149	16,794	232,939	18,057	239,588	17,974	241,137
Magnesium compounds from sea water and brine (except for metals) short tons, MgO equivalent	599,698	42,177	637,857	47,197	[r] 651,187	[r] 46,690	544,428	41,414
Mica:								
Scrap short tons	114,729	3,353	120,255	3,468	113,133	3,733	118,503	2,876
Sheet pounds	242,662	58	716,086	185	4,500	1	20,500	(5)

Perlite short tons	349,867	3,073	392,384	3,352	404,160	3,907	413,001	3,973
Phosphate rock thousand short tons	25,715	161,067	29,482	193,323	r 39,044	r 261,092	39,770	265,947
Potassium salts thousand short tons, K_2O equivalent	2,897	114,095	3,140	129,767	3,320	122,210	3,299	105,313
Pumice thousand short tons	2,776	6,443	3,371	6,550	3,218	6,765	3,446	5,131
Pyrites thousand long tons	847	5,471	875	5,333	873	5,088	861	7,943
Salt thousand short tons	31,623	200,706	34,687	215,699	36,463	229,985	38,946	251,210
Sand and gravel do	868,208	893,375	908,049	957,416	934,481	984,982	905,162	980,356
Sodium carbonate (natural) short tons	1,274,745	30,451	1,494,105	34,717	1,737,511	40,674	1,727,977	40,539
Sodium sulfate (natural) do	575,033	10,989	619,752	11,024	640,329	11,271	636,843	10,710
Stone [6] thousand short tons	725,583	1,134,564	780,242	1,203,831	813,374	1,260,715	785,592	1,240,244
Sulfur:								
Frasch process mines thousand long tons	6,035	120,776	7,251	164,654	7,721	201,292	7,682	251,670
Other mines long tons	794	8	2,852	11	557	5	568	3
Talc, soapstone, and pyrophyllite short tons	889,949	6,218	862,875	6,343	895,045	6,479	902,512	6,871
Tripoli do	64,613	268	71,138	381	66,163	328	70,984	377
Vermiculite thousand short tons	226	3,613	249	4,460	262	4,954	255	4,974
Value of items that cannot be disclosed: Aplite, brucite, diatomite, graphite, iodine, kyanite, lithium minerals, magnesite, greensand marl, olivine, staurolite, wollastonite, and values indicated by footnote [5]	XX	58,771	XX	65,028	XX	69,911	XX	55,734
Total nonmetals	XX	4,623,000	XX	4,933,000	XX	r 5,176,000	XX	5,205,000
Metals:								
Antimony ore and concentrate short tons, antimony content	632	(7)	845	(7)	927	(7)	892	(7)
Bauxite thousand long tons, dried equivalent	1,601	$17,875	1,654	$18,632	1,796	$20,095	1,654	$19,079
Copper (recoverable content of ores, etc.) short tons	1,246,780	812,901	1,351,734	957,028	1,429,152	1,033,850	954,064	729,401
Gold (recoverable content of ores, etc.) troy ounces	1,456,308	50,971	1,705,190	59,682	1,803,420	63,119	1,584,187	55,447
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight	84,300	802,331	84,079	801,388	90,040	854,134	82,415	817,511
Lead (recoverable content of ores, etc.) short tons	286,010	74,935	301,147	93,959	327,368	98,964	316,931	88,741
Manganese ore (35 percent or more Mn) short tons, gross weight	26,058	(7)	29,258	(7)	14,406	(7)	12,585	(7)
Manganiferous ore (5 to 35 percent Mn) do	238,776	(7)	332,763	(7)	324,926	(7)	289,160	(7)
Mercury 76-pound flasks	14,142	4,452	19,582	11,176	22,008	9,722	23,784	11,639
Molybdenum (content of concentrate) thousand pounds	65,097	97,121	77,310	120,801	91,670	144,327	81,596	133,604
Nickel (content of ore and concentrate) short tons	15,420	(7)	16,188	(7)	15,036	(7)	15,287	(7)
Silver (recoverable content of ores, etc.) thousand troy ounces	36,334	46,980	39,806	51,469	43,669	56,463	32,119	49,784
Tin (content of concentrate) long tons	65	185	47	126	97	265	(7)	(7)
Titanium concentrate:								
Ilmenite short tons, gross weight	1,003,997	19,178	948,832	18,058	868,436	17,608	882,414	18,519
Rutile do	10,547	1,016	(7)	(7)	(7)	(7)	(7)	(7)
Tungsten ore and concentrate short tons, 60 percent WO_3 basis	9,244	11,251	7,949	13,028	8,912	17,620	9,088	20,895
Uranium [8] (recoverable content U_3O_8) thousand pounds	27,171	217,375	19,727	157,828	19,037	152,281	20,655	165,239
Vanadium (recoverable in ore and concentrate) short tons	4,362	13,061	5,226	18,284	5,166	22,210	4,963	21,331
Zinc (recoverable content of ores, etc.) do	574,858	156,308	611,153	178,284	572,558	166,044	549,418	151,562

See footnotes at end of table.

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

Mineral	1964		1965		1966		1967	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Value of items that cannot be disclosed: Beryllium concentrate, cobalt, columbium-tantalum concentrate (1967), magnesium chloride for magnesium metal, manganiferous residuum, platinum-group metals (crude), rare-earth metal concentrates, zirconium concentrate, and values indicated by footnote [7]	XX	$40,183	XX	$44,804	XX	r $46,605	XX	$50,190
Total metals	XX	r 2,366,000	XX	r 2,544,000	XX	r 2,703,000	XX	2,333,000
Grand total mineral production	XX	r 20,612,000	XX	r 21,524,000	XX	r 22,991,000	XX	23,736,000

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.
[3] Final figure; supersedes figure given in commodity section.
[4] Grindstones, pulpstones, millstones (weight not recorded), grinding pebbles, sharpening stones, and tube-mill liners.
[5] Figure withheld to avoid disclosing individual company confidential data; value included with "Nonmetal items that cannot be disclosed."
[6] Excludes abrasive stone, bituminous limestone, bituminous sandstone, and ground soapstone, all included elsewhere in table.
[7] Figure withheld to avoid disclosing individual company confidential data; value included with "Metal items that cannot be disclosed."
[8] Beginning with 1964, the basis for reporting uranium ore has been replaced by uranium (recoverable content U_3O_8).

Table 3.—Minerals produced in the United States and principal producing States in 1967

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

See footnotes at end of table.

Table 3.—Minerals produced in the United States and principal producing States in 1967—Continued

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

Table 4.—Value of mineral production in the United States, and principal minerals produced in 1967

(Thousands)

State	Value	Rank	Percent of U.S. total	Principal minerals in order of value
Alabama	$251,391	21	1.06	Coal, cement, petroleum, stone.
Alaska	134,066	29	.56	Petroleum, sand and gravel, coal, natural gas.
Arizona	463,863	15	1.95	Copper, sand and gravel, molybdenum, cement.
Arkansas	179,453	27	.76	Petroleum, stone, bauxite, cement.
California	1,696,233	3	7.15	Petroleum, natural gas, sand and gravel, cement.
Colorado	346,235	17	1.46	Petroleum, molybdenum, coal, sand and gravel.
Connecticut	20,619	45	.09	Stone, sand and gravel, feldspar, lime.
Delaware	2,383	50	.01	Sand and gravel, stone, clays, gem stones.
Dist. of Columbia	---------	----	-------	
Florida	309,797	18	1.31	Phosphate rock, stone, cement, clays.
Georgia	153,458	28	.65	Clays, stone, cement, sand and gravel.
Hawaii	16,936	46	.07	Cement, stone, sand and gravel, pumice.
Idaho	109,408	31	.46	Silver, phosphate rock, lead, zinc.
Illinois	636,801	8	2.68	Coal, petroleum, stone, sand and gravel.
Indiana	244,921	22	1.03	Coal, cement, stone, petroleum.
Iowa	113,222	30	.48	Cement, stone, sand and gravel, gypsum.
Kansas	574,068	10	2.42	Petroleum, natural gas, natural gas liquids, helium.
Kentucky	535,705	11	2.26	Coal, petroleum stone, natural gas.
Louisiana	3,961,750	2	16.69	Petroleum, natural gas, natural gas liquids, sulfur.
Maine	14,882	47	.06	Cement, sand and gravel, stone, peat.
Maryland	72,819	37	.31	Stone, cement, sand and gravel, coal.
Massachusetts	40,612	43	.17	Sand and gravel, stone, lime, clays.
Michigan	610,204	9	2.57	Iron ore, cement, sand and gravel, bromine.
Minnesota	523,326	13	2.20	Iron ore, sand and gravel, stone, cement.
Mississippi	217,010	24	.91	Petroleum, natural gas, sand and gravel, clays.
Missouri	236,659	23	1.00	Stone, cement, lead, iron ore.
Montana	186,524	26	.79	Petroleum, copper, sand and gravel, phosphate rock.
Nebraska	70,868	39	.30	Petroleum, cement, sand and gravel, stone.
Nevada	90,883	33	.38	Copper, gold, sand and gravel, diatomite.
New Hampshire	8,117	48	.03	Sand and gravel, stone, clays, felsdpar.
New Jersey	72,747	38	.31	Sand and gravel, stone, zinc, magnesium compounds.
New Mexico	874,106	7	3.68	Petroleum, natural gas, potassium salts, uranium.
New York	299,318	19	1.26	Cement, stone, sand and gravel, salt.
North Carolina	77,094	36	.32	Stone, sand and gravel, cement, phosphate rock.
North Dakota	97,538	32	.41	Petroleum, sand and gravel, coal, natural gas.
Ohio	498,888	14	2.10	Coal, stone, sand and gravel, cement.
Oklahoma	1,032,126	4	4.35	Petroleum, natural gas, natural gas liquids, cement.
Oregon	66,560	40	.28	Sand and gravel, stone, cement, nickel.
Pennsylvania	898,398	6	3.78	Coal, cement, stone, sand and gravel.
Rhode Island	4,035	49	.02	Sand and gravel, stone.
South Carolina	48,274	42	.20	Cement, stone, clays, sand and gravel.
South Dakota	52,618	41	.22	Gold, sand and gravel, stone, cement.
Tennessee	189,572	25	.80	Stone, zinc, cement, coal.
Texas	5,406,371	1	22.78	Petroleum, natural gas, natural gas liquids, cement.
Utah	354,477	16	1.49	Copper, petroleum, coal, molybdenum.
Vermont	27,268	44	.11	Stone, asbestos, sand and gravel, talc.
Virginia	283,685	20	1.20	Coal, stone, cement, sand and gravel.
Washington	82,067	34	.35	Sand and gravel, cement, stone, zinc.
West Virginia	937,858	5	3.95	Coal, natural gas, natural gas liquids, stone.
Wisconsin	79,612	35	.34	Sand and gravel, stone, cement, zinc.
Wyoming	530,696	12	2.24	Petroleum, uranium, natural gas, sodium salts.
Total	23,736,000	----	100.0	Petroleum, natural gas, coal, stone.

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

Mineral	1964 Quantity	1964 Value (thousands)	1965 Quantity	1965 Value (thousands)	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
ALABAMA								
Cement: [2]								
Portland thousand 376-pound barrels	12,870	$40,108	13,765	$42,604	16,394	$49,537	15,364	$46,510
Masonry thousand 280-pound barrels	2,574	7,794	2,598	7,853	2,570	7,613	2,377	6,938
Clays thousand short tons	[3] 1,991	[3] 4,060	[3] 2,220	[3] 4,888	2,448	5,142	2,724	7,422
Coal (bituminous) do	14,435	102,267	14,832	106,249	14,219	100,112	15,486	110,696
Iron ore (usable) thousand long tons, gross weight	2,106	11,812	1,495	8,241	1,508	8,702	1,472	8,286
Lime thousand short tons	599	7,118	653	7,905	699	8,442	624	7,719
Natural gas million cubic feet	165	18	203	26	252	32	248	31
Petroleum (crude) thousand 42-gallon barrels	8,498	22,095	8,064	21,047	8,030	20,878	7,348	19,500
Sand and gravel thousand short tons	5,840	6,191	6,422	7,195	7,082	7,953	7,229	7,969
Stone do	[4] 15,852	[4] 24,976	[4] 17,987	[4] 30,810	[4] 20,744	[4] 36,839	18,371	33,346
Value of items that cannot be disclosed: Native asphalt, bauxite, slag cement, clays (kaolin 1964–65, bentonite 1964–65), scrap mica, salt, stone (dimension limestone, dimension marble 1964–66, shell 1964–65, crushed sandstone 1965–66), talc, and tripoli (1965)	XX	9,251	XX	9,446	XX	4,528	XX	2,974
Total	XX	235,690	XX	246,264	XX	249,778	XX	251,391
ALASKA								
Antimony ore and concentrate short tons, antimony content	14	$18	1	$1	8	W	10	W
Coal (bituminous) thousand short tons	745	5,008	893	6,095	927	$6,953	925	$7,296
Copper (recoverable content of ores, etc.) short tons	11	7	32	23	W	W	W	W
Gold (recoverable content of ores, etc.) troy ounces	58,416	2,045	42,249	1,479	27,325	956	22,948	803
Lead (recoverable content of ores, etc.) short tons	--------	--------	9	3	14	4	--------	--------
Mercury 76-pound flasks	303	95	W	W	W	W	W	W
Natural gas million cubic feet	6,238	1,719	7,255	1,799	11,267	2,794	14,438	3,610
Peat short tons	2,350	19	1,967	16	W	W	1,528	12
Petroleum (crude) thousand 42-gallon barrels	11,059	33,627	11,128	34,073	14,358	44,007	29,126	91,164
Sand and gravel thousand short tons	26,089	18,488	30,266	34,467	17,457	21,793	22,370	26,248
Silver (recoverable content of ores, etc.) thousand troy ounces	7	9	8	10	7	9	6	9
Value of items that cannot be disclosed: Barite (1966–67), gem stones, platinum-group metals, stone, tin, uranium ore (1964–65) and values indicated by symbol W	XX	[r] 5,013	XX	[r] 5,512	XX	6,167	XX	4,924
Total	XX	[r] 66,048	XX	[r] 83,478	XX	82,683	XX	134,066
ARIZONA								
Asbestos short tons	W	W	3,469	$441	W	W	W	W
Clays [3] thousand short tons	168	$213	129	164	89	$121	67	$37
Coal (bituminous) do	--------	--------	--------	--------	--------	--------	1	5
Copper (recoverable content of ores, etc.) short tons	690,988	450,524	703,377	497,991	739,569	535,004	501,741	383,591
Diatomite do	450	16	295	8	1,353	36	W	W
Fluorspar do	--------	--------	--------	--------	--------	--------	10,000	280
Gem stones	NA	120	NA	120	NA	120	NA	150
Gold (recoverable content of ores, etc.) troy ounces	153,676	5,379	150,431	5,265	142,528	4,988	80,844	2,830

Gypsum ---- thousand short tons --	147	770	103	540	75	394	W	W
Helium, grade A ---- thousand cubic feet --	46,000	1,610	58,000	2,030	63,500	2,222	73,800	2,066
Iron ore (usable) ---- thousand long tons, gross weight --	4	32	8	51	W	W	W	W
Lead (recoverable content of ores, etc.) ---- short tons --	6,147	1,611	5,913	1,845	5,211	1,575	4,771	1,336
Lime ---- thousand short tons --	177	2,920	204	3,543	218	3,721	186	3,142
Mercury ---- 76-pound flasks --	77	24	158	90	363	160	W	W
Molybdenum (content of concentrate) ---- thousand pounds --	6,296	9,532	9,399	15,880	10,161	17,812	9,261	15,385
Natural gas ---- million cubic feet --	2,014	241	3,106	376	3,161	436	1,255	193
Petroleum (crude) ---- thousand 42-gallon barrels --	64	W	97	W	132	370	2,924	8,188
Pumice ---- thousand short tons --	880	1,635	1,161	1,515	1,103	1,674	1,064	904
Sand and gravel ---- do ----	18,116	20,868	14,918	16,621	18,730	20,448	16,580	17,017
Silver (recoverable content of ores, etc.) ---- thousand troy ounces --	5,811	7,513	6,095	7,881	6,339	8,196	4,588	7,112
Stone ---- thousand short tons --	3,759	6,283	2,474	4,171	2,271	4,091	1,910	3,491
Tungsent ore and concentrate ---- short tons, 60-percent WO_3 basis --	16	17	3	5	2	5	W	W
Uranium (recoverable content U_3O_8) ---- thousand pounds --	W	W	W	W	437	3,492	83	666
Vanadium (recoverable in ore and concentrate) ---- short tons --	W	575	W	381	W	453	W	W
Zinc (recoverable content of ores, etc.) ---- do ----	24,690	6,716	21,757	6,353	15,985	4,636	14,330	3,967
Value of items that cannot be disclosed: Cement, clays (bentonite, fire clay 1964), feldspar, scrap mica, perlite pyrites, vermiculite (1967), and values indicated by symbol W ----	XX	[r] 20,222	XX	[r] 17,847	XX	12,125	XX	13,503
Total ----	XX	[r] 536,821	XX	[r] 583,118	XX	[r] 622,079	XX	463,863
ARKANSAS								
Barite ---- thousand short tons --	233	$2,202	249	$2,379	233	$2,266	229	$2,266
Bauxite ---- thousand long tons, dried equivalent --	1,562	17,431	1,593	17,974	1,718	19,439	1,571	18,269
Bromine and bromine in compounds ---- thousand pounds --	W	W	32,254	7,171	42,307	10,467	64,450	14,885
Clays ---- thousand short tons --	892	2,152	866	1,890	[3] 775	[3] 776	941	1,740
Coal (bituminous) ---- do ----	212	1,503	226	1,643	236	1,640	189	1,427
Gem stones ----	NA	33	NA	31	NA	35	NA	35
Lime ---- thousand short tons --	189	2,814	192	2,776	207	3,004	187	2,723
Natural gas ---- million cubic feet --	75,753	11,806	82,831	12,922	105,174	16,407	116,522	17,828
Natural gas liquids:								
Natural gasoline and cycle products ---- thousand gallons --	30,082	1,678	27,787	1,578	32,050	1,923	27,533	1,780
LP gases ---- do ----	61,616	2,460	69,752	3,139	64,664	3,233	53,730	3,009
Petroleum (crude) ---- thousand 42-gallon barrels --	26,737	71,120	25,930	68,974	23,824	63,372	21,075	56,902
Sand and gravel ---- thousand short tons --	11,794	14,836	12,806	15,836	16,056	21,038	14,239	15,531
Stone ---- do ----	20,241	26,172	21,241	26,778	19,109	24,588	17,454	23,236
Value of items that cannot be disclosed: Abrasive stones, cement, clays (Kaolin and fire clay 1966), gypsum, iron ore (1964–65), mercury (1966–67) phosphate rock (1964–66), soapstone, tripoli (1965–67), and values indicated by symbol W ----	XX	20,611	XX	16,019	XX	21,939	XX	19,822
Total ----	XX	174,818	XX	179,110	XX	190,127	XX	179,453
CALIFORNIA								
Antimony ore and concentrate ---- short tons, antimony content --	----	----	----	----	1	([5])	----	----
Asbestos ---- short tons --	55,041	$4,419	74,587	$6,177	81,671	$6,945	77,091	$6,726
Barite ---- thousand short tons --	6	45	4	21	15	104	10	71
Boron minerals ---- do ----	776	60,871	807	64,180	866	68,209	955	74,130
Calcite (optical grade) ---- pounds --	4	2	W	W	W	W	----	----

See footnotes at end of table.

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

Mineral	1964 Quantity	1964 Value (thousands)	1965 Quantity	1965 Value (thousands)	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
CALIFORNIA—Continued								
Cement……thousand 376-pound barrels..	47,204	$149,933	45,352	$144,852	45,387	$146,302	42,034	$137,961
Clays……thousand short tons..	3,685	8,433	3,207	7,226	2,984	6,708	2,609	6,037
Copper (recoverable content of ores, etc.)……short tons..	1,035	675	1,165	825	1,078	780	788	602
Feldspar……long tons..	102,264	W	95,975	W	100,915	W	94,769	W
Gem stones……	NA	200	NA	200	NA	200	NA	200
Gold (recoverable content of ores, etc.)……troy ounces..	71,028	2,486	62,885	2,201	64,764	2,267	40,570	1,420
Gypsum……thousand short tons..	1,893	4,539	1,611	3,881	1,207	3,064	1,241	3,150
Lead (recoverable content of ores, etc.)……short tons..	1,546	405	1,810	565	1,976	597	1,735	486
Lime……thousand short tons..	577	10,294	602	11,073	552	8,764	539	8,696
Magnesium compounds from sea water and bitterns (partly estimated) short tons, MgO equivalent……	94,739	7,143	[r] 95,652	[r] 7,955	87,816	7,413	76,592	6,882
Mercury……76-pound flasks..	10,291	3,240	13,404	7,650	16,070	7,100	16,385	8,018
Natural gas……million cubic feet..	660,444	198,551	660,384	204,059	[6] 715,113	[6] 223,175	681,080	202,290
Natural gas liquids:								
Natural gasoline and cycle products……thousand gallons..	720,373	54,088	655,780	49,850	[6] 677,868	[6] 52,399	643,984	49,122
LP gases……do....	352,614	15,893	339,082	15,467	353,164	17,304	366,643	19,065
Peat……short tons..	35,391	443	30,905	434	29,235	384	30,014	396
Petroleum (crude)……thousand 42-gallon barrels..	300,009	729,022	316,428	753,099	345,295	812,834	359,219	829,133
Pumice……thousand short tons..	443	1,937	676	1,744	580	1,763	866	1,357
Salt……do....	1,525	W	1,638	W	1,693	W	1,732	W
Sand and gravel……do....	112,995	129,333	118,310	136,227	120,692	139,157	116,125	139,212
Silver (recoverable content of ores, etc.)……thousand troy ounces..	172	222	197	254	190	246	145	224
Stone……thousand short tons..	45,805	63,566	42,575	59,668	43,051	61,336	37,186	55,263
Sulfur ore……long tons..	520	3	360	2	557	5	568	3
Talc, soapstone, and pyrophyllite……short tons..	132,601	1,631	141,074	1,725	138,340	1,847	143,466	1,945
Tin (content of concentrate)……long tons..	W	W	W	W	13	21	W	W
Wollastonite……short tons..	3,625	36	W	W	W	W	W	W
Zinc (recoverable content of ores, etc.)……do....	143	39	225	66	335	97	441	122
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, carbon dioxide, coal (lignite), diatomite, iodine (1964–66), iron ore, lithium minerals, scrap mica, molybdenum, perlite, platinum group metals (crude) potassium salts, rare-earth metal concentrates, sodium carbonates and sulfates, tungsten concentrate, uranium (1964–66), and values indicated by symbol W……	XX	[r] 113,080	XX	[r] 117,904	XX	[r] 141,449	XX	143,722
Total……	XX	[r]1,560,529	XX	[r]1,597,305	XX	[r]1,710,470	XX	1,696,233
COLORADO								
Carbon dioxide, natural……thousand cubic feet..	211,830	$36	155,668	$26	147,292	$25	182,701	$31
Clays……thousand short tons..	558	1,275	631	1,446	[r] 599	[r] 1,315	596	1,274
Coal (bituminous)……do....	4,355	23,427	4,790	24,431	5,222	26,075	5,439	25,920
Copper (recoverable content of ores, etc.)……short tons..	4,653	3,034	3,828	2,710	4,237	3,065	3,993	3,053
Feldspar……long tons..	W	W	521	3	891	6	300	2
Gem stones……	NA	80	NA	80	NA	80	NA	118

Gold (recoverable content of ores, etc.)....troy ounces..	42,122	1,474	37,228	1,303	31,915	1,117	21,181	741
Gypsum....thousand short tons..	100	398	[r] 100	[r] 379	75	269	77	265
Iron ore (usable)....thousand long tons, gross weight..	35	231	114	787	164	1,133	W	W
Lead (recoverable content of ores, etc.)....short tons..	20,563	5,388	22,495	7,018	23,082	6,978	21,923	6,138
Lime....thousand short tons..	138	2,193	118	2,074	126	2,327	118	2,028
Manganiferous ore (5 to 35 percent Mn)....short tons, gross weight..	--------	--------	--------	--------	--------	--------	321	3
Molybdenum (content of concentrate)....thousand pounds..	46,378	69,207	[7] 50,715	[7] 78,609	57,289	88,851	52,040	84,728
Natural gas....million cubic feet..	113,691	13,489	126,381	16,303	136,667	17,767	116,857	15,542
Natural gas liquids:								
Natural gasoline....thousand gallons..	52,400	2,845	54,180	3,034	59,420	3,565	51,845	3,215
LP gases....do....	88,916	3,894	91,399	3,930	73,390	3,596	71,544	3,649
Peat....short tons..	27,931	188	31,179	236	37,111	278	21,988	204
Petroleum (crude)....thousand 42-gallon barrels..	34,755	100,094	33,511	96,512	33,492	97,462	33,905	99,003
Pumice....thousand short tons..	61	114	56	134	46	104	18	105
Pyrites....thousand long tons..	W	W	30	90	W	W	W	W
Sand and gravel....thousand short tons..	20,746	22,227	20,810	22,041	22,245	23,485	21,810	22,904
Silver (recoverable content of ores, etc.)....thousand troy ounces..	2,626	3,396	2,051	2,652	2,085	2,697	1,818	2,817
Stone....thousand short tons..	3,217	6,805	4,789	8,638	7,031	11,331	2,992	5,485
Tin (content of concentrate)....long tons..	29	103	32	76	44	99	31	59
Tungsten concentrate....short tons, 60 percent WO_3 basis..	W	W	1,176	1,985	1,494	3,626	1,276	3,039
Uranium (recoverable content U_3O_8)....thousand pounds..	W	W	W	W	2,651	21,205	2,537	20,299
Vanadium (recoverable in ore and concentrate)....short tons..	3,312	9,916	4,017	14,056	3,697	15,888	3,317	14,260
Vermiculite....thousand short tons..	(5)	1	--------	--------	--------	--------	--------	--------
Zinc (recoverable content of ores, etc.)....short tons..	53,682	14,602	53,870	15,730	54,822	15,898	52,442	14,519
Value of items that cannot be disclosed: Beryllium concentrate, cement, fluorspar, scrap mica (1967), molybdenum (1965) perlite, rare-earth metal concentrates (1966–67), salt, and values indicated by symbol W.	XX	[r] 44,193	XX	[r] 35,867	XX	14,699	XX	16,834
Total....	XX	[r] 328,610	XX	[r] 340,150	XX	[r] 362,941	XX	346,235
CONNECTICUT								
Clays....thousand short tons..	212	$262	237	$322	192	$296	191	$334
Gem stones....	NA	8	NA	8	NA	8	NA	8
Lime....thousand short tons..	39	689	W	W	W	W	W	W
Sand and gravel....do....	10,088	9,437	9,940	9,106	9,561	8,963	8,320	8,710
Stone....do....	5,864	10,764	5,871	10,444	5,618	10,482	5,097	10,141
Value of items that cannot be disclosed: Feldspar, scrap mica, peat (1964–66), and values indicated by symbol W....	XX	690	XX	1,354	XX	1,597	XX	1,426
Total....	XX	21,850	XX	21,234	XX	21,346	XX	20,619
DELAWARE								
Clays....thousand short ton..	11	$11	11	$11	11	$11	11	11
Gem stones....	NA	1	NA	1	NA	1	NA	1
Sand and gravel....thousand short tons..	1,282	1,280	1,545	1,441	1,610	1,443	1,966	1,846
Stone....do....	180	450	180	450	210	525	210	525
Value of items that cannot be disclosed: Other nonmetals and values indicated by symbol W....	XX	--------	XX	--------	XX	--------	XX	--------
Total....	XX	1,742	XX	1,903	XX	1,980	XX	2,383

See footnotes at end of table.

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

Mineral	1964 Quantity	1964 Value (thousands)	1965 Quantity	1965 Value (thousands)	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
FLORIDA								
Clays ---- thousand short tons	627	$8,405	651	$9,752	762	$11,408	756	$11,574
Lime ---- do	117	1,814	101	1,558	135	1,966	155	2,425
Natural gas ---- million cubic feet	40	5	107	14	212	30	123	18
Peat ---- short tons	19,813	102	19,253	109	11,500	91	22,180	155
Petroleum (crude) ---- thousand 42-gallon barrels	620	W	1,464	W	1,799	W	1,568	W
Phosphate rock ---- thousand short tons	19,161	119,667	21,563	141,258	W	W	W	W
Sand and gravel ---- do	7,420	6,427	7,298	6,377	7,403	6,417	6,912	6,479
Stone ---- do	33,157	38,362	35,730	41,148	35,023	38,167	33,971	38,723
Value of items that cannot be disclosed: Cement, magnesium compounds, natural gas, liquids, rare-earth metal concentrates, staurolite, stone (dimension limestone 1967) titanium concentrate, zirconium concentrate, and values indicated by symbol W	XX	48,627	XX	49,104	XX	237,368	XX	250,423
Total	XX	223,409	XX	249,320	XX	295,447	XX	309,797
GEORGIA								
Barite ---- thousand short tons	109	$2,022	W	W	W	W	W	W
Clays ---- do	4,365	58,899	4,607	$63,158	5,128	$73,685	4,953	$77,314
Coal (bituminous) ---- do	4	15	----	----	----	----	----	----
Iron ore (usable) ---- thousand long tons, gross weight	354	1,752	430	2,208	447	2,200	267	1,450
Mica								
Scrap ---- short tons	W	W	13,065	W	16,608	380	17,158	291
Sheet ---- pounds	----	----	2,793	(5)	----	----	----	----
Sand and gravel ---- thousand short tons	3,588	3,594	3,675	3,588	3,915	4,185	3,787	4,206
Stone ---- do	22,822	46,428	23,421	48,265	24,690	48,193	23,418	49,953
Talc ---- short tons	40,400	135	44,800	313	41,000	255	46,150	292
Value of items that cannot be disclosed: Bauxite, cement, feldspar, kyanite, peat, rare-earth metal concentrates (1966–67), titanium concentrate (1965–67), zirconium concentrate (1965–67), and values indicated by symbol W	XX	14,292	XX	17,688	XX	19,699	XX	19,952
Total	XX	127,137	XX	135,220	XX	148,597	XX	153,458
HAWAII								
Cement ---- thousand 376-pound barrels	1,717	$8,877	1,564	$8,297	1,749	$9,046	1,395	$7,360
Clays ---- thousand short tons	3	W	W	W	W	W	W	W
Lime ---- do	9	321	9	305	10	320	8	265
Pumice ---- do	365	603	380	624	374	716	290	562
Sand and gravel ---- do	407	979	751	2,237	511	1,591	469	1,467
Stone ---- do	5,282	8,765	5,172	9,353	5,079	9,482	4,100	7,207
Value of items that cannot be disclosed: Other nonmetals and values indicated by symbol W	XX	60	XX	19	XX	98	XX	75
Total	XX	19,605	XX	20,835	XX	21,253	XX	16,936

IDAHO								
Antimony ore and concentrate........short tons, antimony content..	585	W	818	W	834	W	823	W
Clays [3]...............thousand short tons..	29	$25	47	$33	23	$22	19	$16
Cobalt...............thousand pounds..	---------	---------	---------	---------	1	6	---------	---------
Copper (recoverable content of ores, etc.)...............short tons..	4,666	3,042	5,140	3,639	4,961	3,589	4,210	3,219
Gem stones...............	NA	W	NA	150	NA	180	NA	180
Gold (recoverable content of ores, etc.)...............troy ounces..	5,677	199	5,078	178	5,056	177	4,838	169
Iron ore (usable)...............thousand long tons, gross weight..	4	33	9	84	11	97	W	W
Lead (recoverable content of ores, etc.)...............short tons..	71,312	18,684	66,606	20,781	72,334	21,867	61,387	17,188
Mercury...............76-pound flasks..	83	26	1,119	639	1,134	501	898	439
Peat...............short tons..	900	8	W	W	W	W	2,040	16
Pumice...............thousand short tons..	59	100	46	79	55	107	W	W
Sand and gravel...............do....	9,582	8,691	12,151	13,198	7,544	6,672	11,246	11,490
Silver (recoverable content of ores, etc.).......thousand troy ounces..	16,483	21,313	18,457	23,865	19,777	25,571	17,033	26,402
Stone...............thousand short tons..	1,144	2,773	1,831	3,440	2,694	5,415	1,986	4,833
Tungsten concentrate...............short tons, 60-percent WO_3 basis..	11	8	---------	---------	2	1	68	175
Zinc (recoverable content of ores, etc.)...............short tons..	59,298	16,129	58,034	16,946	60,997	17,689	56,528	15,650
Value of items that cannot be disclosed: Barite (1964), cement, clays (fire clay, bentonite 1964–66, kaolin), abrasive garnet, lime, scrap mica (1964), perlite, phosphate rock, titanium concentrate (1964–66), vanadium, and values indicated by symbol W...............	XX	15,231	XX	22,053	XX	[r] 32,991	XX	29,631
Total...............	XX	86,262	XX	105,085	XX	[r] 114,885	XX	109,408
ILLINOIS								
Cement:								
Portland...............thousand 376-pound barrels..	9,790	$32,191	9,358	$30,622	9,203	$28,617	9,069	$30,186
Masonry...............thousand 280-pound barrels..	596	2,038	615	1,907	614	1,868	591	1,851
Clays [3]...............thousand short tons..	2,007	4,358	2,169	4,601	1,894	3,996	1,881	3,799
Coal (bituminous)...............do....	55,023	208,448	58,483	218,972	63,571	244,837	65,133	252,975
Fluorspar...............short tons..	127,454	6,452	159,140	7,861	176,175	8,002	210,207	9,859
Lead (recoverable content of ores, etc.)...............do....	2,180	571	3,005	938	2,285	691	2,384	668
Natural gas...............million cubic feet..	7,824	905	7,396	865	7,230	860	5,144	602
Natural gas liquids:								
Natural gasoline and cycle products...............thousand gallons..	14,109	1,030	W	W	W	W	W	W
LP gases...............do....	312,173	13,758	W	W	W	W	W	W
Peat...............short tons..	W	W	36,774	453	44,374	565	49,716	697
Petroleum (crude)...............thousand 42-gallon barrels..	70,168	205,592	63,708	186,664	[6] 61,982	[6] 185,947	[6] 60,115	[6] 181,581
Sand and gravel...............thousand short tons..	34,880	39,966	36,228	40,480	38,237	43,201	38,801	44,175
Stone...............do....	42,987	56,553	47,066	61,294	46,157	60,961	48,458	66,757
Zinc (recoverable content of ores, etc.)...............short tons..	13,800	3,754	18,314	5,348	15,192	4,406	20,416	5,652
Value of items that cannot be disclosed: Clay (fuller's earth), gem stones, lime, tripoli, and values indicated by symbol W...............	XX	15,520	XX	33,020	XX	34,362	XX	37,999
Total...............	XX	591,136	XX	593,025	XX	618,313	XX	636,801
INDIANA								
Abrasive stones...............short tons..	5	$16	5	$15	5	$15	5	$16
Cement [2]...............thousand 376-pound barrels..	15,038	48,695	14,925	48,797	15,305	49,826	15,924	53,123
Clays...............thousand short tons..	1,545	2,264	1,459	2,160	1,491	2,196	1,489	2,126

See footnotes at end of table.

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

Mineral	1964		1965		1966		1967	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
INDIANA—Continued								
Coal (bituminous) ---- thousand short tons	15,075	$57,246	15,565	$59,927	17,326	$67,857	18,772	$73,419
Natural gas ---- million cubic feet	199	47	239	56	215	51	198	46
Peat ---- short tons	66,568	543	53,873	511	38,111	456	42,962	441
Petroleum (crude) ---- thousand 42-gallon barrels	11,283	32,157	r 11,481	r 32,606	10,617	31,850	10,081	30,041
Sand and gravel ---- thousand short tons	24,416	21,811	24,867	22,220	24,992	23,542	26,265	25,588
Stone ---- do	22,318	39,978	24,574	42,124	24,323	42,474	26,977	46,725
Value of items that cannot be disclosed: Cement (masonry), gypsum, and lime (1966–67)	XX	9,026	XX	10,299	XX	11,743	XX	13,396
Total	XX	211,783	XX	r 218,715	XX	230,010	XX	244,921
IOWA								
Cement:								
Portland ---- thousand 376-pound barrels	13,607	$46,398	13,643	$46,273	14,058	$46,736	13,712	$45,394
Masonry ---- thousand 280-pound barrels	585	1,847	608	1,867	633	1,890	612	1,853
Clays ---- thousand short tons	1,008	1,254	1,085	1,347	1,130	1,438	1,208	1,643
Coal (bituminous) ---- do	973	3,447	1,043	3,694	1,025	3,783	883	3,227
Gypsum ---- do	1,287	5,821	1,254	5,554	1,285	5,577	1,219	5,186
Sand and gravel ---- do	13,890	13,546	18,205	17,152	19,644	18,213	17,734	16,564
Stone ---- do	23,935	33,038	25,891	35,468	27,729	40,081	26,133	37,912
Value of items that cannot be disclosed: Gem stones, lime, peat, and petroleum (1964)	XX	1,279	XX	1,428	XX	1,595	XX	1,443
Total	XX	106,630	XX	112,783	XX	119,313	XX	113,222
KANSAS								
Cement: [2]								
Portland ---- thousand 376-pound barrels	8,483	$25,959	8,801	$26,972	8,979	$27,246	8,833	$25,545
Masonry ---- thousand 280-pound barrels	384	1,173	404	1,178	395	1,151	350	1,000
Clays ---- thousand short tons	785	935	789	953	847	1,006	935	1,339
Coal (bituminous) ---- do	1,263	5,749	1,310	6,072	1,122	5,355	1,136	5,294
Helium: Crude ---- thousand cubic feet	2,170,512	24,941	2,551,026	29,518	2,624,200	30,951	2,719,700	32,554
Grade A ---- do	44,826	1,657	19,763	904	75,500	1,885	225,000	5,364
Lead (recoverable content of ores, etc.) ---- short tons	1,185	310	1,644	513	1,109	335	1,031	289
Natural gas ---- million cubic feet	764,073	96,031	793,379	105,519	847,495	114,412	871,971	116,844
Natural gas liquids:								
Natural gasoline ---- thousand gallons	162,725	8,713	153,485	7,791	175,053	9,399	194,173	10,703
LP gases ---- do	512,747	18,121	587,416	22,322	664,164	25,902	665,057	31,923
Petroleum (crude) ---- thousand 42-gallon barrels	106,252	310,256	104,733	305,820	103,738	306,027	99,200	297,600
Salt [9] ---- thousand short tons	930	11,799	1,053	12,376	969	13,388	1,069	14,686
Sand and gravel ---- do	12,968	9,108	12,544	8,473	11,627	8,374	12,066	8,650
Stone ---- do	14,138	18,912	15,270	20,538	14,027	18,789	13,551	17,806
Zinc (recoverable content of ores, etc.) ---- short tons	4,665	1,269	6,508	1,900	4,769	1,383	4,765	1,319

Value of items that cannot be disclosed: Natural cement, gypsum, pumice, and salt (brine)	XX	3,277	XX	2,642	XX	2,789	XX	3,152
Total	XX	538,210	XX	553,491	XX	568,392	XX	574,068
KENTUCKY								
Barite ... thousand short tons	6	$96	------	------	------	------	------	------
Clays [3] ... do	920	1,801	1,059	$2,580	1,152	$2,277	1,195	$2,066
Coal (bituminous) ... do	82,747	309,896	85,766	324,523	93,156	363,440	100,294	396,883
Fluorspar ... short tons	38,214	1,693	31,992	1,485	28,725	1,361	32,952	1,686
Lead (recoverable content of ores, etc.) ... do	858	225	756	236	484	146	845	237
Natural gas ... million cubic feet	76,940	18,257	78,976	18,638	76,536	18,139	89,168	21,400
Petroleum (crude) ... thousand 42-gallon barrels	19,772	56,746	19,386	55,638	18,066	51,488	15,535	45,052
Sand and gravel ... thousand short tons	6,560	6,297	6,742	6,332	8,064	7,524	7,981	7,859
Silver (recoverable content of ores, etc.) ... thousand troy ounces	2	2	2	2	1	1	1	1
Stone ... thousand short tons	[4] 21,868	[4] 29,594	26,029	34,533	22,667	31,179	24,812	35,481
Zinc (recoverable content of ores, etc.) ... short tons	2,063	561	5,654	1,651	6,586	1,910	6,317	1,749
Value of items that cannot be disclosed: Native asphalt (1966–67), cement, ball clay, natural gas liquids, and stone (dimension sandstone 1964)	XX	19,211	XX	20,763	XX	20,899	XX	23,291
Total	XX	444,379	XX	466,381	XX	498,364	XX	535,705
LOUISIANA								
Clays ... thousand short tons	780	$797	909	$936	1,005	$983	995	$1,260
Lime ... do	725	8,312	842	9,980	835	9,274	758	9,891
Natural gas ... million cubic feet	4,152,731	793,328	4,466,786	812,955	5,081,435	929,902	5,716,857	1,057,619
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	1,352,980	91,931	1,431,836	102,731	1,562,075	113,802	1,754,603	130,212
LP gases ... do	1,247,484	45,935	1,300,038	46,101	1,469,716	72,016	1,844,689	92,234
Petroleum (crude) ... thousand 42-gallon barrels	549,698	1,709,622	594,853	1,841,714	674,318	2,097,129	774,527	2,419,823
Salt ... thousand short tons	6,401	36,056	8,126	41,812	8,736	44,189	9,585	48,483
Sand and gravel ... do	13,594	15,253	14,298	16,405	18,216	22,504	20,312	27,442
Stone [4] ... do	5,459	7,228	7,452	10,905	8,091	11,253	7,599	11,174
Sulfur (Frasch process) ... thousand long tons	2,733	54,996	3,577	81,372	4,018	104,472	4,233	139,739
Value of items that cannot be disclosed: Cement, gypsum, and stone (crushed miscellaneous)	XX	21,549	XX	23,350	XX	24,616	XX	23,873
Total	XX	2,785,007	XX	2,988,261	XX	3,430,140	XX	3,961,750
MAINE								
Clays ... thousand short tons	45	$58	49	$63	45	$58	42	$54
Gem stones	NA	35	NA	35	NA	35	NA	35
Peat ... short tons	6,350	171	1,275	56	1,600	60	W	W
Sand and gravel ... thousand short tons	13,552	6,463	17,294	7,831	15,036	7,027	11,627	5,368
Stone ... do	1,414	4,506	1,100	3,409	1,092	3,622	1,159	2,999
Value of items that cannot be disclosed: Cement, feldspar, and values indicated by symbol W	XX	6,341	XX	6,347	XX	5,932	XX	6,426
Total	XX	17,574	XX	17,741	XX	16,734	XX	14,882

See footnotes at end of table.

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

Mineral	1964 Quantity	1964 Value (thousands)	1965 Quantity	1965 Value (thousands)	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 value (thousands)
MARYLAND								
Clays ... thousand short tons	[3] 635	[3] $798	[3] 914	[3] $1,088	[3] 856	[3] $1,084	998	$1,462
Coal (bituminous) ... do	1,136	4,511	1,210	4,389	1,222	4,367	1,305	4,548
Gem stones	NA	3	NA	3	NA	3	NA	3
Lime ... thousand short tons	W	W	37	481	29	386	W	W
Natural gas ... million cubic feet	1,373	366	408	103	696	181	621	159
Sand and gravel ... thousand short tons	15,041	18,071	16,200	21,188	15,108	20,383	12,868	17,724
Stone ... do	13,348	26,715	14,553	28,432	13,868	27,229	14,479	28,581
Value of items that cannot be disclosed: Cement, ball clay (1964–66), greensand marl, peat, potassium salts, talc and soapstone, and values indicated by symbol W	XX	23,429	XX	22,311	XX	20,528	XX	20,342
Total	XX	73,893	XX	77,995	XX	74,161	XX	72,819
MASSACHUSETTS								
Clays ... thousand short tons	138	$174	181	$238	202	$260	W	W
Gem stones	NA	2	NA	2	NA	2	NA	$2
Lime ... thousand short tons	171	2,703	170	2,779	182	2,712	195	3,044
Sand and gravel ... do	21,341	16,794	22,141	16,172	17,321	17,846	17,881	19,504
Stone ... do	6,519	16,663	6,168	16,980	6,424	17,624	6,203	17,724
Value of items that cannot be disclosed: Nonmetals and value indicated by symbol W	XX	31	XX	27	XX	29	XX	338
Total	XX	36,367	XX	36,198	XX	38,473	XX	40,612
MICHIGAN								
Cement:								
Portland ... thousand 376-pound barrels	26,745	$84,316	27,565	$86,996	28,171	$87,413	29,645	$94,515
Masonry ... thousand 280-pound barrels	1,865	4,954	2,108	5,373	2,032	5,221	1,995	5,296
Clays ... thousand short tons	2,385	2,592	2,402	2,580	2,450	2,620	2,466	2,636
Copper (recoverable content of ores, etc.) ... short tons	69,040	45,014	71,749	50,798	73,449	53,133	58,458	44,692
Gypsum ... thousand short tons	1,421	5,263	1,338	5,027	1,522	5,489	1,422	5,085
Iron ore (usable) ... thousand long tons, gross weight	13,871	143,979	13,527	145,482	14,377	157,377	14,130	162,610
Lime ... thousand short tons	1,430	19,246	1,095	13,057	1,701	20,016	1,787	21,582
Magnesium compounds from sea water and brine (except for metal) short tons, MgO equivalent	306,494	23,385	319,389	26,143	342,482	28,105	309,446	26,388
Natural gas ... million cubic feet	31,388	7,984	34,558	8,674	34,120	8,598	33,589	8,296
Natural gas liquids:								
Natural gasoline ... thousand gallons	W	W	9,054	607	15,703	1,099	47,817	3,491
LP gases ... do	W	W	76,299	3,815	79,719	4,385	59,390	3,444
Peat ... short tons	269,074	2,412	230,950	2,134	235,842	2,175	237,107	2,292
Petroleum (crude) ... thousand 42-gallon barrels	15,601	43,839	14,728	41,091	14,273	40,913	13,664	39,455
Salt ... thousand short tons	4,345	35,711	4,171	36,087	4,465	38,611	4,789	42,389
Sand and gravel ... do	51,921	44,405	53,168	47,176	55,123	49,521	52,310	49,616
Silver (recoverable content of ores, etc.) ... thousand troy ounces	349	452	458	592	483	625	302	468

Stone ---- thousand short tons	34,650	37,002	34,713	36,438	37,864	40,380	36,432	39,910
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, gem stones, iodine, potassium salts, and values indicated by symbol W	XX	54,278	XX	53,490	XX	56,446	XX	58,039
Total	XX	554,832	XX	565,560	XX	602,127	XX	610,204
MINNESOTA								
Clays [3] ---- thousand short tons	213	$319	207	$311	224	$336	228	$342
Iron ore (usable) ---- thousand long tons, gross weight	49,626	449,289	50,873	459,290	55,133	499,388	49,457	468,623
Manganiferous ore (5 to 35 percent Mn) ---- short tons, gross weight	188,481	W	280,705	W	275,581	W	236,753	W
Peat ---- short tons	19,188	405	7,346	123	11,366	197	13,968	257
Sand and gravel ---- thousand short tons	35,817	25,907	37,545	27,296	39,331	28,972	41,212	33,132
Stone ---- do	3,588	12,297	4,371	11,680	4,901	11,688	4,160	11,442
Value of items that cannot be disclosed: Abrasive stones, cement, fire clay, gem stones, lime, and values indicated by symbol W	XX	9,278	XX	9,060	XX	9,696	XX	9,530
Total	XX	497,495	XX	507,760	XX	550,277	XX	523,326
MISSISSIPPI								
Clays ---- thousand short tons	1,331	$6,130	1,502	$6,997	1,727	$7,489	1,654	$7,852
Natural gas ---- million cubic feet	180,428	31,385	166,825	28,861	156,652	27,257	139,497	24,133
Natural gas liquids:								
Natural gasoline and cycle products ---- thousand gallons	27,485	1,644	26,582	1,606	23,765	1,483	17,939	1,167
LP gases ---- do	23,277	780	22,150	975	18,621	987	17,794	1,085
Petroleum (crude) ---- thousand 42-gallon barrels	56,777	151,595	56,183	148,437	55,227	146,353	57,147	155,726
Sand and gravel ---- thousand short tons	7,825	8,569	8,447	8,717	12,675	13,563	14,039	15,485
Stone ---- do	1,553	1,557	[4] 2,357	[4] 2,358	[4] 1,532	[4] 1,641	1,879	2,055
Value of items that cannot be disclosed: Cement, iron ore (1965–67), lime, magnesium compounds, and stone (dimension sandstone 1965–66)	XX	10,533	XX	12,082	XX	12,587	XX	9,507
Total	XX	212,193	XX	210,033	XX	211,360	XX	217,010
MISSOURI								
Asphalt, native ---- short tons	1,522	$13	W	W	W	W	W	W
Barite ---- thousand short tons	267	3,451	329	$4,219	337	$4,280	332	$4,444
Cement:								
Portland ---- thousand 376-pound barrels	12,378	42,618	13,334	46,034	13,848	46,228	15,044	52,119
Masonry ---- thousand 280-pound barrels	334	1,046	377	1,173	382	1,075	372	1,172
Clays ---- thousand short tons	1,966	4,874	2,226	5,439	2,329	5,989	2,305	6,220
Coal (bituminous) ---- do	3,254	13,285	3,564	14,779	3,582	14,834	3,696	15,573
Copper (recoverable content of ores, etc.) ---- short tons	2,059	1,343	2,331	1,650	3,913	2,831	3,215	2,458
Iron ore (usable) ---- thousand long tons, gross weight	1,116	14,907	1,784	24,607	1,887	26,450	1,871	26,673
Lead (recoverable content of ores, etc.) ---- short tons	120,148	31,479	133,521	41,659	132,255	39,981	152,649	42,742
Lime ---- thousand short tons	1,219	14,328	1,442	16,782	1,494	17,910	1,434	16,371
Natural gas ---- million cubic feet	107	26	84	21	--------	--------	121	30
Petroleum (crude) ---- thousand 42-gallon barrels	65	163	73	W	97	W	75	W
Sand and gravel ---- thousand short tons	11,483	13,380	12,068	13,735	10,702	13,540	9,716	12,556
Silver (recoverable content of ores, etc.) ---- thousand troy ounces	--------	--------	300	387	--------	--------	--------	--------
Stone ---- thousand short tons	31,487	47,984	36,247	53,574	35,240	53,393	36,585	53,953

See footnotes at end of table.

Table 5.—Mineral production in the United States, by States—Continued

Mineral	1964 Quantity	1964 Value (thousands)	1965 Quantity	1965 Value (thousands)	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
MISSOURI—Continued								
Zinc (recoverable content of ores, etc.) ... short tons	1,501	$408	4,312	$1,259	3,968	$1,151	7,430	$2,057
Value of items that cannot be disclosed: Tripoli (1965), and values indicated by symbol W	XX	---------	XX	250	XX	288	XX	291
Total	XX	189,305	XX	225,568	XX	227,950	XX	236,659
MONTANA								
Clays [3] ... thousand short tons	49	$59	76	$98	53	$56	46	$50
Coal (bituminous and lignite) ... do	346	925	364	1,050	419	1,290	371	996
Copper (recoverable content of ores, etc.) ... short tons	103,806	67,682	115,489	81,766	128,061	92,639	65,483	50,063
Gem stones	NA	W	NA	77	NA	109	NA	109
Gold (recoverable content of ores, etc.) ... troy ounces	29,115	1,019	22,772	797	25,009	875	9,786	343
Iron ore (usable) ... thousand long tons, gross weight	15	99	9	71	12	93	10	81
Lead (recoverable content of ores, etc.) ... short tons	4,538	1,189	6,981	2,178	4,409	1,333	898	251
Lime ... thousand short tons	136	1,385	159	1,512	225	2,116	143	1,765
Manganese ore (35 percent or more Mn) ... short tons, gross weight	20,264	W	23,621	W	W	W	W	W
Manganiferous ore (5 to 35 percent Mn) ... do	3,638	W	1,968	W	1,755	28	2,763	16
Natural gas ... million cubic feet	25,051	1,965	28,105	2,305	30,685	2,547	25,866	2,173
Petroleum (crude) ... thousand 42-gallon barrels	30,647	74,621	32,778	79,624	35,380	86,273	34,959	87,543
Pumice ... thousand short tons	W	W	---------	---------	22	5	---------	---------
Sand and gravel ... do	16,017	17,840	12,048	13,587	13,816	13,523	12,339	10,655
Silver (recoverable content of ores, etc.) ... thousand troy ounces	5,290	6,840	5,207	6,733	5,320	6,878	2,066	3,203
Stone ... thousand short tons	7,345	8,477	5,512	5,971	4,150	5,212	4,782	6,037
Zinc (recoverable content of ores, etc.) ... short tons	29,059	7,904	33,786	9,866	29,120	8,445	3,341	925
Value of items that cannot be disclosed: Antimony (1966–67), barite (1964–66), cement, clays (fire clay 1964, bentonite), fluorspar, gypsum, natural gas liquids, peat, phosphate rock, talc, tungsten (1966–67), uranium ore (1964, 1966), vermiculite, and values indicated by symbol W	XX	r 21,448	XX	22,528	XX	23,846	XX	22,314
Total	XX	r 211,453	XX	228,163	XX	245,268	XX	186,524
NEBRASKA								
Clays ... thousand short tons	143	$143	141	$141	153	$153	126	$142
Gem stones	NA	5	NA	5	NA	5	NA	5
Natural gas ... million cubic feet	11,094	1,707	10,720	1,565	10,196	1,621	8,453	1,454
Natural gas liquids:								
Natural gasoline ... thousand gallons	9,587	627	7,822	516	9,195	653	7,805	578
LP gases ... do	24,556	1,092	16,946	847	19,670	1,141	20,738	1,223
Petroleum (crude) ... thousand 42-gallon barrels	19,113	51,605	17,216	45,796	13,850	37,673	13,373	36,775
Sand and gravel ... thousand short tons	14,641	15,748	11,993	13,697	13,539	14,179	11,739	10,878
Stone ... do	3,779	6,417	4,198	6,637	5,055	7,916	4,846	7,483
Value of items that cannot be disclosed: Cement, lime, and pumice	XX	14,615	XX	14,622	XX	15,180	XX	12,330
Total	XX	91,959	XX	r 83,826	XX	78,521	XX	70,868

NEVADA								
Antimony ore and concentrate ---- short tons, antimony content	33	$20	26	$19	68	$63	53	$35
Barite ---- thousand short tons	149	1,261	91	583	139	933	154	923
Copper (recoverable content of ores, etc.) ---- short tons	67,272	43,861	71,332	50,503	78,720	56,946	50,771	38,815
Gem stones	NA	100	NA	100	NA	100	NA	100
Gold (recoverable content of ores, etc.) ---- troy ounces	90,469	3,166	229,050	8,017	366,903	12,842	434,993	15,225
Gypsum ---- thousand short tons	799	2,894	710	2,518	594	2,023	409	1,412
Iron ore (usable) ---- thousand long tons, gross weight	911	5,048	1,141	5,330	1,000	4,931	641	2,858
Lead (recoverable content of ores, etc.) ---- short tons	809	212	2,277	710	3,581	1,083	1,500	420
Mercury ---- 76-pound flasks	3,262	1,027	3,333	1,902	3,355	1,482	4,703	2,301
Perlite ---- short tons	15,603	135	13,780	121	W	W	10,712	94
Petroleum (crude) ---- thousand 42-gallon barrels	255	W	209	W	307	W	279	W
Pumice ---- thousand short tons	W	W	68	187	55	190	105	236
Sand and gravel ---- do	14,142	14,427	9,455	11,796	9,085	9,134	10,166	8,644
Silver (recoverable content of ores, etc.) ---- thousand troy ounces	172	223	507	656	867	1,122	566	877
Stone ---- thousand short tons	788	1,396	1,248	2,247	2,002	2,519	1,375	2,145
Sulfur ore ---- long tons	274	5	336	6	--------	--------	--------	--------
Talc and soapstone ---- short tons	5,322	58	3,592	31	4,715	24	2,096	17
Zinc (recoverable content of ores, etc.) ---- do	582	158	3,858	1,127	5,827	1,690	3,035	840
Value of items that cannot be disclosed: Brucite (1965–67), cement (1965–67), clays, diatomite, fluorspar, lime, lithium minerals (1966–67), magnesite, molybdenum, peat, salt, tungsten, uranium (1964–66), and values indicated by symbol W	XX	[r] 11,152	XX	[r] 14,142	XX	[r] 17,555	XX	15,941
Total	XX	[r] 85,143	XX	[r] 99,995	XX	[r] 112,637	XX	90,883
NEW HAMPSHIRE								
Clays ---- thousand short tons	46	$40	53	$47	51	$51	42	$42
Mica, sheet ---- pounds	--------	--------	--------	--------	--------	--------	16,000	W
Peat ---- short tons	--------	--------	--------	--------	175	2	50	(5)
Sand and gravel ---- thousand short tons	8,768	4,996	10,584	5,559	7,626	4,807	8,449	5,137
Stone ---- do	202	2,138	153	1,932	206	2,091	473	2,887
Value of items that cannot be disclosed: Other nonmetals	XX	128	XX	127	XX	49	XX	51
Total	XX	7,302	XX	7,665	XX	7,000	XX	8,117
NEW JERSEY								
Clays ---- thousand short tons	500	$1,441	506	$1,388	488	$1,319	437	$1,189
Gem stones	NA	10	NA	10	NA	10	NA	10
Peat ---- short tons	W	W	40,480	431	36,312	489	43,045	542
Sand and gravel ---- thousand short tons	17,661	27,079	17,389	28,646	17,782	29,322	18,626	29,975
Stone ---- do	12,326	28,461	12,232	27,247	12,453	28,056	12,611	28,253
Zinc (recoverable content of ores, etc.)[9] ---- short tons	32,926	8,935	38,297	11,106	25,237	7,319	26,041	7,031
Value of items that cannot be disclosed: Iron ore, lime, magnesium compounds, manganiferous residuum, greensand marl, titanium concentrate, and values indicated by symbol W	XX	12,246	XX	11,330	XX	9,080	XX	5,747
Total	XX	78,172	XX	80,158	XX	75,595	XX	72,747

See footnotes at end of table.

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

Mineral	1964 Quantity	1964 Value (thousands)	1965 Quantity	1965 Value (thousands)	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
NEW MEXICO								
Barite ... thousand short tons	W	W	([5])	$2	-----	-----	-----	-----
Carbon dioxide, natural ... thousand cubic feet	816,168	$61	833,819	62	795,885	$58	771,516	$57
Clays ... thousand short tons	[3] 104	[3] 167	60	101	W	W	46	74
Coal (bituminous) ... do	2,969	9,763	3,212	10,710	2,755	9,110	3,463	12,641
Copper (recoverable content of ores, etc.) ... short tons	86,104	56,140	98,658	69,850	108,614	78,571	75,008	57,345
Fluorspar ... do	137	3	-----	-----	-----	-----	W	W
Gem stones	NA	45	NA	45	NA	45	NA	60
Gold (recoverable content of ores, etc.) ... troy ounces	6,110	214	9,641	337	9,295	325	5,188	182
Gypsum ... thousand short tons	W	W	W	W	146	545	155	588
Helium, grade A ... thousand cubic feet	82,105	2,958	80,583	r 2,821	95,900	3,357	71,200	2,492
Lead (recoverable content of ores, etc.) ... short tons	1,626	426	3,387	1,057	1,596	482	1,827	512
Lime ... thousand short tons	25	352	33	465	34	472	17	243
Manganese ore (35 percent or more Mn) ... short tons, gross weight	5,794	149	5,637	156	W	W	W	W
Manganiferous ore (5 to 35 percent Mn) ... do	46,657	300	50,090	328	47,590	324	49,323	348
Mica: Scrap ... short tons	6,922	105	4,263	45	W	W	W	W
Natural gas ... million cubic feet	873,947	101,932	937,205	110,590	998,076	124,760	1,067,510	138,776
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	356,047	21,570	358,487	20,824	338,732	19,736	338,114	20,730
LP gases ... do	739,190	21,641	759,311	25,817	816,202	31,832	909,168	40,003
Perlite ... short tons	286,329	2,568	331,011	2,905	343,334	3,423	346,586	3,424
Petroleum (crude) ... thousand 42-gallon barrels	113,863	326,565	119,166	334,977	124,154	352,101	126,144	368,340
Potassium salts ... thousand short tons, K_2O equivalent	2,675	104,861	2,848	117,771	2,953	108,653	2,883	91,098
Pumice ... thousand short tons	260	760	264	915	245	787	220	639
Salt ... do	62	559	64	572	66	716	82	1,036
Sand and gravel ... do	8,781	10,160	11,763	12,130	15,503	13,029	14,672	14,336
Silver (recoverable content of ores, etc.) ... thousand troy ounces	242	313	288	372	243	314	157	244
Stone ... thousand short tons	2,760	4,244	1,911	3,020	2,652	4,056	1,391	2,403
Uranium (recoverable content U_3O_8) ... thousand pounds	W	W	W	W	9,340	74,721	11,202	89,615
Vanadium (recoverable in ore and concentrate) ... short tons	W	154	W	221	W	53	W	W
Zinc (recoverable content of ores, etc.) ... do	29,833	8,115	36,460	10,646	29,296	8,496	21,380	5,919
Value of items that cannot be disclosed: Cement, fire clay (1964), iron ore, molybdenum, tin (1964–66), and values indicated by symbol W	XX	r 80,196	XX	r 79,936	XX	20,328	XX	23,001
Total	XX	r 754,321	XX	r 806,675	XX	r 856,294	XX	874,106
NEW YORK								
Clays ... thousand short tons	1,499	$1,993	1,354	$1,717	1,464	$1,726	1,506	1,814
Emery ... short tons	9,214	172	10,720	204	11,102	210	W	W
Gem stones	NA	10	NA	10	NA	10	NA	10
Gypsum ... thousand short tons	653	3,321	662	3,511	559	2,998	570	3,118
Lead (recoverable content of ores, etc.) ... short tons	732	192	601	188	1,097	332	1,653	463
Lime ... thousand short tons	W	W	W	W	1,096	9,870	1,139	10,570
Natural gas ... million cubic feet	3,108	963	3,340	1,029	2,699	837	3,837	1,201
Peat ... short tons	32,574	261	25,098	232	27,211	250	23,053	232

Petroleum (crude) thousand 42-gallon barrels	1,874	8,321	1,632	7,246	1,735	7,925	1,972	9,026
Salt thousand short tons	4,816	34,216	5,002	35,771	4,980	36,203	5,320	41,568
Sand and gravel do	39,282	38,583	39,225	40,370	41,903	43,091	43,500	44,499
Silver (recoverable content of ores, etc.) thousand troy ounces	13	17	11	15	22	28	31	48
Stone thousand short tons	29,141	46,669	30,801	48,675	34,130	54,543	33,389	56,615
Zinc (recoverable content of ores, etc.) short tons	60,754	16,525	69,880	20,405	73,454	21,302	70,555	19,534
Value of items that cannot be disclosed: Cement, abrasive garnet, iron ore, talc, titanium concentrate, wollastonite, and values indicated by symbol W	XX	137,202	XX	130,684	XX	[r] 121,482	XX	110,620
Total	XX	288,445	XX	290,057	XX	[r] 300,807	XX	299,318
NORTH CAROLINA								
Barite thousand short tons	-------	-------	-------	-------	-------	-------	1	6
Clays [3] do	3,199	$2,064	3,383	$2,162	3,381	$2,241	2,977	2,012
Feldspar long tons	[r] 281,449	[r] 2,342	278,990	3,153	301,610	3,157	265,690	3,113
Gem stones	NA	15	NA	15	NA	15	NA	25
Mica:								
Scrap short tons	64,010	2,027	72,199	1,987	63,480	2,348	69,639	1,751
Sheet pounds	242,662	58	713,293	185	4,500	1	4,500	W
Phosphate rock thousand short tons	7	41	-------	-------	W	W	W	W
Sand and gravel do	11,150	10,404	10,499	10,076	11,601	11,132	10,014	9,962
Stone do	[4] 17,943	[4] 30,378	[4] 18,835	[4] 30,920	[4] 22,377	[4] 36,136	24,507	41,488
Talc and pyrophyllite short tons	106,035	495	109,721	556	113,366	576	109,393	513
Value of items that cannot be disclosed: Asbestos, cement, clay (kaolin), lithium minerals, olivine, stone (crushed and dimension marble and dimension slate 1964–66), tungsten concentrate (1964), and values indicated by symbol W	XX	7,903	XX	11,329	XX	16,272	XX	18,224
Total	XX	55,727	XX	60,383	XX	71,878	XX	77,094
NORTH DAKOTA								
Clays thousand short tons	85	$119	81	$114	[r] 76	$100	W	W
Coal (lignite) do	2,637	5,659	2,732	5,848	3,543	6,976	4,156	$7,967
Gem stones	NA	1	NA	1	NA	1	NA	1
Natural gas million cubic feet	34,512	7,634	35,652	5,704	46,585	7,547	40,462	6,636
Natural gas liquids:								
Natural gasoline thousand gallons	21,368	1,338	21,059	1,263	23,200	1,415	23,284	1,443
LP gases do	84,338	2,960	85,174	3,066	91,884	3,859	88,665	3,901
Petroleum (crude) thousand 42-gallon barrels	25,731	63,813	26,350	65,875	27,126	69,170	25,315	65,818
Sand and gravel thousand short tons	10,520	10,142	7,574	7,895	10,145	10,568	8,822	9,118
Stone do	31	56	356	624	170	305	596	1,092
Value of items that cannot be disclosed: Lime (1965–67), molybdenum, peat, salt, uranium, vanadium (1965), and values indicated by symbol W	XX	[r] 1,336	XX	[r] 3,403	XX	[r] 2,327	XX	1,562
Total	XX	[r] 93,058	XX	[r] 93,793	XX	[r] 102,268	XX	97,538

See footnotes at end of table.

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

Mineral	1964 Quantity	1964 Value (thousands)	1965 Quantity	1965 Value (thousands)	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
OHIO								
Cement:								
Portland ... thousand 376-pound barrels	15,553	$50,647	14,786	$47,499	15,181	$48,740	14,726	$46,860
Masonry ... thousand 280-pound barrels	1,068	3,127	1,050	3,004	976	2,785	946	2,730
Clays ... thousand short tons	5,005	14,426	5,070	14,816	5,089	14,522	4,670	15,185
Coal (bituminous) ... do	37,310	137,776	39,390	146,028	43,341	164,444	46,014	176,921
Gem stones	NA	3	NA	3	NA	3	NA	3
Lime ... thousand short tons	3,664	53,308	3,831	53,208	3,858	50,997	3,636	48,817
Natural gas ... million cubic feet	37,106	8,880	35,684	8,421	43,133	10,223	41,315	9,957
Peat ... short tons	6,363	83	5,352	80	5,214	84	7,301	100
Petroleum (crude) ... thousand 42-gallon barrels	15,859	46,420	12,908	37,940	10,899	32,700	9,924	31,427
Salt ... thousand short tons	4,537	31,092	5,026	34,816	5,138	35,735	5,407	39,549
Sand and gravel ... do	37,771	45,567	40,852	49,305	43,851	52,909	43,196	52,888
Stone ... do	[4] 37,715	[4] 61,814	42,263	66,969	45,002	72,900	45,458	72,534
Value of items that cannot be disclosed: Abrasive stone, gypsum, stone (calcareous marl 1964)	XX	1,794	XX	2,163	XX	1,998	XX	1,917
Total	XX	454,937	XX	464,252	XX	488,040	XX	498,888
OKLAHOMA								
Clays [3] ... thousand short tons	835	$854	794	$806	745	$754	744	$869
Coal (bituminous) ... do	1,028	5,474	974	5,520	843	4,935	823	4,703
Gypsum ... do	694	1,899	761	2,343	785	2,212	804	2,266
Helium, grade A ... thousand cubic feet	298,803	8,591	310,700	10,874	352,400	12,333	309,100	9,835
Lead (recoverable content of ores, etc.) ... short tons	2,781	729	2,813	878	2,999	907	2,727	764
Natural gas ... million cubic feet	1,316,201	166,747	1,320,995	182,297	1,351,225	189,172	1,412,952	202,052
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	554,053	34,011	570,129	34,561	576,124	35,715	568,905	35,846
LP gases ... do	880,804	28,055	894,665	32,208	986,254	44,381	1,005,633	49,276
Petroleum (crude) ... thousand 42-gallon barrels	202,524	587,320	203,441	587,944	224,839	654,281	230,749	676,095
Salt ... thousand short tons	6	41	9	65	W	W	10	76
Sand and gravel ... do	6,680	7,003	5,218	6,023	6,040	7,565	4,540	5,280
Stone ... do	13,987	15,087	16,417	18,071	15,334	17,393	16,355	18,932
Zinc (recoverable content of ores, etc.) ... short tons	12,159	3,307	12,715	3,713	11,237	3,259	10,670	2,954
Value of items that cannot be disclosed: Clay (bentonite), cement, copper (1965–67), lime, pumice, silver (1965–67), tripoli, and values indicated by symbol W	XX	22,670	XX	23,953	XX	24,484	XX	23,178
Total	XX	881,788	XX	909,256	XX	997,391	XX	1,032,126
OREGON								
Clays ... thousand short tons	290	$356	291	$359	361	$362	[3] 295	[3] $295
Copper (recoverable content of ores, etc.) ... short tons	15	10	W	W	W	W	---	---
Diatomite ... do	W	W	W	W	W	W	108	2

Gem stones	NA	W	NA	750	NA	750	NA	750
Gold (recoverable content of ores, etc.) troy ounces	661	23	499	17	281	10	186	7
Lime thousand short tons	95	1,918	98	1,853	116	2,283	99	2,059
Mercury 76-pound flasks	126	40	1,364	779	700	309	943	461
Nickel (content of ore and concentrate) short tons	15,420	W	16,188	W	15,036	W	15,287	W
Peat do	---	---	---	---	900	17	W	W
Perlite do	5	(5)	---	---	W	W	8	(5)
Pumice thousand short tons	566	909	657	1,181	714	1,256	834	1,195
Sand and gravel do	18,253	25,158	21,800	32,849	35,327	34,986	19,630	25,250
Silver (recoverable content of ores, etc.) thousand troy ounces	14	19	9	11	(5)	(5)	(5)	(5)
Stone thousand short tons	16,120	19,296	21,212	27,301	33,288	48,335	13,201	20,256
Tungsten concentrate short tons, 60-percent WO_3 basis	1	1	---	---	---	---	---	---
Value of items that cannot be disclosed: Cement, clay (fire clay 1967), iron ore (pigment material 1965–66), lead (1964–65), talc (1967), uranium (1964), vanadium (1964), zinc (1964–65), and values indicated by symbol W	XX	r 16,634	XX	r 17,866	XX	19,176	XX	16,285
Total	XX	r 64,364	XX	82,966	XX	107,484	XX	66,560

PENNSYLVANIA

Cement:								
Portland thousand 376-pound barrels	37,663	$113,409	40,153	$116,925	40,004	$114,357	40,197	$114,592
Masonry thousand 280-pound barrels	2,818	7,594	3,006	7,991	2,960	7,860	2,929	7,948
Clays [3] thousand short tons	3,187	15,814	3,394	17,697	3,293	17,033	2,994	16,703
Coal:								
Anthracite do	17,184	148,648	14,866	122,021	12,941	100,663	12,256	96,160
Bituminous do	76,531	388,218	80,308	407,267	81,443	425,168	79,412	419,345
Copper (recoverable content of ores, etc.) short tons	3,614	2,356	4,354	3,083	3,178	2,299	4,401	3,365
Gem stones	NA	4	NA	4	NA	4	NA	4
Lime thousand short tons	1,440	20,656	1,568	22,496	1,585	22,816	1,719	24,715
Natural gas million cubic feet	81,720	22,349	84,461	22,551	90,914	25,820	89,966	25,280
Natural gas liquids:								
Natural gasoline thousand gallons	1,138	64	1,022	55	3,211	186	1,167	77
LP gases do	1,481	100	1,683	109	1,863	121	1,757	114
Peat short tons	39,500	397	45,600	527	52,912	562	39,505	437
Petroleum (crude) thousand 42-gallon barrels	5,113	22,088	4,922	21,263	4,337	19,300	4,387	19,701
Sand and gravel thousand short tons	16,199	26,414	18,502	29,606	17,567	29,562	17,479	29,614
Stone do	52,829	91,075	56,806	99,627	59,088	99,233	60,155	103,157
Zinc (recoverable content of ores, etc.)[9] short tons	30,754	8,345	27,635	8,014	28,080	8,143	35,067	9,468
Value of items that cannot be disclosed: Clays (kaolin), cobalt, gold, iron ore, scrap mica, pyrites, pyrophyllite, silver, and tripoli	XX	34,519	XX	34,587	XX	30,281	XX	27,718
Total	XX	902,050	XX	913,823	XX	903,408	XX	898,398

RHODE ISLAND

Sand and gravel thousand short tons	1,647	$1,613	1,681	$1,811	2,276	$2,212	2,334	2,416
Stone do	450	935	437	1,119	535	1,734	481	1,618
Value of items that cannot be disclosed: Other nonmetals	XX	1	XX	1	XX	1	XX	1
Total	XX	2,549	XX	2,931	XX	3,947	XX	4,035

See footnotes at end of table.

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

Mineral	1964 Quantity	1964 Value (thousands)	1965 Quantity	1965 Value (thousands)	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
SOUTH CAROLINA								
Clays ---- thousand short tons	1,743	$8,309	1,837	$8,539	2,139	$8,830	1,733	8,048
Sand and gravel ---- do	4,622	5,262	5,248	6,638	6,016	7,668	5,248	7,178
Stone ---- do	[4] 6,109	[4] 9,176	[4] 5,948	[4] 8,447	8,129	12,510	[4] 8,310	[4] 12,366
Value of items that cannot be disclosed: Barite (1964–66), cement, feldspar, kyanite, scrap mica, peat, pyrites, stone (crushed limestone 1964–65 and dimension granite 1965, 1967), and vermiculite	XX	15,966	XX	17,587	XX	16,585	XX	20,682
Total	XX	38,713	XX	41,261	XX	45,593	XX	48,274
SOUTH DAKOTA								
Beryllium concentrate ---- short tons, gross weight	W	W	W	W	124	$40	W	W
Cement:								
Portland ---- thousand 376-pound barrels	2,001	$6,873	1,575	$5,127	1,974	6,367	1,406	$4,815
Masonry ---- thousand 280-pound barrels	57	200	55	180	51	170	54	178
Clays ---- thousand short tons	245	1,076	223	1,220	231	870	199	799
Coal (lignite) ---- do	13	63	10	49	10	45	5	27
Feldspar ---- long tons	26,980	180	51,560	346	[r] 53,810	[r] 369	61,411	420
Gem stones	NA	20	NA	20	NA	20	NA	30
Gold (recoverable content of ores, etc.) ---- troy ounces	616,913	21,592	628,259	21,989	606,467	21,226	601,785	21,062
Gypsum ---- thousand short tons	19	76	7	27	17	68	12	49
Lithium minerals ---- short tons	W	W	150	[e] 5	W	W	W	W
Mica: Scrap ---- do	996	32	W	W	W	W	W	W
Petroleum (crude) ---- thousand 42-gallon barrels	247	495	219	438	239	479	211	502
Sand and gravel ---- thousand short tons	13,770	13,641	13,998	14,155	13,630	13,585	13,463	13,737
Silver (recoverable content of ores, etc.) ---- thousand troy ounces	133	172	129	167	110	142	121	188
Stone ---- thousand short tons	2,118	6,245	1,554	5,387	2,186	7,995	1,866	9,694
Value of items that cannot be disclosed: Columbium-tantalum concentrates (1967), lime, molybdenum, tin (1966), uranium, vanadium, and values indicated by symbol W	XX	[r] 3,882	XX	[r] 1,553	XX	[r] 1,796	XX	1,117
Total	XX	[r] 54,547	XX	[r] 50,663	XX	[r] 53,172	XX	52,618
TENNESSEE								
Barite ---- thousand short tons	39	$519	31	$442	29	$412	15	$235
Cement:								
Portland ---- thousand 376-pound barrels	8,343	26,791	8,724	27,535	8,177	25,718	8,062	25,548
Masonry ---- thousand 280-pound barrels	1,212	3,228	1,185	3,140	1,095	2,822	1,092	2,992
Clays ---- thousand short tons	[3] 1,310	[3] 5,576	1,495	6,103	[3] 1,359	[3] 4,909	1,574	5,152
Coal (bituminous) ---- do	5,990	22,674	5,865	20,930	6,309	23,763	6,832	26,974
Copper (recoverable content of ores, etc.) ---- short tons	13,889	9,056	14,823	10,495	15,410	11,148	14,600	11,162
Gold (recoverable content of ores, etc.) ---- troy ounces	133	5	122	4	141	5	181	6
Lead (recoverable content of ores, etc.) ---- short tons	----	----	----	----	181	55	----	----
Natural gas ---- million cubic feet	77	15	85	16	----	----	58	11

Petroleum (crude)....thousand 42-gallon barrels..	10	W	11	W	7	W	7	W
Phosphate rock....thousand short tons..	2,734	18,971	2,954	22,296	3,125	23,886	2,992	22,571
Sand and gravel....do....	7,972	10,245	8,193	10,690	8,628	11,142	7,975	10,679
Silver (recoverable content of ores, etc.)....thousand troy ounces..	91	117	94	122	101	130	130	202
Stone [4]....thousand short tons..	26,497	38,239	28,888	38,859	31,260	41,432	31,463	41,958
Zinc (recoverable content of ores, etc.)....short tons..	115,943	31,536	122,387	35,737	103,117	29,904	113,065	31,303
Value of items that cannot be disclosed: Clay (fuller's earth) (1964, 1966–67), lime, pyrites, stone (crushed sandstone, dimension sandstone 1967), and values indicated by symbol W....	XX	6,993	XX	6,572	XX	7,258	XX	10,779
Total....	XX	173,965	XX	182,941	XX	182,584	XX	189,572
TEXAS								
Cement:								
Portland....thousand 376-pound barrels..	30,030	$94,492	30,820	$97,598	30,827	$97,188	31,944	99,329
Masonry....thousand 280-pound barrels..	930	2,805	968	3,011	884	2,872	888	2,847
Clays....thousand short tons..	[3] 4,156	[3] 6,695	4,469	6,865	4,516	7,187	4,497	8,081
Gem stones....	NA	140	NA	150	NA	150	NA	150
Gypsum....thousand short tons..	1,131	4,049	1,045	3,794	899	3,258	984	3,419
Helium: Crude....thousand cubic feet..	1,026,504	10,381	1,015,708	10,330	1,030,500	10,605	977,600	10,246
Grade A....do....	358,747	11,107	350,000	12,250	364,100	12,744	335,900	9,900
Lime....thousand short tons..	1,350	17,201	1,338	19,663	1,473	18,696	1,564	20,713
Natural gas....million cubic feet..	6,490,202	809,180	6,636,555	858,396	6,953,790	903,993	7,188,900	948,935
Natural gas liquids:								
Natural gasoline and cycle products....thousand gallons..	3,512,460	232,245	3,772,471	256,959	3,890,267	269,332	4,031,589	277,105
LP gases....do....	5,521,236	167,492	5,847,601	204,666	6,359,870	260,755	7,449,439	320,326
Perlite....short tons..	300	3	1,000	8	W	W	W	W
Petroleum (crude)....thousand 42-gallon barrels..	989,525	2,928,994	1,000,749	2,962,119	1,057,706	3,141,387	1,119,962	3,375,565
Salt....thousand short tons..	6,410	28,797	6,964	30,771	7,724	33,797	8,344	36,435
Sand and gravel....do....	29,155	33,394	32,649	36,075	26,222	31,313	31,398	39,170
Stone....do....	40,240	52,070	39,520	53,659	43,578	56,659	49,424	61,577
Sulfur (Frasch process)....thousand long tons..	3,302	65,780	3,674	83,282	3,703	96,820	3,448	111,931
Talc and soapstone....short tons..	89,334	395	64,211	204	102,399	367	90,836	356
Values of items that cannot be disclosed: Native asphalt, barite (1964–66), bromine, clays (fuller's earth 1964–65, kaolin 1964), coal (lignite), graphite, iron ore, magnesium chloride (for metal), magnesium compounds (except for metal), mercury (1965–67), pumice, sodium sulfate, uranium, vermiculite (1967), and values indicated by symbol W....	XX	[r] 85,125	XX	[r] 79,026	XX	[r] 74,918	XX	80,286
Total....	XX	[r] 4,550,345	XX	[r] 4,718,826	XX	[r] 5,022,041	XX	5,406,371
UTAH								
Carbon dioxide, natural....thousand cubic feet..	96,432	$7	86,201	$6	94,006	$7	65,664	$5
Clays [3]....thousand short tons..	127	330	149	332	89	[r] 240	114	288
Coal (bituminous)....do....	4,720	33,184	4,992	31,811	4,635	26,763	4,175	24,281
Copper (recoverable content of ores, etc.)....short tons..	199,588	130,131	259,138	183,470	265,383	191,978	168,609	128,905
Gem stones....	NA	75	NA	75	NA	75	NA	80
Gold (recoverable content of ores, etc.)....troy ounces..	287,674	10,069	426,299	14,921	438,736	15,356	288,350	10,092
Iron ore (usable)....thousand long tons, gross weight..	2,082	14,306	2,139	14,229	1,956	13,478	1,708	11,916
Lead (recoverable content of ores, etc.)....short tons..	40,249	10,545	87,700	11,762	64,124	19,385	58,818	15,068

See footnotes at end of table.

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

Mineral	1964 Quantity	1964 Value (thousands)	1965 Quantity	1965 Value (thousands)	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
UTAH—Continued								
Lime ... thousand short tons	163	$2,917	189	$3,470	200	$3,640	169	$3,182
Natural gas ... million cubic feet	79,739	10,904	71,616	8,952	69,366	8,809	48,965	6,463
Perlite ... short tons	2,003	12	W	W	W	W	W	W
Petroleum (crude) ... thousand 42-gallon barrels	28,575	74,867	25,298	66,045	24,112	63,760	24,048	63,221
Salt ... thousand short tons	371	3,848	384	3,591	427	3,770	403	3,525
Sand and gravel ... do	10,218	10,405	10,032	10,464	12,368	12,937	9,412	8,631
Silver (recoverable content of ores, etc.) ... thousand troy ounces	4,552	5,886	5,636	7,287	7,755	10,028	4,875	7,556
Stone ... thousand short tons	3,105	6,930	[r] 2,328	[r] 4,765	2,246	4,269	1,831	4,108
Sulfur ore ... long tons, gross weight	----	----	2,156	3	----	----	----	----
Uranium (recoverable content (U_3O_8)) ... thousand pounds	W	W	W	W	1,225	9,797	1,287	10,300
Vanadium (recoverable in ore and concentrate) ... short tons	405	1,214	387	1,353	353	1,519	471	2,024
Zinc (recoverable content of ores, etc.) ... do	31,428	8,548	27,747	8,102	37,323	10,824	34,251	9,483
Value of items that cannot be disclosed: Asphalt (gilsonite), cement, clays (fire clay, kaolin 1965–67), fluorspar, gypsum, magnesium compounds (1966–67), molybdenum, natural gas liquids, phosphate rock, potassium salts, pumice, pyrites (1966–67), tungsten concentrate (1967), and values indicated by symbol W	XX	[r] 87,271	XX	[r] 68,510	XX	52,243	XX	45,349
Total	XX	[r] 411,449	XX	[r] 439,148	XX	[r] 448,878	XX	354,477
VERMONT								
Peat ... short tons	286	$4	780	$3	333	$5	280	$4
Sand and gravel ... thousand short tons	1,764	1,494	2,084	1,670	2,323	1,744	3,718	2,178
Stone ... do	2,070	20,652	2,591	21,564	2,650	19,926	2,761	20,520
Value of items that cannot be disclosed: Asbestos, clays, gem stones, lime, and talc	XX	3,977	XX	4,155	XX	4,235	XX	4,566
Total	XX	26,127	XX	27,392	XX	25,910	XX	27,268
VIRGINIA								
Clays ... thousand short tons	1,440	$1,614	1,415	$1,657	1,486	$1,813	1,382	$1,623
Coal (bituminous) ... do	31,654	123,123	34,053	139,291	35,565	153,341	36,721	171,183
Gem stones	NA	6	NA	7	NA	7	NA	7
Lead (recoverable content of ores, etc.) ... short tons	3,857	1,010	3,651	1,139	3,078	930	3,430	960
Lime ... thousand short tons	780	9,781	847	10,584	840	10,486	829	10,345
Natural gas ... million cubic feet	1,600	479	3,152	942	4,249	1,275	3,818	1,149
Petroleum (crude) ... thousand 42-gallon barrels	6	W	4	W	1	W	3	W
Sand and gravel ... thousand short tons	10,588	13,722	15,322	18,019	17,191	16,635	9,863	12,494
Soapstone ... short tons	3,775	9	3,549	9	3,989	10	W	W
Stone ... thousand short tons	30,407	52,153	36,350	59,397	34,151	55,550	31,324	52,470
Zinc (recoverable content of ores, etc.)[9] ... short tons	21,004	5,700	20,491	5,942	17,666	5,123	18,846	5,088
Value of items that cannot be disclosed; Aplite, cement, feldspar, gypsum, iron ore (pigment materials), kyanite, salt, titanium concentrate, and values indicated by symbol W	XX	29,818	XX	30,990	XX	29,127	XX	28,366
Total	XX	237,415	XX	267,977	XX	274,297	XX	283,685

WASHINGTON

Barite .... thousand short tons..	--------	--------	(5)	$1	--------	--------	(5)	$1
Carbon dioxide .... thousand cubic feet..	W	W	11,848	3	W	W	W	W
Cement:								
Portland .... thousand 376-pound barrels..	W	W	6,258	22,351	6,820	$24,340	5,614	20,581
Masonry .... thousand 280-pound barrels..	W	W	62	201	60	187	65	200
Clay [3] .... thousand short tons..	128	$119	162	211	185	249	139	203
Coal (bituminous) .... do....	68	575	55	497	59	514	59	517
Copper (recoverable content of ores, etc.) .... short tons..	35	23	30	21	34	25	21	16
Gem stones	NA	W	NA	75	NA	75	NA	75
Lead (recoverable content of ores, etc.) .... short tons..	5,731	1,502	6,328	1,974	5,859	1,771	2,762	773
Peat .... do....	35,609	170	29,729	131	25,599	136	40,608	181
Sand and gravel .... thousand short tons..	31,920	25,971	31,301	27,234	29,002	26,806	28,164	27,520
Stone .... do....	10,498	15,204	12,461	17,446	13,250	20,273	14,454	19,099
Talc and soapstone .... short tons..	2,680	18	2,861	17	3,880	22	4,916	26
Zinc (recoverable content of ores, etc.) .... do....	24,296	6,609	22,230	6,491	24,772	7,184	21,540	5,964
Value of items that cannot be disclosed: Clays (fire clay, bentonite 1965), diatomite, gold, gypsum (1966–67), lime, pumice, magnesite, mercury (1965), olivine, silver, tungsten (1965, 1967), uranium (1964–66), vanadium (1966), and values indicated by symbol W	XX	r 34,236	XX	r 11,011	XX	r 7,514	XX	6,911
Total	XX	r 84,427	XX	r 87,664	XX	r 89,096	XX	82,067

WEST VIRGINIA

Clays [3] .... thousand short tons..	261	$309	289	$328	300	$334	245	$254
Coal (bituminous) .... do....	141,409	693,572	149,191	726,096	149,681	753,851	153,749	800,683
Lime .... do....	W	W	W	W	240	3,492	217	3,099
Natural gas .... million cubic feet..	202,765	50,968	207,416	48,743	211,610	49,940	211,460	50,962
Petroleum (crude) .... thousand 42-gallon barrels..	3,370	12,975	3,530	13,591	3,674	14,623	3,561	14,244
Salt .... thousand short tons..	1,033	3,666	1,153	5,539	1,147	5,446	1,127	5,137
Sand and gravel .... do....	5,472	11,555	5,253	11,480	5,448	11,569	5,827	12,167
Stone [4] .... do....	7,481	13,105	8,482	14,587	9,738	16,354	9,445	16,447
Value of items that cannot be disclosed: Calcium-magnesium chloride, cement, clay (fire clay), gem stones, natural gas liquids, stone (dimension sandstone) and values indicated by symbol W	XX	36,541	XX	39,240	XX	36,191	XX	34,865
Total	XX	822,691	XX	859,604	XX	891,800	XX	937,858

WISCONSIN

Clays .... thousand short tons..	119	$147	119	$147	123	$148	89	$112
Iron ore (usable) .... thousand long tons, gross weight..	524	W	141	W	--------	--------	--------	--------
Lead (recoverable content of ores, etc.) .... short tons..	1,742	456	1,645	513	1,694	512	1,596	447
Lime .... thousand short tons..	W	W	197	3,076	204	3,186	212	3,414
Peat .... short tons..	3,261	136	3,090	122	2,379	164	1,823	W
Sand and gravel .... thousand short tons..	34,348	24,695	38,751	27,707	41,523	30,713	42,542	32,955
Stone .... thousand short tons..	18,901	20,232	15,344	21,924	16,150	23,735	17,122	24,863
Zinc (recoverable content of ores, etc.) .... short tons..	26,278	7,148	26,993	7,882	24,775	7,185	28,953	8,016
Value of items that cannot be disclosed: Abrasive stones, cement, gem stones, and values indicated by symbol W	XX	17,193	XX	11,628	XX	10,367	XX	9,805
Total	XX	70,007	XX	72,999	XX	76,010	XX	79,612

See footnotes at end of table.

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

Mineral	1964 Quantity	1964 Value (thousands)	1965 Quantity	1965 Value (thousands)	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
WYOMING								
Clays ... thousand short tons	1,271	$12,816	1,352	$13,633	1,559	$15,874	1,495	$14,313
Coal (bituminous) ... do	3,101	9,774	3,260	10,150	3,670	11,840	3,588	11,876
Copper (recoverable content of ores, etc.) ... short tons	5	3	6	4	---	---	---	---
Gem stones	NA	120	NA	120	NA	120	NA	125
Gold (recoverable content of ores, etc.) ... troy ounces	6	(5)	3	(5)	---	---	---	---
Iron ore (usable) ... thousand long tons, gross weight	2,056	24,543	2,087	25,198	1,978	19,700	1,854	19,186
Natural gas ... million cubic feet	231,613	29,808	235,849	31,840	243,381	35,290	240,074	35,051
Natural gas liquids:								
Natural gasoline ... thousand gallons	86,803	5,607	95,093	6,195	96,372	6,281	99,180	6,447
LP gases ... do	152,982	6,433	143,331	6,020	166,080	7,308	173,821	7,648
Petroleum (crude) ... thousand 42-gallon barrels	138,752	351,043	138,314	345,785	134,470	344,243	136,312	351,685
Sand and gravel ... thousand short tons	5,632	5,936	7,996	8,373	7,187	7,496	8,181	8,253
Stone ... do	2,154	3,671	1,594	2,791	1,393	2,560	1,246	2,375
Uranium (recoverable content U_3O_8) ... thousand pounds	W	W	W	W	4,593	36,741	4,655	37,243
Vanadium (recoverable in ore and concentrate) ... short tons	W	359	W	444	W	555	W	W
Value of items that cannot be disclosed; Beryllium concentrate (1964–65), cement, feldspar (1965–67), gypsum, lime, phosphate rock, pumice (1964, 1967), silver (1964–65), sodium carbonates and sulfates, vermiculite (1967), and values indicated by symbol W	XX	r 79,835	XX	r 64,901	XX	36,379	XX	36,494
Total	XX	r 529,948	XX	r 515,454	XX	r 524,387	XX	530,696

e Estimate. r Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data. XX Not applicable.

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

[2] Excludes certain cement, included with "Value of items that cannot be disclosed."

[3] Excludes certain clays, included with "Value of items that cannot be disclosed."

[4] Excludes certain stone, included with "Value of items that cannot be disclosed."

[5] Less than ½ unit.

[6] Final figure, supersedes figure given in commodity section volume I–II.

[7] Excludes shipments from Nye Metals, Inc., included with "Value of items that cannot be disclosed."

[8] Excludes salt in brine, included with "Value of items that cannot be disclosed."

[9] Recoverable zinc valued at the yearly average price of Prime Western slab zinc, 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	1964 Quantity	1964 Value (thousands)	1965 Quantity	1965 Value (thousands)	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
American Samoa:								
Pumice .... thousand short tons..	--------	--------	--------	--------	17	$22	28	24
Sand and gravel .... do....	22	$20	60	$55	20	18	7	7
Stone .... do....	157	234	60	60	12	12	28	50
Total	XX	254	XX	115	XX	52	XX	81
Canal Zone:								
Sand and gravel .... thousand short ton..	84	82	83	85	72	91	56	94
Stone (crushed .... do....	153	349	153	366	114	267	100	245
Total	XX	431	XX	451	XX	358	XX	339
Canton: Stone (crushed) .... thousand short tons..	--------	--------	--------	--------	--------	--------	--------	--------
Guam: Stone .... do....	469	868	483	925	900	1,396	511	820
Virgin Islands: Stone (crushed) .... do....	69	342	68	302	88	303	183	851
Wake: Stone (crushed .... do....	2	5	1	4	11	66	31	150

XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Production data for Canton and 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	1964 Quantity	1964 Value (thousands)	1965 Quantity	1965 Value (thousands)	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
Cement .... thousand 376-pound barrels..	7,926	$23,879	7,284	$23,415	7,603	$24,277	8,447	$27,397
Clays .... thousand short tons..	341	271	357	288	350	271	291	244
Lime .... do....	18	574	27	867	30	960	35	1,106
Salt .... do....	5	74	8	138	11	183	12	195
Sand and gravel .... do....	7,816	11,492	8,147	12,405	9,879	14,554	14,101	21,633
Stone .... do....	5,504	8,586	5,344	9,111	5,732	10,541	7,269	12,795
Total	XX	44,876	XX	46,224	XX	50,786	XX	63,370

XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

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

Mineral	1966		1967	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals:				
Aluminum:				
Ingots, slabs, crude ---- short tons--	188,240	$90,012	209,009	$99,961
Scrap ---- do----	48,666	16,239	54,531	17,686
Plates, sheets, bars, etc ---- do----	86,396	71,272	96,275	70,757
Castings and forgings ---- do----	2,524	8,592	2,816	11,173
Antimony: Metals and alloys, crude--short tons--	29	24	82	75
Bauxite, including bauxite concentrates thousand long tons--	62	4,275	2	218
Aluminum sulfate ---- short tons--	22,059	652	16,173	531
Other aluminum compounds ---- do----	353,364	37,374	578,627	51,075
Beryllium ---- pounds--	61,254	1,083	76,117	530
Bismuth: Metals and alloys ---- do----	89,382	226	152,684	395,695
Cadmium ---- thousand pounds--	379	795	691	1,669
Chrome:				
Ore and concentrate:				
Exports ---- thousand short tons--	19	740	8	328
Reexports ---- do----	173	7,119	157	5,422
Chromic acid ----	1	482	1	392
Ferrochrome ----	r 8	1,870	13	3,479
Cobalt ---- thousand pounds--	1,021	1,822	1,498	2,367
Columbium metals, alloys and other forms thousand pounds--	7	249	6	341
Copper:				
Ore, concentrate, composition metal and unrefined (copper content) ---- short tons--	2,149	927	59,692	32,951
Refined copper and semimanufactures short tons--	319,314	338,184	200,078	213,604
Other copper manufactures ---- do----	6,934	7,804	6,570	7,472
Copper sulfate or blue vitriol ---- do----	3,563	1,725	979	776
Copper base alloys ---- do----	56,311	60,069	78,213	75,809
Ferroalloys:				
Ferrosilicon ---- do----	5,812	2,004	11,774	3,228
Ferrophosphorous ---- do----	62,942	2,975	22,901	847
Gold:				
Ore and base bullion ---- troy ounces--	49,117	1,719	112,578	3,940
Bullion, refined ---- do----	13,017,549	455,614	28,607,404	1,001,259
Iron ore ---- thousand long tons--	7,779	92,157	5,943	71,585
Iron and steel:				
Pig iron ---- short tons--	12,122	731	7,451	319
Iron and steel products (major):				
Semimanufactures ---- short tons--	1,375,166	281,887	1,377,676	272,160
Manufactured steel mill products short tons--	r 769,153	r 390,217	701,400	383,201
Advanced products ----	NA	r 203,659	NA	201,938
Iron and steel scrap: Ferrous scrap, including rerolling materials ---- short tons--	5,880,925	177,461	7,666,630	251,236
Lead:				
Pigs, bars, anodes ---- do----	5,435	3,966	6,536	4,767
Scrap ---- do----	498	165	394	198
Magnesium:				
Metal and alloys and semimanufactured forms, n.e.c ---- short tons--	15,448	10,240	13,173	9,115
Manganese:				
Ore and concentrate ---- do----	16,487	1,491	15,375	1,502
Ferromanganese ---- do----	545	228	1,861	760
Mercury:				
Exports ---- 76-pound flasks--	357	197	2,627	1,281
Reexports ---- do----	476	280	475	193
Molybdenum:				
Ore and concentrates (molybdenum content) thousand pounds--	29,768	54,765	30,000	51,434
Metals and alloys, crude and scrap thousand pounds--	59	251	50	131
Wire ---- do----	19	624	34	661
Semifabricated forms, n.e.c. thousand pounds--	72	398	292	702
Powder ---- do----	120	502	241	434
Ferromolybdenum ---- do----	2,200	4,085	1,533	2,436
Nickel:				
Alloys and scrap (including Monel metal), ingots, bars, sheets, etc ---- short tons--	r 21,458	r 38,631	26,169	53,225
Catalysts ---- do----	3,135	6,589	3,441	9,387
Nickel-chrome electric resistance wire short tons--	475	2,203	565	2,530
Semifabricated forms, n.e.c ---- do--	1,319	4,661	1,362	5,587

See footnotes at end of table.

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

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
Metals—Continued				
Platinum:				
Ore, concentrate, metal and alloys in ingots, bars, sheets, anodes, and other forms, including scrap____troy ounces__	102,031	$13,414	161,585	$19,248
Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap)____troy ounces__	103,425	6,711	118,017	9,723
Platinum group manufactures, except jewelry_	NA	3,794	NA	2,378
Rare earths:				
Cerium ore, metal, alloys and lighter flints pounds__	61,620	209	141,338	303
Silver:				
Ore and base bullion_thousand troy ounces__	369	476	2,365	4,242
Bullion, refined____do____	85,169	110,057	68,404	91,718
Tantalum:				
Ore, metal, and other forms thousand pounds__	198	1,798	134	1,724
Powder____do____	51	1,564	157	1,839
Tin:				
Ingots, pigs, bars, etc:				
Exports____long tons__	1,866	6,985	2,050	6,962
Reexports____do____	981	3,849	429	1,412
Tin scrap and other tin-bearing material except tinplate scrap____long tons__	7,233	1,957	2,957	1,490
Titanium:				
Ore and concentrate____short tons__	1,300	213	3,027	167
Sponge (including iodide titanium and scrap short tons__	1,733	1,988	1,429	1,703
Intermediate mill shapes and mill products, n.e.c____short tons__	1,371	9,585	1,811	13,344
Dioxide and pigments____do____	26,872	7,601	25,852	7,165
Tungsten: Ore and concentrates:				
Exports____do____	98	223	944	2,932
Reexports____do____	195	557	269	576
Vanadium ore and concentrate, pentoxide, etc. (vanadium content)____thousand pounds__	1,771	4,226	1,575	4,043
Zinc:				
Slabs, pigs, or blocks____short tons__	1,406	749	16,809	4,287
Sheets, plates, strips, or other forms, n.e.c. short tons__	4,921	3,198	3,565	2,709
Scrap (zinc content)____do____	4,469	702	1,665	530
Semifabricated forms, n.e.c____do____	r 3,034	r 1,894	2,161	1,177
Zirconium:				
Ore and concentrate____do____	2,311	326	2,729	360
Metals and alloys and other forms_pounds__	421,516	4,567	637,612	6,909
Nonmetals:				
Abrasives:				
Dust and powder of precious or semiprecious stones, including diamond dust and powder thousand carats__	2,403	6,815	4,317	12,526
Crushing bort____do____	58	325	18	210
Industrial diamonds____do____	1,097	4,470	148	924
Diamond grinding wheels____do____	436	3,331	429	2,946
Other natural and artificial, metallic abrasives and products____	NA	36,812	NA	34,290
Asbestos: Unmanufactured:				
Exports____short tons__	46,690	5,712	47,356	5,951
Reexports____do____	306	51	362	74
Boron: Boric acid, borates, crude and refined short tons__	207,359	20,682	186,482	18,710
Cement____thousand 376-pound barrels__	1,069	4,836	980	4,452
Clays:				
Kaolin or china clay____short tons__	253,408	8,443	321,929	9,921
Fire clay____do____	215,534	3,396	176,367	2,789
Other clays____do____	605,625	19,354	651,366	19,853
Fluorspar____do____	5,732	301	10,345	517
Graphite____do____	3,161	428	3,569	460
Gypsum:				
Crude, crushed or calcines thousand short tons__	38	1,458	39	1,707
Manufactures, n.e.c____	NA	1,216	NA	1,211
Kyanite and allied minerals____short tons__	17,339	1,131	21,428	1,408
Lime____do____	59,848	1,195	52,143	1,099
Mica sheet, waste and scrap and ground_pounds__	10,810,194	929	14,301,524	781
Manufactured____do____	537,556	1,612	526,690	1,753

See footnotes at end of table.

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

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
Nonmetals—Continued				
Mineral-earth pigments: Iron oxide, natural and manufactured short tons	4,753	$1,307	3,123	$1,312
Nitrogen compounds (major) thousand short tons	2,794	154,559	2,911	165,008
Phosphate rock do	9,255	85,835	10,282	94,413
Phosphatic fertilizers (superphosphates) thousand short tons	763	40,705	743	35,139
Pigments and compounds (lead and zinc):				
Lead pigments short tons	2,599	1,044	1,909	772
Zinc pigments do	6,650	1,733	4,175	1,331
Potash:				
Fertilizer do	1,024,996	32,867	1,146,131	35,010
Chemical do	28,489	5,292	29,060	4,886
Quartz, natural, quartzite, cryolite and chiolite short tons	2,779	472	1,228	285
Salt:				
Crude and refined thousand short tons	662	4,472	678	4,583
Shipments to noncontiguous Territories thousand short tons	10	805	11	892
Sodium and sodium compounds:				
Sodium sulfate thousand short tons	28	779	28	856
Sodium carbonate do	346	12,249	304	9,914
Stone				
Dolomite, block do	101	1,692	113	1,756
Limestone, crushed, ground, broken thousand short tons	1,207	3,500	1,159	3,496
Marble and other building and monumental thousand cubic feet	NA	1,104	NA	958
Stone, crushed, ground, broken thousand short tons	276	3,406	306	3,743
Manufactures of stone	NA	1,432	NA	1,203
Sulfur:				
Crude thousand long tons	2,326	78,759	2,043	81,492
Crushed, ground, flowers of thousand long tons	47	3,404	150	9,522
Talc, crude and ground short tons	70,377	3,917	66,195	3,450
Fuels:				
Carbon black pounds	297,281	28,407	236,032	24,456
Coal:				
Anthracite thousand short tons	766	9,755	595	7,622
Bituminous do	49,302	457,899	49,510	474,853
Briquets do	120	2,182	120	2,293
Coke do	1,102	23,415	710	16,492
Petroleum:				
Crude thousand barrels	1,478	4,130	26,502	85,565
Gasoline do	2,369	14,274	3,603	19,106
Jet do	118	548	283	1,142
Naphtha do	1,982	22,232	2,299	21,999
Kerosine do	249	2,214	158	1,252
Distillate oil do	6,251	18,407	6,054	17,650
Residual oil do	13,275	29,102	22,148	43,793
Lubricating oil do	14,767	189,648	17,746	208,358
Asphalt do	434	3,705	348	3,167
Liquefied petroleum gases do	8,171	30,007	9,269	32,182
Wax do	1,877	36,028	1,677	34,077
Coke do	16,235	49,604	16,279	55,187
Petrochemical feedstocks do	2,698	14,894	2,983	15,344
Miscellaneous do	1,357	37,074	893	19,455

[r] Revised. NA Not available.

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

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
Metals:				
Aluminum:				
Metal ... short tons	r 521,021	r $217,013	449,716	$194,995
Scrap ... do	33,616	10,782	30,489	10,040
Plates, sheets, bars, etc ... do	r 124,023	r 76,852	58,341	40,243
Antimony:				
Ore (antimony content) ... do	12,460	4,754	10,517	4,090
Needle or liquated ... do	63	42	29	18
Metal ... do	2,767	2,031	2,654	1,849
Oxide ... do	5,383	3,998	5,098	3,762
Arsenic: White (As_2O_3 content) ... do	18,675	1,477	27,075	2,503
Bauxite: Crude ... thousand long tons	11,529	147,335	11,673	151,418
Beryllium ore ... short tons	2,147	581	9,511	3,167
Bismuth (general imports) ... pounds	1,681,472	6,243	1,379,729	5,172
Boron carbide ... do	183,321	513	214,620	469
Cadmium:				
Metal ... thousand pounds	3,358	6,813	1,587	3,817
Flue dust (cadmium content) ... do	1,181	989	1,166	1,093
Calcium:				
Metal ... pounds	85,941	72	423,631	370
Chloride ... short tons	r 2,499	r 81	4,385	158
Chromate:				
Ore and concentrates (Cr_2O_3 content) thousand short tons	841	30,379	568	21,854
Ferrochrome (chromium content) ... do	66	22,076	39	13,758
Metal ... do	2	3,739	1	1,842
Cobalt:				
Metal ... thousand pounds	17,871	27,734	7,946	14,420
Oxide (gross weight) ... do	1,279	1,411	1,044	1,670
Salts and compounds (gross weight) thousand pounds	150	81	167	200
Columbium ore ... do	9,278	5,678	7,431	5,266
Copper: (copper content)				
Ore and concentrates ... short tons	6,843	4,118	35,673	28,820
Regulus, black, coarse ... do	117	85	2	35
Unrefined, black, blister ... do	337,955	272,996	272,728	218,430
Refined in ingots, etc ... do	77,783	63,654	332,065	311,164
Old and scrap ... do	23,908	24,662	16,655	14,731
Old and clippings ... do	5,056	5,846	2,549	2,479
Ferroalloys: Ferrosilicon (silicon content) short tons	13,133	4,610	15,337	4,456
Gold:				
Ore and base bullion ... troy ounces	333,119	11,698	219,382	7,671
Bullion ... do	866,926	30,306	710,487	24,876
Iron ore ... thousand long tons	46,259	462,354	44,627	444,079
Iron and steel:				
Pig iron ... short tons	1,186,739	45,914	605,234	27,599
Iron and steel products (major):				
Iron products ... short tons	36,452	7,776	34,452	9,107
Steel products ... do	r 11,006,993	1,273,730	11,411,753	1,333,221
Scrap ... do	390,205	7,672	215,635	8,181
Tinplate ... do	16,450	535	13,527	381
Lead:				
Ore, flue dust, matte (lead content) short tons	63,850	13,871	144,156	29,111
Base bullion (lead content) ... do	1,928	575	677	1,224
Pigs and bars (lead content) ... do	285,788	75,312	363,596	88,697
Reclaimed, scrap, etc. (lead content) short tons	3,956	886	9,368	1,951
Sheets, pipe, and shot ... do	919	283	1,212	322
Babbitt metal and solder (lead content) short tons	731	3,203	413	1,423
Manufactures ... do	r 1,373	r 563	1,363	524
Magnesium:				
Metallic and scrap ... do	3,265	1,613	9,213	4,909
Alloys (magnesium content) ... do	689	1,656	354	1,529
Sheets, tubing, ribbons, wire and other forms (magnesium content) ... short tons	5	36	153	433
Manganese:				
Ore (35 percent or more manganese) (manganese content) ... short tons	1,261,490	77,047	977,163	55,813
Ferromanganese (manganese content) short tons	194,563	r 29,455	167,548	26,108
Mercury:				
Compounds ... pounds	16,340	94	14,011	14
Metal ... 76-pound flasks	31,364	12,322	24,348	10,735
Minor metals: Selenium and salts ... pounds	286,775	1,834	300,638	1,545

See footnotes at end of table.

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

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
Metals—Continued				
Nickel:				
Pigs, ingots, shot, cathodes short tons	r 112,886	$170,806	113,860	$193,848
Scrap do	941	709	1,104	1,240
Oxide do	7,711	7,967	6,208	8,130
Platinum group:				
Unrefined materials:				
Grains and nuggets, including crude dust and residues troy ounces	86,700	9,498	41,798	5,195
Scrap do	851	86	NA	NA
Osmiridium do	4,910	440	4,179	458
Refined metal:				
Platinum do	r 273,333	r 31,741	322,764	38,282
Palladium do	902,376	28,010	737,082	27,504
Iridium do	8,161	1,130	8,784	1,505
Osmium do	751	292	321	109
Rhodium do	65,861	11,984	47,689	10,079
Ruthenium do	10,164	385	56,563	2,049
Radium:				
Radioactive substitutes	NA	2,104	NA	3,000
Rare earths: Ferrocerium and other cerium alloys pounds	13,903	65	4,293	19
Silver:				
Ore and base bullion thousand troy ounces	35,992	43,601	25,642	33,437
Bullion do	27,040	32,586	29,878	43,650
Tantalum: Ore thousand pounds	2,143	4,782	1,675	5,510
Tin:				
Ore (tin content) long tons	4,372	12,467	3,255	7,635
Blocks, pigs, grains, etc do	41,699	152,761	50,223	166,529
Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f long tons	108	124	449	462
Tin foil, powder, flitters, etc	NA	251	NA	449
Titanium:				
Ilmenite short tons	186,539	6,698	207,906	5,145
Rutile do	151,482	8,494	167,100	19,566
Metal pounds	11,959,375	10,854	14,950,359	14,415
Ferrotitanium do	60,461	21	306,317	85
Compounds and mixtures do	96,465,373	17,495	96,251,565	16,726
Tungsten: (tungsten content)				
Ore and concentrate thousand pounds	4,298	6,859	1,699	3,784
Metal do	335	666	129	524
Ferrotungsten do	379	696	----------	----------
Other alloys pounds	75,227	227	10,767	65
Zinc:				
Ore (zinc content) short tons	396,375	51,696	431,319	58,075
Blocks, pigs, and slabs do	280,307	75,624	222,002	57,531
Sheets do	1,708	670	648	276
Old, dross, and skimmings do	6,563	1,295	3,963	673
Dust do	1,286	398	3,771	1,211
Manufactures	NA	545	NA	318
Zirconium: Ore, including zirconium sand short tons	57,976	1,652	59,303	1,891
Nonmetals:				
Abrasives: Diamonds (industrial) thousand carats	18,569	69,110	17,102	63,559
Asbestos short tons	726,459	73,100	645,112	65,743
Barite:				
Crude and ground do	699,045	5,766	532,314	4,659
Witherite do	2,138	100	1,260	53
Chemicals do	6,552	927	5,243	682
Cement thousand 376 pound barrels	7,066	17,846	5,913	14,698
Clays:				
Raw short tons	132,336	2,644	103,404	2,039
Manufactured do	6,359	238	5,382	252
Cryolite do	31,655	3,199	36,319	4,118
Feldspar: Crude long tons	----------	----------	280	8
Fluorspar short tons	878,546	21,968	911,870	24,485
Gem stones:				
Diamonds thousand carats	3,484	373,776	3,961	387,472
Emeralds do	r 218	r 5,914	242	5,518
Other	NA	46,937	NA	46,655
Graphite short tons	56,748	2,545	56,675	2,348
Gypsum:				
Crude, ground, calcined thousand short tons	5,481	15,852	5,212	9,809
Manufactures	NA	1,429	NA	1,544
Iodine, crude thousand pounds	7,133	5,934	3,459	3,177
Kyanite short tons	3,405	141	1,821	75

See footnotes at end of table.

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

Mineral	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
Nonmetals—Continued				
Lime:				
Hydrated short tons	203	$5	545	$12
Other do	151,703	1,772	79,983	961
Dead-burned dolomite [1] do	43,637	2,038	42,413	1,832
Magnesium:				
Magnesite do	186,200	10,941	127,955	7,612
Compounds do	11,864	542	11,293	547
Mica:				
Uncut sheet and punch thousand pounds	3,247	3,993	1,733	1,990
Scrap do	2,642	71	1,016	25
Manufactures do	7,535	6,670	5,440	3,373
Mineral-earth pigments: Iron oxide pigments:				
Natural short tons	3,662	200	3,670	271
Synthetic do	15,234	2,626	14,034	2,626
Ocher, crude and refined do	146	8	236	16
Siennas, crude and refined do	1,192	145	951	104
Umber, crude and refined do	3,762	135	4,275	162
Vandyke do	554	49	272	24
Nitrogen compounds (major), including urea thousand short tons	1,561	75,974	1,688	83,922
Phosphate, crude do	178	4,256	139	3,261
Phosphatic fertilizers do	67	3,740	105	6,167
Pigments and salts:				
Lead pigments and compounds short tons	30,497	7,353	30,645	6,569
Zinc pigments and compounds do	18,649	3,633	18,988	3,404
Potash do	r 2,544,112	r 71,821	2,925,082	73,491
Pumice:				
Crude or unmanufactured do	9,393	91	5,702	49
Wholly or partly manufactured do	273,338	723	240,273	580
Manufactures, n.s.p.f	NA	25	NA	22
Quartz crystal (Brazillian pebble) pounds	1,470,341	896	1,049,544	730
Salt thousand short tons	2,479	6,464	2,843	8,541
Sand and gravel:				
Glass sand do	18	95	44	159
Other sand and gravel do	631	811	588	753
Sodium sulfate do	237	3,981	291	4,506
Stone and whiting	NA	20,739	NA	19,823
Strontium: Mineral short tons	11,517	267	5,612	118
Sulfur and pyrites:				
Sulfur:				
Ores and other forms, n.e.s. thousand long tons	1,514	33,525	1,474	47,612
Pyrites do	16	84	10	51
Talc: Unmanufactured short tons	21,908	834	15,361	658
Fuels:				
Carbon black:				
Acetylene pounds	7,058,926	1,185	5,784,814	987
Gas black and carbon black do	385,381	61	330,910	56
Coal:				
Bituminous, slack, culm and lignite short tons	177,672	1,654	227,338	1,992
Briquets do	10,856	163	17,422	260
Coke do	95,761	1,790	92,001	1,704
Peat:				
Fertilizer grade do	289,823	11,416	277,241	12,088
Poultry and stable grade do	4,020	199	3,601	189
Petroleum thousand barrels	r 940,489	r 2,208,589	925,806	2,207,384

r Revised.
NA Not available.
[1] Dead-burned basic refractory material consisting chiefly of magnesia and lime.

Table 10.—Comparison of world [1] and United States production of principal metals and minerals, 1966–67

Mineral	1966			1967 [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
Fuels:						
Carbon black .... thousand pounds	4,325,710	2,571,552	59	4,091,593	2,483,840	61
Coal:						
Bituminous	2,096,599	530,001	25	1,993,134	546,590	27
Lignite	807,593	3,881	(2)	803,000	4,410	(2)
Pennsylvania anthracite	214,760	12,941	6	205,857	12,256	6
Coke (excluding breeze):						
Gashouse [3]	36,382	168	(2)	30,489	163	(2)
Oven and beehive	341,166	67,402	20	316,270	64,580	20
Natural gas (marketable) .... millon cubic feet	26,445,895	[r] 17,206,628	65	28,384,043	18,171,337	64
Peat	210,586	[4] 611	(2)	201,374	NA	NA
Petroleum (crude) .... thousand barrels	12,015,830	3,027,763	25	12,889,705	3,215,742	25
Nonmetals:						
Asbestos	3,359	126	4	3,193	123	4
Barite	4,023	1,007	25	2,447	944	(5)
Cement [6] .... thousand barrels	2,722,561	[r] 401,771	15	2,686,749	385,848	14
China clay	12,426	4,385	35	7,484	3,973	(5)
Corundum	5	------------	-------	(2)	------------	-------
Diamonds .... thousand carats	39,955	------------	-------	42,388	------------	-------
Diatomite	1,779	[r] [e] 700	[r] 39	NA	[e] 686	NA
Feldspar .... thousand long tons	1,934	[r] 655	34	1,598	615	38
Fluorspar	3,129	253	8	2,365	296	(5)
Graphite	534	W	NA	350	W	NA
Gypsum	49,629	9,647	[r] 19	31,477	9,393	(5)
Lime (sold or used by producers)	82,959	18,057	22	68,912	17,974	(5)
Magnesite	11,008	W	NA	9,947	W	NA
Mica (including scrap) .... thousand pounds	319,943	[r] 226,267	[r] 71	295,678	237,026	(5)
Nitrogen, agricultural [6] [7]	21,300	[r] 5,711	27	23,400	6,101	26
Phosphate rock .... thousand long tons	83,215	[r] 39,044	[r] 47	86,969	39,770	46
Potash (K_2O equivalent)	16,048	3,320	[r] 21	16,860	3,299	20
Pumice [8]	15,646	3,234	[r] 21	9,901	3,474	(5)
Pyrites .... thousand long tons	21,134	873	4	[e] [9] 21,618	861	4
Salt [6]	120,119	36,474	30	111,304	38,958	35
Strontium [8]	8	------------	-------	NA	------------	-------
Sulfur, elemental .... thousand long tons	16,465	[r] 8,242	50	17,247	8,283	48
Talc, pyrophylite, and soapstone	4,031	895	22	4,016	903	22
Vermiculite [8]	382	262	69	368	255	69
Metals, mine basis:						
Antimony (content of ore and concentrate) .... short tons	68,513	927	1	64,402	892	1
Arsenic, white [8]	53	W	NA	25	W	NA
Bauxite .... thousand long tons	38,666	1,796	5	41,326	1,654	4
Beryllium concentrate .... short tons	3,578	W	NA	6,950	NA	NA
Bismuth .... thousand pounds	6,660	W	NA	6,931	W	NA
Cadmium .... thousand pounds	28,707	10,460	[r] 36	19,403	8,602	(5)
Chromite	4,974	------------	-------	5,111	------------	-------

Cobalt (contained) ---- short tons	22,094	W	NA	8,236	W	NA
Columbium-tantalum concentrates [8] ---- thousand pounds	22,973	----	----	NA	----	----
Copper (content of ore and concentrate)	5,789	1,429	[r] 25	5,436	954	18
Gold ---- thousand troy ounces	46,567	1,803	4	[e] [9] 45,610	1,584	4
Iron ore ---- thousand long tons	627,974	90,147	[r] 14	618,152	84,179	14
Lead (content of ore and concentrate)	3,131	327	10	2,781	317	11
Manganese ore (35 percent or more Mn)	19,141	14	([2])	18,650	13	([2])
Mercury ---- thousand 76-pound flasks	265	22	8	242	24	10
Molybdenum (content of ore and concentrate) ---- thousand pounds	124,967	90,532	[r] 72	109,080	87,554	([5])
Nickel (content of ore and concentrate)	440	13	3	453	15	3
Platinum groups (Pt., Pd., etc.) ---- thousand troy ounces	3,039	51	2	3,154	16	([2])
Silver ---- thousand troy ounces	265,970	43,669	[r] 16	[e] [9] 261,600	32,119	12
Tin (content of ore and concentrate) ---- long tons	208,577	97	([2])	211,664	W	NA
Titanium concentrates:						
Ilmenite [8]	2,884	965	33	2,169	935	([5])
Rutile [8]	279	W	NA	NA	W	NA
Tungsten concentrate (contained tungsten) ---- short tons	31,510	[r] 4,241	[r] 13	30,673	4,150	14
Vanadium (content of ore and concentrate)[8] ---- short tons	10,029	5,166	[r] 52	10,595	4,963	47
Zinc (content of ore and concentrate)	4,960	573	12	5,175	549	11
Metals, smelter basis:						
Aluminum	7,561	2,968	[r] 39	8,021	3,269	41
Copper	6,073	[r] 1,466	[r] 24	5,850	862	15
Iron, pig (including ferroalloys)	382,500	94,000	25	385,802	89,479	23
Lead	2,988	441	15	2,712	380	14
Magnesium ---- short tons	179,844	79,794	[r] 44	202,608	97,406	48
Selenium [8] ---- thousand pounds	2,001	620	[r] 31	2,069	598	29
Steel ingots and castings	524,693	[r] 134,101	26	538,435	127,213	24
Tellurium [8]	334	199	[r] 60	247	135	55
Tin ---- long tons	203,665	[10] 4,372	[r] 2	219,135	[10] 3,048	1
Uranium oxide (U_3O_8)[8] ---- short tons	18,993	9,587	[r] 51	17,458	9,125	52
Zinc	4,563	1,025	23	4,233	939	22

[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 as it does not represent total world production. Confidential U.S. data are excluded. The data includes 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] Less than ½ unit.

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

[4] Agricultural use only.

[5] Data significantly incomplete.

[6] Including Puerto Rico.

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

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

[9] Total includes an aggregate estimate for data unavailable at the date of completion of the table.

[10] U.S. imports of tin concentrates (tin content).

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Injury Experience and Worktime in the Mineral Industries

By Forrest T. Moyer [1]

The overall injury experience for the mineral mining and processing industries was improved slightly in 1967. The totals of 508 fatalities and 31,380 nonfatal disabling injuries occurred at respective frequency rates of 0.27 and 16.83 per million man-hours of worktime. The comparable data for 1966 were 544 fatal and 32,823 nonfatal injuries at respective frequencies of 0.28 and 17.04 per million man-hours.

Operating activity in most major segments of the mineral industries, as gaged by man-hours worked, was generally at lower levels in 1967 than in the preceding year. In fact, coal mining was the only major segment for which there was an indicated slight gain in operating activity during 1967.

Scope of Report.—These statistics comprise the 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 data are final except those for most industry groups in 1967 which are preliminary as footnoted. The 1967 data were collected and compiled by the Division of Statistics with some modification of procedures from those used in past years.

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, using 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

The combined safety record of operations mining and processing nonfuel minerals was improved in 1967. Fatal injuries totaled 191 or 13 fewer than in 1966. However, the fatality frequency rate of 0.30 per million man-hours in 1967 was unchanged from the preceding year. An estimated 12,175 nonfatal disabilities occurred in 1967 at a frequency of 19.08 per million man-hours. In 1966, there were 13,424 nonfatal injuries with a rate of 19.60 per million man-hours.

METAL MINES AND MILLS

At metal mines in 1967, there were 65 fatal and 2,870 nonfatal injuries, both well below the corresponding total for 1966. However, man-hours of work declined sharply owing to the work stoppages at nonferrous operations. As a result, the frequency rate of 30.70 for all injuries in 1967 was only 2 percent less than in 1966. On the other hand, the injury-severity rate of 5,838 days lost per

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million man-hours was 2 percent higher than in 1966.

At metal mills in 1967 there were seven fatalities, the same as in 1966, but nonfatal injuries increased to a total of 585. As a result, the frequency rate for all injuries rose to 12.61 in 1967. The injury-severity rate of 1,483 was slightly improved over that of 1966.

Operating activity at copper mines and mills, as indicated by man-hours worked, was sharply lower in 1967, because of the work stoppages starting shortly after mid-year that closed a number of operations. At the mines, the number of injuries was reduced substantially and the injury-frequency rate was improved to 22.58 in 1967. However, the injury-severity rate was less favorable and increased to 5,352 days lost per million man-hours. The safety record at copper mills worsened appreciably. There were three fatalities in 1967 compared with none in 1966; nonfatal injuries also increased to a total of 110. The injury-frequency and injury-severity rates of 10.44 and 2,077, respectively, were well above those in any of the past several years.

The safety record at gold-silver lode and placer mines and mills in 1967 showed improvement in all general measures except the severity rate at mines. The number of both fatal and nonfatal injuries was reduced at both mines and mills and the rates of occurrence were appreciably better than in 1966. Operating activity of gold-silver operations, as measured by hours of worktime, continued the downtrend shown in recent years.

Injury experience at iron mines was improved over 1966 levels in all respects, with a marked reduction in the number of both fatal and nonfatal injuries. Likewise, both the frequency and severity rates showed substantial improvement. However, at mills treating iron ores, the number of nonfatal injuries increased sharply and resulted in a substantial rise in the frequency rate of all injuries to 9.98 per million man-hours. There was only one fatality in 1967 compared with three in 1966. Hence, the injury-severity rate at mills was improved markedly. Operating activity at iron mines was off sharply in 1967 as measured by the decline in man-hours worked. However, at iron-ore mills, the operating activity in 1967 showed little change from the preceding year in man-hours worked.

At lead-zinc mines, the injury-frequency rate was improved over the 1966 rate owing to a reduction in the number of nonfatal injuries. However, the 15 fatalities reported in 1967 equaled the 1966 number and the severity rate of 8,563 was well above that of 1966. At lead-zinc mills, the frequency and severity rates worsened appreciably in 1967. Operating activity at both mines and mills, indicated by man-hours worked, was lower than in 1966, probably owing to the work stoppages in the latter part of 1967.

The total of five fatalities reported at uranium mines was two fewer than in 1966. However, there was a substantial increase in nonfatal injuries to a total of 310 in 1967. As a result, the injury-frequency rate rose sharply to 46.95. With the fewer fatalities, the injury-severity rate was improved to 7,139 in 1967. Man-hours worked advanced markedly at the mines, but were only slightly higher at the uranium mills. The reduction in the number of nonfatal injuries resulted in a distinct improvement in the frequency rate at mills in 1967. No fatalities have been reported in milling operations since 1964. The injury-severity rate for 1967 fell to 342 days lost per million man-hours.

The injury-frequency rate at miscellaneous metal (molybdenum, titanium, mercury, bauxite, etc.) mines was improved sharply in 1967, owing to the lower number of nonfatal injuries. However, fatalities increased by one to a total of eight and the resulting injury-severity rate retrogressed sharply. Injury experience at mills associated with miscellaneous metal mines was improved as the numbers of injuries and the frequency and severity rates were lower in 1967.

NONFERROUS REDUCTION AND REFINING PLANTS

The injury-frequency rate at primary nonferrous smelting, reducing, and refining plants was improved moderately in 1967 owing to the lower total of nonfatal injuries. There were nine fatalities in 1967, the same as in the preceding year. However, the severity rate of injuries was moderately less favorable in 1967 because of the reduction in overall operating activity.

The frequency rate of injuries was improved only at zinc and miscellaneous metal smelters in 1967 and was less favorable at copper, lead, and aluminum smelters and refineries. Primarily owing to improved fatality experience, the severity rates of injuries at copper and lead plants were improved substantially. Fatality experience worsened at zinc, aluminum, and miscellaneous metal plants in 1967 and the severity rate of injuries in these groups was less favorable than in 1966.

Operating activity, as measured by man-hours worked, was sharply curtailed at copper and lead smelters and refineries because of the work stoppages in the last half of 1967. Activity at zinc plants was virtually unchanged from 1966 levels, but at aluminum and miscellaneous metal smelters and refineries operating activity was moderately increased over 1966 figures.

NONMETAL (EXCEPT STONE) MINES AND MILLS

The frequency rate of injuries at both nonmetal mines and mills was less favorable than in 1966. The number of nonfatal injuries was slightly lower, but these decreases were more than compensated for by the declines in man-hours of worktime at both mines and mills. There were 17 fatalities at mines and 13 at mills in 1967 compared with 16 and 11, respectively, in 1966. However, the injury-severity rate at mines was slightly improved and at mills was virtually unchanged from 1966.

Injury experience at clay-shale mines was improved in 1967 and both the frequency and severity rates of injuries were lower than in 1966. However, at clay-shale mills the total of six fatalities was double that of 1966, and the injury-severity rate was less favorable. The safety records at mines and mills in the gypsum industry were improved in both the frequency and severity rates. Nonfatal injuries at mines in 1967 were less than half the number reported the preceding year. One fatal injury occurred in 1967 at a gypsum mine, but there were no fatal accidents at gypsum mills.

At phosphate-rock mines and mills, the general measures of injury experience were improved in all instances except the injury-frequency rate at mines which was less favorable than in 1966. There were four fatalities at phosphate-rock operations in 1967 compared with eight the preceding year. At potash mines, both the frequency and severity rates of injuries were improved appreciably in 1967. However, at potash plants the totals of two fatal and 50 nonfatal injuries resulted in worsened frequency and severity rates.

The number of nonfatal injuries increased sharply at salt mines and resulted in a virtual doubling of the injury-frequency rate in 1967. There was a slight improvement shown in the severity rate compared with 1966. At salt mills, the injury-frequency rate was only slightly higher than in 1966. However, the severity rate in 1967 was only about one-fourth that of 1966 due to the absence of fatalities in the current year compared with two reported for the preceding year.

Injury experience at sulfur mines retrogressed in 1967 for which two fatalities were reported. The injury-frequency rate was slightly higher and the severity rate sharply higher than in the 1966 record of sulfur mines.

Injury frequency was improved at both mines and mills producing miscellaneous nonmetals (barite, boron minerals, feldspar, fluorspar, magnesite, mica, talc, and other nonmetals n.e.c.). This improvement resulted from a reduced number of nonfatal injuries in 1967. However, the number of fatalities was increased to a total of eight at mines and mills. This less favorable fatality experience resulted in markedly higher injury-severity rates at both mines and mills in 1967.

STONE QUARRIES AND MILLS

The overall safety record at stone quarries and mills was improved in 1967. Fatalities totaled 45 or six less than in 1966 and the number of nonfatal injuries was reduced by more than 300 to 3,260. The injury-frequency and injury-severity rates were substantially below those of 1966.

At cement quarries and mills, the injury-frequency rate showed virtually no change from the 1966 level. The severity rate was lowered appreciably, owing to the lower number of fatalities in 1967.

In the lime, limestone, marble, sandstone, and miscellaneous stone industries, both the frequency and severity rates of injuries were improved, largely by reductions in the numbers of injuries in each of the industries.

At granite quarries, there was a slight increase in the injury-frequency rate. However, the severity rate for this industry was improved in 1967 although there were three fatalities compared with two in 1966. The safety records for both the slate and traprock industries worsened in 1967. Increased numbers of fatal and nonfatal injuries in the slate industry resulted in higher frequency and severity rates in 1967. At traprock operations, the injury-frequency rate was changed only slightly from 1966 but, because of three additional fatalities in 1967, the injury-severity rate was appreciably higher.

SAND AND GRAVEL OPERATIONS

The safety record of sand and gravel operations in 1967 was changed only slightly from that of 1966. There were fewer fatal and nonfatal injuries in 1967, but this resulted largely from the reduced rate of operating activity as gaged from the man-hours worked. As a result, the injury-frequency rate improved slightly from 1966. However, the injury-severity rate was less favorable than in 1966.

SLAG (IRON-BLAST-FURNACE) OPERATIONS

Injury experience at slag operations in 1967 was not favorable. As the number of injuries increased sharply, the frequency rate was well above that in 1966. There were three fatalities in 1967, and as a result, the severity rate was advanced approximately eightfold.

MINERAL FUELS

The overall safety record of the mineral-fuels industries was virtually unchanged from 1966. The fatality experience was improved slightly in that the 317 reported cases occurred at a frequency rate of 0.26 in 1967, compared with 340 cases at a rate of 0.27 in 1966. The frequency of nonfatal injuries in 1967 was 15.67 compared with 15.64 in 1966.

COAL MINES

Injury experience (fatal and nonfatal) of the coal-mining industry was improved in 1967. The frequency rate of 42.12 injuries per million man-hours of exposure was 4 percent lower than in 1966 and the severity rate (7,204 days lost per million man-hours) decreased 7 percent.

The fatality count of 220 was 13 lower than in 1966 and was the lowest annual total in recorded history. The year 1967 was the sixth in statistical history in which no major disasters occurred in the Nation's coal-mining industry. The five preceding years were 1949, 1950, 1955, 1956, and 1964.

Nonfatal injuries totaled 10,164 in 1967, a decrease of 3 percent from 1966 and a record low annual figure in complete records back to 1930 when nearly 100,000 nonfatal injuries occurred at coal mines.

The average number of men working on active days was 144,350, or 1 percent fewer than in 1966. However, the mines were active an average of 4 days more for a total of 216 days in 1967. As a result, aggregate worktime of 246.5 million man-hours was 1 percent above the 1966 total.

Employment and injury statistics for 1967 are based on final data for anthracite mines and preliminary data for bituminous-coal and lignite mines.

Bituminous-Coal and Lignite Mines.—According to preliminary data, the safety record of bituminous-coal and lignite mines continued to improve in 1967. The combined (fatal and nonfatal) frequency rate of 41.71 injuries per million man-hours of exposure was 3 percent lower than in 1966 and the severity rate of 7,293 days lost per million man-hours decreased 8 percent.

In all, 211 men were killed in bituminous-coal and lignite mines during 1967 at the frequency rate of 0.90 per million man-hours of exposure. This rate was only slightly above the all-time low of 0.89 in 1953. Of the total fatalities, 165 occurred underground, 12 at surface operations, 21 in strip mines, two in auger mines, and 11 in mechanical-coal cleaning plants. In underground workings, the principal causes of fatalities (falls of roof or face and haulage) declined in 1967. Deaths from falls of roof or face dropped 15 percent from 110 in 1966 to 94 in 1967 and fatal haulage accidents decreased 28 percent from 40 in 1966 to 29 in 1967.

The 1967 frequency rate of 40.81 for nonfatal injuries represented a 2-percent improvement over that of 1966. It was the second lowest annual rate, bettered only by that of 39.15 in 1959.

Employment increased slightly to a total of 136,600 in 1967. The average number of active days increased from 213 in 1966 to 216 in 1967. Man-hours of worktime increased 2 percent which resulted in a workyear of 1,714 hours per man—22 more than in 1966.

Anthracite.—Injuries in the anthracite industry in 1967 decreased in frequency of occurrence but their severity rate was higher. The frequency rate of 50.00 per million man-hours was 18 percent lower than in 1966 but the severity rate of 5,511 increased 23 percent, owing to the larger number of fatalities.

Fatal injuries totaled nine, or three more than in 1966. Deaths occurred at the rate of 0.73 per million man-hours in 1967 compared with 0.44 in 1966. Eight of the deaths in 1967 occurred in underground workings and one at a strip mine. Of the underground fatalities, seven were caused by falls of roof or face compared with five in 1966. Two deaths resulted from machinery accidents—one underground and one at a stripping operation.

A total of 609 nonfatal injuries occurred in 1967 at the rate of 49.27 per million man-hours worked. Compared with similar data for 1966, nonfatal injuries decreased 27 percent in number and 19 percent in frequency.

Employment at Pennsylvania anthracite mines continued to decline in 1967. An average daily working force of 7,750 men worked 219 days, accumulating 12.4 million man-hours. This was a 17 percent decline in the average number of men working daily and a 10-percent drop in the total man-hours when compared with 1966. The men worked 16 more days than in 1966 and averaged 1,595 hours each per year—124 more than the average per man last year.

COKE OPERATIONS

Injury experience in the coking industry worsened appreciably at both slot- and beehive-oven plants. There were nine fatal and 226 nonfatal injuries, respectively, six and 35 more injuries than in 1966. As a result, the frequency rate of all injuries advanced to 6.03 per million man-hours and the severity rate to 1,602 days lost per million man-hours. Operating activity was lower in 1967 as indicated by the 4-percent decline in man-hours worked.

Slot Ovens.—Five fatalities, two more than in the preceding year, and 201 nonfatal disabilities occurred at slot-oven plants. The frequency rate of all injuries, 5.34 per million man-hours, was 35 percent higher than in 1966. Likewise, the severity rate retrogressed to 963 days lost per million man-hours compared with 658 in 1966. Man-hours worked in 1967 were 3 percent less than in the preceding year.

Beehive Ovens.—Four fatalities were reported at beehive plants, the first since 1962. There were fewer nonfatal injuries in 1967 but, because of the greatly reduced worktime, the frequency rate of all injuries was nearly double that of 1966. The injury-severity rate in 1967 advanced to 67,561 days lost per million man-hours.

OIL AND GAS OPERATIONS

Injury experience in the oil and gas industry was slightly better during 1967 than in 1966. However, the measures of experience fluctuated from item to item. The total number of injuries in the industry increased less than 1 percent, which, coupled with a 2 percent decrease in worktime, resulted in a 2 percent increase in the combined injury-frequency rate to 9.44 injuries per million man-hours worked. The disabling injury-severity rate of 981 days lost per million man-hours of exposure in 1967 was 7 percent below the similar rate for 1966 principally because of a 15-percent decrease in the number of fatalities reported.

PEAT

Injury experience at operations extracting and processing peat during 1967 deteriorated drastically. Although no fatal accidents occurred during 1967, all other measures of experience were much less favorable than in 1966. The number of injuries increased 50 percent and the rate of occurrence increased 54 percent to 19.11 per million man-hours worked. The disabling injury-severity rate in 1967 was 733 days lost per million man-hours, 97 percent higher than in the previous year.

Peat plants operated an average of 187 days during 1967, 2 percent more than in

1966. Employment and man-hours decreased 3 to 2 percent, respectively.

NATIVE ASPHALT

A total of 33 disabling work injuries occurred at native asphalt plants during 1967 at a frequency of 40.21 per million man-hours, representing increases of 13 percent in number and 1 percent in the rate of occurrence. No fatalities were reported during 1967, for the first time since 1962, therefore, the disabling injury-severity rate declined 62 percent, from 7,872 in 1966 to 2,985 in 1967.

Employment and man-hours increased 7 and 2 percent, respectively, while the average number of days active declined 6 percent.

Table 1.—Employment 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:								
1963	14,547	297	4,326	34,611	14	908	26.64	4,199
1964	15,820	288	4,549	36,323	13	1,034	28.82	3,468
1965	16,880	298	5,033	40,285	19	896	22.71	4,348
1966	16,278	317	5,164	41,323	23	976	24.18	4,856
1967 p	NA	NA	3,743	29,935	18	660	22.58	5,352
Gold-silver (lode-placer):								
1963	4,823	210	1,015	8,162	6	265	33.20	6,405
1964	4,312	228	983	7,885	4	208	26.89	3,956
1965	4,074	241	982	7,896	4	264	33.94	5,970
1966	3,847	236	907	7,254	10	305	43.42	9,846
1967 p	3,600	237	855	6,845	8	265	39.60	10,022
Iron:								
1963	13,353	251	3,357	27,079	10	402	15.21	3,339
1964	14,189	258	3,659	29,443	12	452	15.76	3,309
1965	14,439	273	3,942	31,752	5	510	16.22	1,727
1966	14,056	277	3,898	31,360	13	553	18.05	3,526
1967 p	12,800	282	3,600	28,860	11	480	16.94	2,846
Lead-zinc:								
1963	7,443	234	1,738	13,901	6	961	69.56	5,076
1964	8,158	260	2,118	16,969	19	1,038	62.19	10,113
1965	8,805	259	2,279	18,240	17	1,089	60.64	8,128
1966	8,692	261	2,273	18,212	15	1,096	61.00	8,108
1967 p	7,800	252	1,962	15,725	15	915	59.01	8,563
Uranium:								
1963	5,086	199	1,011	8,163	4	348	43.12	4,531
1964	4,772	203	969	7,833	4	349	45.07	6,401
1965	3,654	211	771	6,205	10	282	47.06	12,144
1966	3,604	204	735	5,945	7	210	36.50	8,845
1967 p	3,700	223	834	6,750	5	310	46.95	7,139
Miscellaneous:								
1963	2,592	251	650	5,196	1	191	36.95	2,613
1964	2,514	286	718	5,750	3	185	32.69	4,755
1965	3,568	276	987	7,898	3	251	32.16	3,467
1966	3,443	281	967	7,762	7	295	38.91	7,555
1967 p	3,300	285	933	7,460	8	245	33.91	8,607
Total:[1]								
1963	47,844	253	12,096	97,111	41	3,075	32.09	4,212
1964	49,765	261	12,996	104,204	55	3,266	31.87	4,833
1965	51,420	272	13,994	112,277	58	3,292	29.84	4,704
1966	49,920	279	13,944	111,857	75	3,435	31,38	5,736
1967 p	NA	NA	11,926	95,575	65	2,870	30.70	5,838

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

Table 2.—Employment 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	Nonfatal	Frequency	Severity
Copper:								
1963	4,839	320	1,550	12,402	1	91	7.42	1,545
1964	5,062	316	1,600	12,800	1	89	7.03	883
1965	5,190	335	1,737	13,897	------	90	6.48	364
1966	5,369	344	1,847	14,765	------	75	5.08	394
1967 p	NA	NA	1,376	11,010	3	110	10.44	2,077
Gold-silver (lode-placer):								
1963	335	263	88	708	------	25	35.31	768
1964	318	282	90	716	------	13	18.14	361
1965	388	258	100	798	------	24	30.09	563
1966	406	287	117	934	1	31	34.26	8,479
1967 p	300	283	98	785	------	25	29.26	4,877
Iron:								
1963	4,856	287	1,392	11,189	------	65	5.81	283
1964	5,534	293	1,622	12,944	1	103	8.03	719
1965	6,334	288	1,823	14,651	1	121	8.33	718
1966	6,293	299	1,881	15,090	3	117	7.95	1,615
1967 p	6,100	305	1,875	15,030	1	150	9.98	1,049
Lead-zinc:								
1963	1,356	229	310	2,484	2	65	26.97	7,093
1964	1,285	267	343	2,731	1	46	17.21	2,883
1965	1,271	278	353	2,825	2	76	27.61	5,061
1966	1,449	268	389	3,104	------	77	24.81	2,290
1967 p	1,400	251	354	2,835	1	80	27.86	3,430
Uranium:								
1963	1,796	275	494	3,988	------	75	18.81	404
1964	1,441	300	432	3,560	1	59	16.85	2,142
1965	1,248	313	391	3,112	------	71	22.81	1,713
1966	1,420	297	422	3,398	------	69	20.31	1,291
1967 p	1,500	281	427	3,420	------	55	16.38	342
Miscellaneous:								
1963	4,834	339	1,638	13,103	2	89	6.94	1,134
1964	4,735	329	1,560	12,492	1	96	7.77	873
1965	5,053	331	1,671	13,373	------	90	6.73	221
1966	5,238	325	1,701	13,760	3	206	15.19	2,192
1967 p	5,600	315	1,751	14,010	2	170	12.20	1,177
Total:[1]								
1963	18,016	304	5,472	43,874	5	410	9.46	1,293
1964	18,375	307	5,646	45,243	5	406	9.08	1,045
1965	19,484	312	6,074	48,657	3	472	9.76	793
1966	20,175	315	6,357	51,050	7	575	11.40	1,563
1967 p	NA	NA	5,881	47,095	7	585	12.61	1,483

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

Table 3.—Employment 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:								
1963	10,289	334	3,443	27,579	2	339	12.36	1,020
1964	10,495	323	3,385	27,106	1	355	13.13	751
1965	10,875	334	3,635	29,060	3	314	10.91	1,257
1966	10,411	335	3,486	27,779	5	362	13.21	1,673
1967 p	10,800	226	2,434	19,470	2	260	13.46	1,219
Lead:								
1963	2,581	277	715	5,720	1	61	10.84	2,057
1964	2,327	321	746	6,002	1	67	11.33	2,353
1965	2,326	301	701	5,608	1	74	13.37	2,897
1966	2,508	317	795	6,360	3	105	16.98	3,392
1967 p	2,000	289	587	4,680	------	110	23.51	1,546
Zinc:								
1963	6,108	346	2,114	16,909	3	261	15.61	1,498
1964	6,848	334	2,284	18,064	3	314	17.55	1,622
1965	7,128	340	2,426	18,971	4	284	15.18	1,897
1966	7,086	330	2,337	18,432	1	338	18.39	895
1967 p	7,300	316	2,304	18,425	5	290	15.96	2,493
Aluminum:								
1963	14,036	358	5,022	40,179	------	269	6.70	389
1964	15,794	334	5,278	42,917	3	242	5.71	790
1965	19,582	343	6,712	52,048	3	278	5.40	629
1966	18,372	348	6,393	50,986	------	228	4.47	368
1967 p	19,500	346	6,753	53,965	1	245	4.56	463
Miscellaneous:								
1963	1,428	312	446	3,633	1	27	7.71	1,888
1964	1,492	312	465	3,719	------	21	5.65	155
1965	1,716	283	485	3,880	1	21	5.67	1,795
1966	2,024	351	711	5,699	------	34	5.97	763
1967 p	2,500	307	761	6,080	1	35	5.59	1,093
Total:[1]								
1963	34,442	341	11,740	94,020	7	957	10.25	933
1964	36,956	329	12,158	97,807	8	999	10.30	1,005
1965	41,627	335	13,959	109,567	12	971	8.97	1,173
1966	40,401	340	13,722	109,257	9	1,067	9.85	985
1967 p	42,100	305	12,839	102,620	9	935	9.22	1,058

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

Table 4.—Employment 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:								
1963	4,651	199	927	7,490	1	192	25.77	1,659
1964	5,450	212	1,156	9,366	7	254	27.87	6,169
1965	5,544	220	1,217	9,877	4	291	29.87	4,034
1966	5,776	219	1,266	10,316	2	281	27.43	2,147
1967 p	5,200	225	1,180	9,590	2	250	26.49	1,975
Gypsum:								
1963	992	256	254	2,051	1	23	11.70	3,841
1964	1,019	255	260	2,091	------	15	7.17	302
1965	970	255	247	2,001	2	19	10.49	6,439
1966	935	244	228	1,848	------	23	12.45	3,743
1967 p	900	249	222	1,800	1	10	7.23	3,628
Phosphate rock:								
1963	2,012	279	561	4,536	3	72	16.53	5,088
1964	2,124	296	629	5,063	2	92	18.57	3,410
1965	2,507	294	738	5,962	2	122	20.80	2,460
1966	3,183	302	960	7,791	5	161	21.31	4,329
1967 p	3,200	272	865	6,990	3	160	23.32	3,554
Potash:								
1963	1,723	353	608	4,851	19	206	46.38	24,431
1964	2,022	333	673	5,384	4	171	32.50	6,138
1965	1,753	357	625	5,004	1	192	38.57	4,334
1966	1,934	357	690	5,516	4	209	38.61	5,663
1967 p	1,900	328	627	5,015	3	165	33.09	4,713
Salt:								
1963	1,532	270	414	3,443	3	113	33.69	5,214
1964	1,551	273	423	3,487	1	122	35.27	4,335
1965	1,638	279	457	3,745	3	97	26.70	7,103
1966	1,809	279	504	4,104	2	90	22.42	4,371
1967 p	1,800	266	470	3,890	2	170	43.68	4,318
Sulfur:								
1963	1,366	361	493	4,247	1	61	14.60	1,816
1964	1,313	363	476	4,106	------	53	12.91	418
1965	1,371	363	497	4,466	2	55	12.76	3,073
1966	1,491	360	537	4,632	------	54	11.66	1,985
1967 p	1,600	365	588	4,700	2	55	11.91	2,924
Miscellaenous:								
1963	3,294	223	733	5,921	3	190	32.60	4,117
1964	3,608	223	803	6,479	4	199	31.33	4,993
1965	3,431	242	831	6,706	7	213	32.81	9,127
1966	3,599	234	841	6,796	3	240	35.76	3,810
1967 p	3,400	235	798	6,440	4	220	35.09	4,724
Total:[1]								
1963	15,570	256	3,990	32,539	31	857	27.29	6,630
1964	17,087	259	4,420	35,977	18	906	25.68	4,389
1965	17,214	268	4,612	37,761	21	989	26.75	5,048
1966	18,727	268	5,027	41,003	16	1,058	26.19	3,586
1967 p	18,000	264	4,750	38,430	17	1,030	27.27	3,511

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

Table 5.—Employment 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: Fatal	Number of injuries: Nonfatal	Injury rates per million man-hours: Frequency	Injury rates per million man-hours: Severity
Clay-shale:								
1963	15,746	250	3,942	31,762	------	881	27.74	836
1964	15,250	261	3,982	32,058	4	1,011	31.66	2,025
1965	14,136	264	3,738	30,116	5	890	29.72	2,047
1966	15,603	270	4,214	34,028	3	1,020	30.06	2,101
1967 p	15,900	256	4,067	32,730	6	1,005	30.92	2,169
Gypsum: [1]								
1963	1,615	289	466	3,731	------	14	3.75	294
1964	1,589	278	442	3,467	------	20	5.77	1,804
1965	2,890	283	817	6,557	------	25	3.81	588
1966	2,589	269	696	5,557	1	21	3.96	1,721
1967 p	2,200	266	588	4,740	------	15	3.17	154
Phosphate rock:								
1963	2,297	310	712	5,714	1	29	5.25	1,260
1964	2,163	319	690	5,514	------	38	6.89	1,017
1965	2,476	312	773	6,198	4	54	9.36	5,194
1966	1,948	335	653	5,237	3	60	12.03	3,821
1967 p	2,000	297	607	4,855	1	55	11.54	3,420
Potash:								
1963	1,020	330	337	2,695	1	25	9.65	2,612
1964	1,003	332	333	2,666	1	45	17.25	2,644
1965	1,126	357	402	3,214	------	72	22.40	1,959
1966	1,030	360	371	2,967	------	47	15.84	2,028
1967 p	1,000	347	344	2,750	2	50	18.54	4,921
Salt:								
1963	4,539	301	1,368	10,999	------	182	16.55	369
1964	4,870	289	1,405	11,229	------	183	16.30	657
1965	3,909	284	1,109	8,967	------	154	17.17	867
1966	3,814	292	1,112	8,898	2	162	18.43	1,787
1967 p	3,700	283	1,047	8,395	------	155	18.59	448
Sulfur:								
1963	20	300	6	47	------	1	21.28	553
1964	11	273	3	21	------	-------	-------	-------
1965	10	300	3	24	------	2	83.33	83
1966	2	300	1	5	------	-------	-------	-------
1967 p	(3)	250	(4)	(5)	------	(6)	500.00	12,500
Miscellaneous:								
1963	8,495	309	2,621	20,996	------	344	16.38	514
1964	7,081	291	2,060	16,506	1	283	17.21	1,185
1965	6,668	296	1,976	15,898	1	286	18.05	1,840
1966	7,015	286	2,006	16,118	2	254	15.88	1,541
1967 p	6,700	289	1,940	15,605	4	240	15.70	2,236
Total: [2]								
1963	33,732	280	9,452	75,944	2	1,476	19.45	589
1964	31,967	279	8,914	71,461	6	1,580	22.19	1,550
1965	31,215	283	8,819	70,975	10	1,483	21.04	1,987
1966	32,001	283	9,052	72,810	11	1,564	21.63	2,030
1967 p	31,500	273	8,593	69,070	13	1,525	22.24	2,034

p Preliminary.
[1] Beginning with 1965, includes data on certain mills not reported in prior years.
[2] Data may not add to totals shown because of rounding.
[3] Less than 50.
[4] Less than 500.
[5] Less than 2,500.
[6] Less than 3.

Table 6.—Employment 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]								
1963	24,956	309	7,715	61,727	7	306	5.07	950
1964	23,017	318	7,323	58,592	8	303	5.31	1,017
1965	22,947	319	7,322	58,563	10	331	5.82	1,399
1966	22,611	326	7,381	59,044	6	359	6.18	1,245
1967 p	22,200	318	7,054	56,485	4	345	6.21	1,132
Granite:								
1963	8,131	234	1,900	15,797	13	423	27.60	7,388
1964	8,743	236	2,065	17,076	6	466	27.64	3,753
1965	8,956	243	2,176	18,284	6	409	22.70	2,966
1966	8,141	246	2,005	16,756	2	412	24.71	3,069
1967 p	7,600	249	1,889	15,795	3	400	25.52	2,370
Lime: [1]								
1963	7,439	300	2,230	17,890	3	237	13.42	1,716
1964	6,956	304	2,117	17,026	5	296	17.68	2,310
1965	7,671	291	2,234	17,958	4	282	15.93	1,808
1966	7,467	299	2,236	18,039	6	345	19.46	3,269
1967 p	7,600	281	2,146	17,230	4	285	16.83	2,123
Limestone:								
1963	33,093	230	7,603	64,500	29	1,499	23.69	3,958
1964	31,660	236	7,482	63,476	34	1,424	22.97	4,468
1965	32,872	240	7,904	67,038	21	1,448	21.91	3,182
1966	30,380	245	7,434	63,422	30	1,542	24.79	4,385
1967 p	31,100	245	7,610	64,795	26	1,430	22.44	3,333
Marble:								
1963	2,792	254	710	5,763	1	168	29.33	3,454
1964	2,602	258	671	5,456	------	174	31.89	581
1965	2,534	249	631	5,165	2	181	35.43	3,303
1966	2,953	255	753	6,178	1	213	34.64	2,523
1967 p	2,900	251	725	6,080	------	190	31.09	1,115
Sandstone:								
1963	5,982	222	1,329	11,096	2	334	30.28	2,844
1964	5,427	221	1,197	9,779	4	282	29.24	3,180
1965	5,745	227	1,305	10,696	4	278	26.36	3,192
1966	5,447	240	1,308	10,895	3	314	29.10	2,739
1967 p	5,000	241	1,202	9,995	------	240	24.22	626
Slate:								
1963	1,270	264	335	2,719	------	103	37.88	1,047
1964	1,402	263	369	2,993	1	86	29.07	3,035
1965	1,232	262	322	2,630	------	84	31.93	723
1966	1,376	266	366	2,975	1	79	26.89	2,762
1967 p	1,400	264	357	2,915	3	95	34.31	6,844
Traprock:								
1963	6,254	216	1,351	11,146	2	319	28.80	2,014
1964	5,417	208	1,125	9,401	2	240	25.74	2,285
1965	5,530	213	1,180	9,855	1	215	21.92	1,166
1966	5,562	221	1,231	10,263	1	241	23.58	1,975
1967 p	4,700	224	1,057	8,795	4	205	23.88	3,312
Miscellaneous:								
1963	2,043	186	379	3,046	4	79	27.25	8,524
1964	2,635	199	525	4,200	1	96	23.10	1,799
1965	2,093	220	460	3,811	------	77	20.21	1,416
1966	1,889	211	398	3,216	1	78	24.56	2,528
1967 p	1,800	217	393	3,175	1	65	20.47	2,333
Total: [2]								
1963	91,960	256	23,553	193,685	61	3,468	18.22	2,913
1964	87,859	260	22,873	188,000	61	3,367	18.23	2,761
1965	89,580	263	23,535	194,000	48	3,305	17.28	2,330
1966	85,826	269	23,113	190,787	51	3,583	19.05	2,852
1967 p	84,300	266	22,434	185,260	45	3,260	17.83	2,286

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

Table 7.—Employment and injury experience at sand and gravel plants in the United States

Year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
1963	52,804	216	11,400	95,786	33	1,894	20.12	3,095
1964	55,886	217	12,129	100,891	34	1,957	19.73	3,237
1965	54,159	221	11,947	100,083	40	1,870	19.08	3,214
1966	55,344	225	12,459	104,971	35	2,098	20.32	2,901
1967 p	52,300	216	11,273	96,445	32	1,910	20.11	2,931

p Preliminary.

Table 8.—Employment 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		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
1963	1,421	252	358	2,867	2	35	12.90	4,562
1964	1,472	264	389	3,107	1	53	17.38	3,895
1965	1,537	277	425	3,415	1	50	14.93	3,173
1966	1,472	277	407	3,332	------	44	13.20	709
1967	1,721	255	439	3,539	3	53	15.82	5,762

Table 9.—Employment and injury experience at coal mines in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequeucy	Severity
Bituminous coal and lignite mines:								
1963	143,628	204	29,289	232,136	252	9,838	43.47	8,834
1964	137,617	212	29,200	232,037	218	9,728	42.86	8,312
1965	137,602	213	29,242	232,613	251	10,071	44.37	9,243
1966	135,952	213	28,928	230,087	227	9,617	42.78	7,900
1967 p	136,600	216	29,484	234,150	211	9,555	41.71	7,293
Anthracite mines:								
1963	13,498	216	2,912	21,048	32	1,295	63.05	12,367
1964	13,144	214	2,812	20,368	24	1,342	67.07	9,650
1965	11,132	204	2,271	16,375	8	1,067	65.65	4,936
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
Total: [1]								
1963	157,126	205	32,200	253,185	284	11,133	45.09	9,128
1964	150,761	212	32,012	252,405	242	11,070	44.82	8,420
1965	148,734	212	31,513	248,988	259	11,138	45.77	8,960
1966	145,244	212	30,811	243,759	233	10,446	43.81	7,708
1967 p	144,350	216	31,185	246,509	220	10,164	42.12	7,204

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

Table 10.—Employment 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		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
Slot ovens:								
1963	12,696	356	4,524	36,192	7	190	5.44	NA
1964	13,021	362	4,713	37,675	1	164	4.38	703
1965	14,003	357	4,998	39,984	7	192	4.98	1,816
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
Beehive ovens:								
1963	347	209	73	567	------	23	40.57	NA
1964	426	220	94	743	------	40	53.83	5,457
1965	518	222	115	885	------	36	40.68	1,318
1966	471	236	111	821	------	36	43.82	1,048
1967	292	179	52	374	4	25	77.61	67,561
Total: [1]								
1963	13,043	352	4,596	36,759	7	213	5.98	NA
1964	13,447	357	4,807	38,418	1	204	5.34	795
1965	14,521	352	5,113	40,869	7	228	5.75	1,805
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

NA Not available.
[1] Data may not add to totals shown because of rounding.

Table 11.—Employment 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		Injury rates per million man-hours	
			Fatal	Nonfatal	Frequency	Severity
1963	461,021	974,877	93	9,125	9.46	1,040
1964	427,697	910,525	109	8,551	9.51	1,172
1965	436,935	931,645	78	8,963	9.70	934
1966	451,747	954,527	103	8,724	9.25	1,050
1967	445,562	938,946	88	8,776	9.44	981

Table 12.—Employment and injury experience in the peat industry in the United States

Year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
1963	674	163	110	957	------	11	11.49	510
1964	781	170	133	1,122	------	24	21.39	1,851
1965	623	150	94	784	------	13	16.57	593
1966	523	184	96	804	------	10	12.44	373
1967	506	187	95	785	------	15	19.11	733

Table 13.—Employment and injury experience in the native asphalt industry (bituminous limestone, bituminous sandstone, and gilsonite mines and mills) in the United States

Year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
1963	417	260	108	873	2	35	42.41	14,576
1964	369	256	94	762	2	30	41.97	16,701
1965	427	253	108	874	1	26	30.90	8,335
1966	368	270	99	806	1	28	35.98	7,872
1967	393	255	100	821	------	33	40.21	2,985

Abrasive Materials

By James D. Cooper [1]

Domestic production of natural abrasive materials rose slightly in total quantity, with tripoli accounting for all of the increase thereby compensating for the slight to moderate decreases in output of the other types. The nonabrasive uses of tripoli were responsible for the significant increase in output. After five successive annual increases, ranging from 9 to 17 percent, the value of 1967 natural abrasives output declined 5 percent from the 1966 record high. Crude, artificial abrasives production in Canada and the United States declined 9 percent in volume and 3 percent in value. Metallic abrasives declined very slightly in quantity but increased 5 percent in value over the 1966 figures. Shipments of manufactured abrasive products—grinding wheels, coated abrasives, and abrasive grain—declined slightly in 1967. General Electric Co. completed the installation of production equipment for making industrial diamond grit in a newly acquired plant at Worthington, Ohio, and E. I. du Pont de Nemours & Co., Inc., started commercial production of micron-size industrial diamond by a patented explosive process.

Table 1.—Salient abrasive statistics in the United States

Kind	1963	1964	1965	1966	1967
Natural abrasives (domestic) sold or used by producers:					
Tripoli ... short tons	66,635	64,613	71,138	66,163	70,984
Value ... thousands	$266	$268	$381	$328	$377
Special silica-stone products [1] ... short tons	2,693	3,186	3,603	3,806	2,701
Value ... thousands	$255	$292	$432	$515	$574
Garnet ... short tons	14,626	16,123	19,330	21,952	20,494
Value ... thousands	$1,412	$1,622	$1,717	$2,092	$1,849
Emery ... short tons	6,732	9,214	10,720	11,102	W
Value ... thousands	$119	$172	$204	$210	W
Artificial abrasives [2] ... short tons	402,823	459,169	524,305	607,508	552,812
Value ... thousands	$56,523	$63,370	$73,102	$82,794	$80,405
Foreign trade (natural and artificial abrasives):					
Exports (value) ... thousands	$35,774	$43,455	$50,418	$51,753	$50,896
Reexports (value) ... do	$12,918	$17,142	$13,750	$13,143	$17,239
Imports for consumption (value) ... do	$77,500	$89,299	$89,332	$110,650	$100,410

W Withheld to avoid disclosing individual company confidential data.
[1] Includes grinding pebbles, grindstones, oilstones, tube-mill liners, whetstones, and value of millstones (1963).
[2] Production of silicon carbide and aluminum oxide (United States and Canada); shipments of metallic abrasives (United States).

Foreign Trade.—Net imports of abrasive materials declined by $13.5 million in 1967, owing in large part to significantly decreased imports and increased exportation of industrial diamond. However, sharply reduced shipments of crude fused aluminum oxide and silicon carbide from Canada also had a significant effect on the net reduction. The only major abrasive product running counter to the trend was coated abrasives, with net exportation in 1967 declining $1.9 million from the preceding year.

[1] Commodity specialist, Division of Mineral Studies.

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

Kind	1966 Quantity (thousands)	1966 Value (thousands)	1967 Quantity (thousands)	1967 Value (thousands)
Natural abrasives:				
Dust and powder of precious or semiprecious stones, including diamond dust and powder ---- carats	2,403	$6,815	4,317	$12,526
Crushing bort ---- do	58	325	18	210
Industrial diamond ---- do	1,097	4,470	148	924
Emery, natural corundum, and other natural abrasives, n.e.c ---- pounds	32,763	2,006	28,000	1,935
Manufactured abrasives:				
Artificial corundum (fused aluminum oxide) ---- do	36,572	5,122	39,128	5,633
Silicon carbide, crude or in grains ---- do	17,906	3,444	12,924	2,680
Carbide abrasives, n.e.c ---- do	1,884	1,855	1,930	1,881
Grinding and polishing wheels and stones:				
Diamonds ---- carats	436	3,331	429	2,946
Pulpstone ---- pounds	4,371	1,236	4,116	1,215
Hand polishing stones, whetstones, oilstones, hones, and similar stones ---- pounds	611	832	918	928
Wheels and stones, n.e.c ---- do	4,391	6,818	3,628	6,333
Abrasive paper and cloth, coated with natural or artificial abrasive materials ---- reams	378	11,021	321	9,290
Coated abrasives, n.e.c	NA	252	NA	138
Metallic abrasives ---- pounds	41,877	4,226	44,118	4,257
Total	XX	51,753	XX	50,896

NA Not available. XX Not applicable.

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

Kind	1966 Quantity (thousands)	1966 Value (thousands)	1967 Quantity (thousands)	1967 Value (thousands)
Natural abrasives:				
Dust and powder of precious or semiprecious stones, including diamond dust and powder ---- carats	203	$742	238	$807
Crushing bort ---- do	99	812	192	1,355
Diamond suitable only for industrial use ---- do	1,692	11,561	2,271	15,016
Emery, natural corundum, and other natural abrasives, n.e.c. ---- pounds	21	6	22	4
Manufactured abrasives:				
Carbide abrasives, n.e.c ---- do	1	2	7	7
Grinding and polishing wheels and stones:				
Diamond ---- carats	(1)	2	(1)	6
Wheels and stones, n.e.c ---- pounds	1	6	2	12
Pulpstones ---- do	----	----	1	2
Hand polishing stones, whetstones, oilstones, hones, and similar stones ---- pounds	1	1	2	3
Abrasive paper and cloth, coated with natural or artificial abrasive materials ---- reams	----	----	(1)	6
Coated abrasives, n.e.c	NA	9	NA	8
Metallic abrasives ---- pounds	4	2	18	13
Total	XX	13,143	XX	17,239

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

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

Kind	1966 Quantity (thousands)	1966 Value (thousands)	1967 Quantity (thousands)	1967 Value (thousands)
Corundun, crude or crushed ---- short tons	3	$57	2	$59
Emery, flint, rottenstone, and tripoli, crude or crushed ---- short tons	39	737	16	463
Silicon carbide, crude ---- do	103	12,482	89	10,925
Aluminum oxide, crude ---- do	183	19,441	151	16,446
Other crude artificial abrasives ---- do	5	625	6	566
Abrasives, ground, grains, pulverized, or refined:				
Silicon carbide ---- do	2	497	3	444
Aluminum oxide ---- do	10	1,867	7	1,552
Emery, corundum, flint, garnet, and other, including artificial abrasives ---- short tons	(1)	92	(1)	174
Papers, cloths, and other materials wholly or partly coated with natural or artificial abrasives	(2)	4,159	(2)	4,292
Hones, whetstones, oilstones, and polishing stones ---- number	r 353	83	324	79
Abrasive wheels and millstones:				
Burrstones, manufactured or bound up into millstones ---- short tons	1	10	-----	-------
Solid natural stone wheels ---- number	1	8	4	13
Diamond ---- do	56	213	67	242
Other	(2)	561	(2)	752
Articles not especially provided for:				
Emery or garnet	(2)	17	(2)	7
Natural corundum or artificial abrasive materials	(2)	101	(2)	211
Other	(2)	49	(2)	65
Grit, shot, and sand of iron and steel ---- short tons	2	325	2	332
Diamonds:				
Diamond dies ---- number	10	216	10	229
Crushing bort ---- carats	3,336	8,079	4,255	10,065
Other industrial diamond ---- do	7,410	39,931	6,043	35,657
Miners' diamond ---- do	759	4,191	731	4,213
Dust and powder ---- do	7,064	16,909	6,073	13,624
Total	XX	110,650	XX	100,410

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

TRIPOLI[2]

Tripoli output increased slightly in 1967, in response to increased demand for use in fillers and other nonabrasive products. The quantity sold for abrasive uses declined about 2 percent in quantity but increased 2 percent in value. Production in 1967 was from four States: Arkansas, Illinois, Oklahoma, and Pennsylvania. Essentially all of the Arkansas and Oklahoma material was sold or used for abrasives, but significant quantities of the amorphous silica from Illinois and rottenstone from Pennsylvania went into filler and other uses.

Producers in 1967 were Caddo Minerals Co., Inc., Pike County, Ark.; Illinois Minerals Co. and Tamms Industries Co., both in Alexander County, Ill.; The American Tripoli Division of The Carborundum Co., Ottawa County, Okla.; and Keystone Filler & Manufacturing Co. and Penn Paint & Filler Co., both in Lycoming County, Pa.

2 This section includes data for Tripoli from the Missouri-Oklahoma and Arkansas fields, amorphous or soft silica from Alabama and southern Illinois, and rottenstone from Pennsylvania. Although they differ in some respects, all are fine-grained, porous silica materials.

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

Kind		1963	1964	1965	1966	1967
Abrasives	short tons	38,979	42,371	48,935	45,785	44,961
Value	thousands	$1,645	1,831	2,025	1,880	1,916
Filler	short tons	10,145	10,865	11,011	10,581	11,240
Value	thousands	$276	295	296	285	354
Other	short tons	5,619	5,253	4,830	4,491	4,797
Value	thousands	$197	169	142	133	143
Total	short tons	54,743	58,489	64,776	60,857	60,998
Value	thousands	$2,118	2,295	2,463	2,298	2,413

[1] Includes amorphous silica and Pennsylvania rottenstone.
[2] Partly estimated.

Prices quoted in Metals Week for December 25, 1967, for tripoli and amorphous silica were as follows:

Tripoli, per pound, paper bags, 30-ton carload lots, f.o.b. Missouri:
- Once ground through 40 mesh, rose or cream .... 2¾¢
- Double ground through 40 mesh, rose or cream .... 2¾¢
- Air floated through 200 mesh .... 3¢

Amorphous silica, per ton, bags, f.o.b. mine or mill:
- 90–95 percent through 325 mesh $27
- 96–98 percent through 325 mesh 27
- 98–99.4 percent through 325 mesh 28
- 99.5 percent through 325 mesh 39
- 99 percent minus 400 mesh 59
- 99 percent minus 15 microns 65
- 99 percent minus 10 microns 85

SPECIAL SILICA STONE PRODUCTS

Special silica stone products that were produced in 1967 included oilstones from Arkansas, whetstones from Indiana, grinding pebbles from Minnesota and Wisconsin, grindstones from Ohio, and tube-mill liners from Minnesota. No production of millstones from North Carolina has been reported since 1963. Although the total quantity of output declined by 29 percent in 1967, production of oilstones and tube-mill liners, the higher unit-value items, rose significantly, resulting in an 11-percent increase in total value.

In 1967 novaculite for oilstones was produced by Norton Pike Division of Norton Co., Arkansas Abrasives, Inc., and Arkansas Oilstone Co., Inc., all in Garland County, Ark.; whetstones by Hindostan Whetstone Co., Orange County, Ind.; grinding pebbles and tube-mill liners by The Jasper Stone Co., Rock County, Minn.; grinding pebbles by Baraboo Quarries, Inc., Sauk County, Minn.; and grindstones by Cleveland Quarries Co., Amherst County, Ohio.

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

Year	Short tons	Value (thousands)
1963	2,693	$255
1964	3,186	292
1965	3,603	432
1966	3,806	515
1967	2,701	574

[1] Includes grinding pebbles, grindstones, oilstones, tube-mill liners, whetstones, and value of millstones (1963).

NATURAL SILICATE ABRASIVES

Garnet.—Domestic production of natural garnet declined by 7 percent in quantity and 12 percent in value in 1967, following 6 consecutive years of increasing output and a record high in 1966. 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 optical lenses and plate glass. The Warren County garnet is particularly suitable for those uses because it has nearly cubic cleavage. Cabot 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., produced garnet for sandblasting and other uses from placer deposits in Benewah County, Idaho.

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

Year	Short tons	Value (thousands)
1963	14,626	$1,412
1964	16,123	1,622
1965	19,330	1,717
1966	21,952	2,092
1967	20,494	1,849

NATURAL ALUMINA ABRASIVES

Corundum.—All of the corundum used in the United States in 1967 was imported from Southern Rhodesia. American Abrasive Co. of Westfield, Mass., the only domestic firm importing corundum, processed it into closely sized grain and fine powders. The principal uses were for lens grinding and metal lapping. Complete data on world output in 1967 are not available, but it was probably in excess of 10,000 tons, with the U.S.S.R. and Southern Rhodesia accounting for over 90 percent of the total. India and the Republic of South Africa were the other producing countries.

Table 8.—World production of corundum, by countries [1] [2]

(Short tons)

Country	1963	1964	1965	1966	1967
India	725	595	530	r 424	338
Rhodesia, Southern	5,940	2,870	e 4,630	e 4,630	e 5,000
South Africa, Republic of	79	60	344	r 400	351
Total [3]	6,744	3,525	5,504	5,454	e 5,689

e Estimate. r Revised.
1 Corundum is produced in U.S.S.R. but data on production are not available.
2 Compiled mostly from data available June 1968.
3 Totals are of listed figures only; no undisclosed data included.

Emery.—Three emery producers were active in 1967, all located in Westchester County, N.Y. They include the Di Rubbo American Emery Ore Company operating the Kingston mine; De Luca Emery Mine, Inc., producing from the De Luca No. 2 mine; and Peekskill Emery Co., working the Peekskill mine. Most of the De Luca material was used as nonskid aggregates for floors, stairways, highway interchanges, and airport runways. Emery from the other producers was used in grinding wheels, coated abrasive paper and cloth, tumbling media, and abrasive grains for use in grinding and polishing. The American Abrasive Co. and three subsidiary firms purchased and distributed much of the domestic emery.

Table 9.—Emery sold or used by producers in the United States

Year	Short tons	Value (thousands)
1963	6,732	$119
1964	9,214	172
1965	10,720	204
1966	11,102	210
1967	W	W

W Withheld to avoid disclosing individual company confidential data.

INDUSTRIAL DIAMOND

Imports of industrial diamond continued at a very high rate in 1967, exceeded only by the record high achieved in 1966. Nearly half of the imports came from Ireland, which in recent years has acquired a preeminent position with respect to world distribution of industrial diamond, and probably ranks second after the United States as a producer of synthetic diamond. The producing firm, Synthetic Diamond Corporation of Ireland, owned by the De Beers organization, purchased 50 percent interest in two synthetic diamond subsidiaries of the Swedish company Allmänna Svenska Elektriska Aktiebolaget (ASEA), and sublicensed the Swedish producer to use General Electric Co. patents. This move apparently ended a patent dispute of several years' duration between General Electric Co. and ASEA. Synthetic diamond was produced in Japan and West Germany by Komatsu Diamond Co., in the Republic of South Africa by a De Beers subsidiary, and by State-owned firms in the U.S.S.R. and Czechoslovakia.

Table 10.—U.S. imports for consumption of industrial diamond (excluding diamond dies)

(Thousand carats and thousand dollars)

Year	Quantity	Value
1965	12,992	$55,678
1966	18,569	69,110
1967	17,102	63,559

E. I. du Pont de Nemours & Co., Inc., manufactured and marketed diamond grit and powders in sizes ranging from 0.5 to 15 microns. The Du Pont diamond, formed by a patented explosive process, was cleaned, graded, and marketed at Gibbstown, N.J. The material was said to be appreciably different in crystal form from other manufactured diamond, making it especially suitable for some lapping and polishing operations. Prices were competitive with other diamond of the same size range. Techniques for improvement of diamond production by the explosive method were under study, and output of larger material was expected by Du Pont in the future.

Domestic output of synthetic diamond by General Electric Co. and E. I. du Pont de Nemours & Co., Inc, was estimated at 8 million carats. In addition, salvage of diamond from industrial swarf and sludge was probably about 2.5 million carats, bringing to 10.5 million carats the domestic contribution to the Nation's total estimated requirements of 20.4 million carats. Domestic output of synthetic diamond was expected to increase appreciably in future years with the new plant of General Electric Co. at Worthington, Ohio, going on stream at yearend.

Table 11.—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				Dust and powder			
	1966		1967		1966		1967		1966		1967		1966		1967	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	----	----	----	----	----	----	(1)	$12	----	----	(1)	$1	----	----	----	----
Australia	----	----	----	----	2	$9	----	----	----	----	----	----	----	----	----	----
Belgium-Luxembourg	178	$410	83	$228	763	4,361	616	4,039	6	$44	3	13	448	$948	121	$297
Bermuda	----	----	----	----	----	----	----	----	----	----	----	----	----	----	20	48
Brazil	(1)	5	(1)	1	12	148	5	48	8	130	2	18	1	7	(1)	3
British West Africa	----	----	3	6	82	497	13	134	----	----	----	----	1	1	----	----
Canada	3	7	4	20	61	278	122	829	12	55	36	210	24	54	130	120
Central African Republic	8	21	11	30	77	1,042	63	1,025	19	40	29	46	----	----	----	----
Colombia	----	----	----	----	25	8	----	----	----	----	----	----	----	----	----	----
Congo (Kinshasa)	1,164	2,762	850	1,923	451	1,714	832	2,877	4	15	4	23	108	266	22	39
France	----	----	----	----	1	15	1	14	6	35	6	64	----	----	----	----
Germany, West	----	----	(1)	1	17	273	35	343	2	13	----	----	12	27	29	59
Ghana	3	7	9	24	317	1,715	373	1,966	----	----	----	----	----	----	19	54
Guyana	----	----	----	----	----	----	1	8	----	----	(1)	5	----	----	----	----
Iceland	----	----	----	----	----	----	----	----	8	47	----	----	4	10	----	----
Ireland	1,503	3,720	2,664	6,239	1,911	5,973	534	1,918	585	3,114	368	2,097	5,022	12,394	4,761	10,975
Israel	3	8	----	----	19	156	12	97	----	----	1	38	3	6	6	7
Italy	----	----	----	----	----	----	----	----	----	----	----	----	7	22	----	----
Japan	1	2	(1)	(1)	42	549	140	958	(1)	(1)	----	----	171	381	160	355
Latvia	----	----	----	----	----	----	----	----	----	----	----	----	17	37	----	----
Liberia	26	60	----	----	20	79	1	9	----	----	----	----	----	----	----	----
Madeira Island	----	----	4	10	----	----	1	2	----	----	----	----	----	----	----	----
Malawi	----	----	----	----	----	----	1	13	----	----	----	----	----	----	----	----
Mozambique	----	----	----	----	----	----	6	29	----	----	----	----	----	----	----	----
Netherlands	51	118	97	216	498	2,027	201	1,567	----	----	12	82	133	334	115	276
New Guinea	----	----	----	----	13	52	----	----	----	----	----	----	----	----	----	----
Nigeria	8	19	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Portuguese Western Africa, n.e.c	22	56	----	----	39	156	----	----	----	----	----	----	2	6	----	----
Sierra Leone	----	----	----	----	----	----	43	811	----	----	----	----	----	----	----	----
South Africa, Republic of	231	568	461	1,116	1,684	8,852	1,907	10,829	64	440	235	1,364	383	849	81	197
Southern Africa, n.e.c	----	----	4	11	----	----	7	59	----	----	----	----	----	----	----	----
Spain	----	----	----	----	----	----	----	----	22	112	----	----	----	----	----	----
Sweden	----	----	----	----	1	3	----	----	----	----	----	----	174	407	23	46
Switzerland	6	14	----	----	79	786	3	8	----	----	----	----	26	43	73	146
Togo	----	----	----	----	----	----	2	14	----	----	----	----	----	----	----	----
United Kingdom	121	283	5	22	971	9,125	698	4,966	14	81	30	208	524	1,106	489	942
Venezuela	2	5	2	7	14	96	14	127	9	57	----	----	----	----	----	----
Western Africa, n.e.c	6	14	58	211	310	2,013	411	2,952	(1)	6	5	44	3	8	16	40
Yugoslavia	----	----	----	----	----	----	----	----	----	----	----	----	----	----	8	19
Other countries	----	----	----	----	1	4	1	3	(1)	2	----	----	1	3	(1)	1
Total	3,336	8,079	4,255	10,065	7,410	39,981	6,043	35,657	759	4,191	731	4,213	7,064	16,909	6,073	13,624

[1] Less than ½ unit.

Table 12.—World production of natural industrial diamond, by countries [1]

(Thousand carats)

Country	1963	1964	1965	1966	1967
Africa:					
Angola	325	345	277	304	e 300
Central Africa Republic	r 281	221	r 269	270	260
Congo, (Kinshasa)	14,468	14,457	12,490	12,417	12,890
Congo, (Brazzaville) e 2 3	5,343	4,949	4,982	r 5,000	5,000
Ghana	r 2,678	r 2,290	r 2,248	2,537	2,283
Guinea e	32	2 51	51	51	50
Ivory Coast	117	80	79	74	70
Liberia 2	508	273	263	212	197
Sierra Leone	833	878	804	833	e 800
South-West Africa	119	154	r 165	176	e 200
Tanzania	313	326	414	473	494
South Africa, Republic of:					
Premier	1,565	1,668	1,829	1,975	NA
De Beers Group 4	753	759	726	1,169	NA
Other pipe mines	36	41	288	306	NA
Alluvial	225	192	154	200	NA
Total South Africa	r 2,579	2,660	2,997	3,650	e 4,900
Total Africa	r 27,596	r 26,684	r 25,039	r 25,997	27,444
Other Areas:					
Brazil e	175	175	175	150	160
Guyana	40	50	68	55	57
India	(5)	(5)	1	(5)	1
Indonesia	NA	NA	1	1	1
U.S.S.R. e	r 2,400	r 3,200	r 4,000	r 4,800	5,600
Venezuela	31	58	r 39	43	32
World total 2	r 30,242	r 30,167	r 29,323	r 31,046	33,295

e Estimate. r Revised. NA Not available.
[1] Compiled mostly from data available May 1968.
[2] Exports.
[3] Probable origin, Congo (Kinshasa).
[4] Includes some alluvial from De Beers Properties.
[5] Less than ½ unit.
[5] Total is of listed figures only; no undisclosed data included.

WORLD REVIEW

Angola.—Diamond output for the first half of 1967 was 630,927 carats, an increase of 18 percent over production during the first half of 1966. The exclusive producing company, Companhia de Diamantes de Angola, was the principal employer in the country.[3]

Botswana.—A De Beers subsidiary, Kimberlite Searches, Ltd., discovered a diamond-bearing kimberlite pipe near Lothlikane, 120 miles west of Francistown. A year of sampling was to be conducted to determine the economic potential of the find.[4]

Canada.—Kimberlite Mining Corp. explored for diamond on 30 claims that it holds in the area of Coral Rapids, Ontario, near the Abitibi River south of Hudson Bay.[5]

Central African Republic.—Two laws relating to diamond mining and marketing were passed on March 3, 1967. One law permits noncitizen collectors to purchase diamond from the native miner for an annual fee of $2,000 and to then resell it to international buying offices. The other provides for a 5-percent tax on the collectors' sales, to be withheld by the international buying offices.[6]

Congo (Kinshasa).—The Government of the Congo executed agreements with British Diamond Distributors, Ltd. (Britmond), Hamilton, Bermuda under which the firm would purchase all of the Congo diamond that could be marketed. A 6.5-percent profit margin was provided for Britmond, based on selling price.[7]

Ghana.—Recently installed washing facilities (1965-66 by Consolidated Afri-

[3] Bureau of Mines. Mineral Trade Notes. V. 65, No. 4, April 1968, pp. 6–7.
[4] Bureau of Mines. Mineral Trade Notes. V. 64, No. 10, October 1967, p. 16.
[5] Mining Journal (London). V. 269, No. 6891, Sept. 15, 1967, p. 192.
[6] Bureau of Mines. Mineral Trade Notes. V. 64, No. 6, June 1967, p. 4.
[7] Bureau of Mines. Mineral Trade Notes. V. 64, No. 9, September 1967, pp. 14–19.

can Selection Trust Ltd. resulted in a 10 percent increase in processing capacity that should assure the company an annual output of well over 2 million carats for many years. Most of the output of native, independent diggers was still being smuggled out of the country in 1967, because better prices and firmer currency were available in Nigerian and Liberian markets.[8]

Lesotho.—The government of Lesotho and Rio Tinto Zinc Corp. signed an agreement for prospecting and mining of diamond near Letseng-La-Terai in northeastern Lesotho. The agreement calls for a 2- or 3-year prospecting period during which Rio Tinto will spend about $350,000 per year if commercial-scale operations are indicated. A new company is to be formed to operate the venture. Exports from Lesotho in 1967 totaled 21,737 carats, of which about 78 percent was industrial stones and 22 percent was gem quality material. This compared favorably with the 1966 figure of 12,505 carats of 73 percent industrial and 27-percent gem material.[9]

Sierra Leone.—Major changes were made in the diamond mining and marketing laws. Penalties for smuggling were increased, the export duty was raised to 10 percent compared with the 1966 rate of 7.5 percent, and, a special development levy was imposed on each dealer. The agreement between the Government and the Sierra Leone Selection Trust (SLST) was revised to increase the taxes and assess tax liability on a current-year basis rather than a previous-year basis. Some of SLST's territory was released for alluvial mining. SLST was improving its diamond mining, transportation and processing facilities to the extent of $5.5 million.[10]

South Africa, Republic of.—Prospecting on a large scale continued in the alluvial mining areas of Namaqualand and northwestern Cape. The Voorspoed mine in the Orange Free State was being examined to determine whether it could be reopened for profitable exploitation. The Voorspoed is a local enlargement of a kimberlite dike which has been traced for over 4 miles.[11]

The Finsch mine reached its full, designed production of 2 million carats per year early in 1967. The Finsch pipe is similar in most respects to other diamondiferous pipes being exploited in South Africa. However, the diamond is "refractory", that is, does not adhere readily to grease, and requires special treatment prior to recovery on grease belts. Final separation of much of the material is made with a machine patterned after an electronic seed sorter. Plans call for operation of the mine as an open pit until about 1992, after which mining is to be by underground methods. The ratio of industrial—gem-quality diamond is about 3:1,—approximately the same as the Premier, but higher than that of other large pipe mines.[12]

South-West Africa, Territory of.—The new barge, *Pomona,* built in Cape Town for ocean diamond mining off the South-West Africa coast by Marine Diamond Corp. Ltd., was damaged during towing tests early in 1967 and returned to Cape Town for redesign and repair of the dredging structure. When finally commissioned, the *Pomona* will be the largest diamond dredge in operation, with accommodations for a crew of 114 and a 10-berth penthouse for visiting officials.[13]

Other diamond firms operating off the South-West Africa coast were Eiland Diamante Beperk, dredging diamondiferous gravel near Luderitz and pumping the material by pipeline to a land-based, 25-ton-per-hour treatment plant; and Tidal Diamonds S.W.A. (Pty) Ltd., prospecting near Hottentot Bay.[14]

U.S.S.R.—Synthetic diamond particles 3 to 4 millimeters in size have been made experimentally by the U.S.S.R. Institute of High Pressure Physics. Further work aimed at eventual commercial production of the particles at the Ukrainian Institute for Synthetic Superhard Materials was underway in 1967.[15]

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[8] Page 19 of work cited in footnote 7.
[9] Bureau of Mines. Mineral Trade Notes. V. 65, No. 2, February 1968, pp. 9–10; v. 65, No. 4, April 1968, p. 7.
[10] Mining Journal (London). V. 269, No. 6890, September 1967, pp. 172–173.
Pages 16–18 of work cited in footnote 4.
[11] Pages 18–19 of work cited in footnote 4.
[12] South African Mining and Engineering Journal (Johannesburg). R 13-M A Year From Finsch Diamond Mines. V. 78, pt. 1, No. 3865, Mar. 3, 1967, pp. 517–522.
[13] South African Mining and Engineering Journal (Johannesburg). Marine Diamond's New Vessels. V. 78, Pt. 1, No. 3857, Jan. 6, 1967, pp. 36–37; Diamond Barge Strikes Trouble. V. 78, Pt. 1, No. 3866, Mar. 10, 1967, p. 563.
[14] Pages 20–21 of work cited in footnote 4.
[15] Industrial Diamond Review. V. 27, No. 316, March 1967, p. 118.

TECHNOLOGY

The manufacturing capacity of synthetic diamond is increasing and future output is limited only by demand. Research was underway, therefore, to develop new equipment, new methods, and improved diamond and diamond-containing products that could compete to a greater extent with aluminum oxide and silicon carbide abrasives, tool steel, and carbides for use in large-scale machining and grinding of metals, alloys, cermets, and ceramics. The diamond manufacturers have shown that the structure and properties of synthetic diamond can be modified extensively by a number of methods, including the type of production process, changes in pressure and temperature, type of carbon starting material, type of catalyst, control of impurity content (particularly nitrogen), and various treatments of the diamond after production, the latest and perhaps most important being metal cladding.

To date, the metal-clad diamond has been used primarily in resin-band wheels for wet grinding of tungsten carbide. The metal coating (usually nickel) adheres strongly to the bond to prevent pull-out of the grains. It also causes the diamond to break down in a manner favorable to proper grinding, and aids in dissipation of heat from the diamond-carbide contact. In wet grinding of tungsten carbide, increases in efficiency of 40 to 60 percent were common, with greater efficiency attained in many cases. When used in volume, diamond wheels containing metal-clad diamond dropped their premium from 30 percent to about 5 percent above the regular prices. It seems that maximum efficiency was attained when the metal-coating material made up about 50 percent of the weight of the clad grit, and when the abrasive-containing section of the wheel was approximately 0.06 inch deep.

Many problems involved with precise sawing and grinding of enriched uranium carbide nuclear fuel slugs were solved by using dry diamond saws and wheels at slow speeds. Use of a coolant in previous methods required a lengthy cleaning process to remove all traces of the coolant prior to encapsulation of the slugs. In the dry grinding process, a high-velocity, vacuum process with water scrubbers removes all of the resultant fine particles.[16]

Economically competitive methods of grinding cast iron and steel may well be the next major technological advance for industrial diamond. Some tests with metal-clad diamond resulted in a grinding efficiency many times that attained using the unclad diamond.[17]

Laboratory research concerning the use of electroplated diamond on bearing surfaces showed that greatly reduced wear on both the plated bearing surface and the unplated rollers could be attained. It is suggested for use in precision instruments and machine tools.[18]

Preliminary research on factors affecting diamond grinding unexpectedly determined that the composition of diamond wheel hubs has a profound effect on grinding efficiency. Of those tested, fiber-filled Bakelite performed better than four other materials, with a grinding efficiency nearly double that of 66 tungsten carbide when operating under the most severe testing conditions.[19]

ARTIFICIAL ABRASIVES

In 1967, crude, fused aluminum oxide abrasive material was produced in the United States and Canada by six firms, including one new company, Pyrominerals Limited, Sydney, Nova Scotia, which is partly owned by American Abrasive Co., Westfield, Mass. Of the total output, 181,419 tons was regular grade, and 25,406 tons was white, high-purity material. Output was at 63 percent of rated plant capacity. Nonabrasive uses, principally refractories, accounted for 10 percent of the fused aluminum oxide output.

Silicon carbide was produced by six firms in the United States and Canada in 1967, five of which produced material for both abrasive and nonabrasive uses. The remaining firm, Satellite Alloy Corp., produced exclusively for nonabrasive uses.

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[16] Grinding and Finishing. Cool Grinding of "Hot" Carbide. V. 13, No. 3, March 1967, pp. 27, 82.

[17] South African Mining and Engineering Journal (Johannesburg). Increased Applications of Industrial Diamond. V. 78, pt. 1, No. 3870, Apr. 7, 1967, pp. 798–804.

[18] Bakul, V. N., A. A. Sagarda, A. A. Orap, and Ye L. Prudnikov. Diamond Electroplating of Bearing Surfaces. Industrial Diamond Review, v. 27, No. 325, December 1967, pp. 533–535.

[19] Iron Age. Diamond Sparks Grinding Technology. V. 199, No. 13, Mar. 30, 1967, p. 68.

Output for the two countries was at 80 percent of plant capacity. In 1967, 55 percent of the total production of silicon carbide was destined for abrasives and 45 percent for various other uses, principally in refractories and as a silicon source and deoxidizer for the steel and foundry industries.

Essentially all of the abrasive aluminum oxide and silicon carbide produced in Canada was shipped to the United States for processing into graded abrasive grains. Some of the graded grain was subsequently returned to Canada for manufacturing into grinding wheels and other abrasive products.

The quantity of metallic abrasives produced in the United States fell less than 1 percent below the record high achieved in 1966, but the value in 1967 was 5 percent above the 1966 figure and a new high for the industry. Ohio maintained a preeminent position with 37 percent of the United States total and a production almost double that of any other State. Illinois, Indiana, and Pennsylvania together accounted for 52 percent, and five other North Central and Northeastern States accounted for the remaining 11 percent of the 1967 output.

Table 13.—Crude artificial abrasives produced in the United States and Canada

(Thousand short tons and thousand dollars)

Kind		1963	1964	1965	1966	1967
Silicon carbide	Quantity	109	132	138	159	142
Value		$15,530	$18,432	$19,963	$21,674	$19,612
Aluminum oxide (abrasive grade)	Quantity	160	171	195	244	207
Value		20,936	21,493	24,909	29,981	28,183
Metallic abrasives	Quantity	134	156	191	205	204
Value		20,057	23,445	28,230	31,139	32,610
Total	Quantity	403	459	524	608	553
Value		56,523	63,370	73,102	82,794	80,405

[1] Figures include material used for refractories and other nonabrasive purposes.
[2] Shipments for U.S. plants only.

Table 14.—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)		
1966:						
Chilled iron shot and grit	42,227	$4,128	43,213	$4,748	5,435	218,950
Annealed iron shot and grit	46,111	4,828	47,224	5,991	545	[1] 96,179
Steel shot and grit	108,964	15,568	110,142	19,645	5,756	144,815
Other [2]	4,248	748	4,039	755	927	9,700
Total	201,550	25,272	204,618	31,139	[3] 12,663	373,465
1967:						
Chilled iron shot and grit	41,585	$4,099	41,014	$4,662	6,006	245,605
Annealed iron shot and grit	44,115	4,870	43,704	5,622	956	[1] 72,299
Steel shot and grit	119,065	17,055	116,302	21,736	8,519	143,142
Other [2]	2,801	466	3,312	590	416	11,400
Total	207,566	26,490	204,332	32,610	15,897	400,147

[1] Included in capacity of chilled iron shot and grit.
[2] Includes cut wire shot.
[3] Includes revisions in product detail.

Table 15.—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
1963	11.2	146.5	20.6	303.4	19.2	380.5
1964	15.0	152.5	14.5	298.8	23.1	386.0
1965	9.1	155.9	10.9	304.8	17.9	376.8
1966	17.5	174.4	18.6	310.8	r 12.7	373.5
1967	12.9	176.1	30.2	330.2	15.9	400.1

r Revised.
[1] United States only.

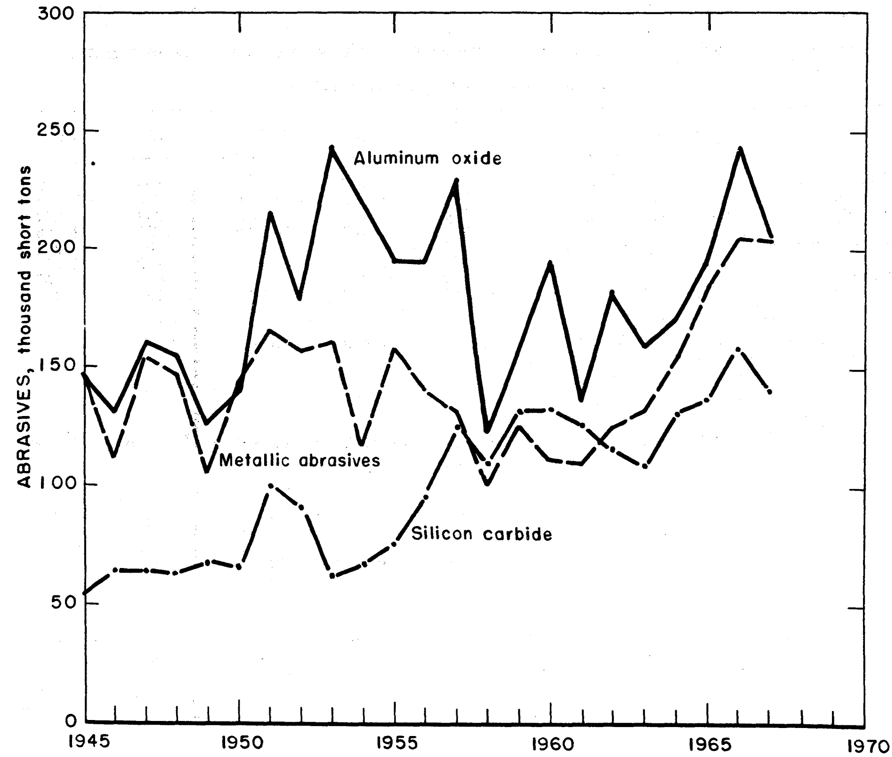

Figure 1.—Artificial abrasives production.

TECHNOLOGY

Further advances in high speed grinding were made in 1967, with the production of some vitrified wheels for operation at 12,000 surface-feet per minute and the testing of hot-pressed snagging wheels at speeds up to 18,000 surface-feet per minute. A special type of cutoff wheel was developed to operate at 22,000 surface-feet per minute to cut extruded bars and tubing at 2,000°F. Two major problems, related to the much higher grinding speeds in use and under development, concern redesign of grinding machines to withstand the forces involved, and the development of sensible safety standards and protective devices.[20] New abrasives have been necessitated by the higher speeds, particularly for snagging wheels. The latest, and probably the most important one, was the fused alumina-zirconia grain that has become widely available within a short period of years. The zirconia content ranges from 25 to 40 percent.

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[20] Grinding and Finishing. High Speed, Hot and Economical. V. 13, No. 5, May 1967, p. 25.
———. The View From the Top. V. 13, No. 1, January 1967, pp. 22–31, 36.
McKee, Richard L. That Speed Thing. Grinding and Finishing. V. 13, No. 5, May 1967, pp. 21–24.

Aluminum

By John W. Stamper [1] and Robert F. Griffith [1]

World production of primary aluminum was 10 percent higher than in 1966, but demand in the principal market areas of Europe and North America leveled off or declined. Despite the apparent oversupply situation that was developing at yearend, substantial expansions of productive capacity were planned or under construction throughout the world in anticipation of increased industrial activity and of aluminum's competitive position relative to other metals such as copper. Technological improvements reported in 1966 and 1967 in the traditional process for making aluminum metal foreshadowed further strengthening of the industry's ability to compete with other metal industries.

Legislation and Government Programs.—Sales of primary aluminum to primary producers under the disposal program that became effective November 23, 1965, totaled 61,450 tons in 1967. Cumulative sales from November 1965 through 1967 totaled 403,046 tons valued at $198.4 million, leaving 1,045,453 tons yet to be delivered under the agreement with the major producers.

At yearend General Services Administration announced the continuation through 1968 of offers for sale of 23,000 tons of primary aluminum (99.0 to 99.9 percent Al) to nonprimary producers, affiliates, or subsidiaries.

The aluminum set-aside for defense and related orders was established by the Business and Defense Service Administration, U.S. Department of Commerce, at 150,000 tons per quarter throughout 1967.

Table 1.—Salient aluminum statistics

(Thousand short tons and thousand dollars)

	1963	1964	1965	1966	1967
United States:					
Primary production	2,313	2,553	2,754	2,968	3,269
Value	$1,039,812	$1,196,013	$1,337,795	$1,446,011	$1,614,483
Price: Ingot, average cents per pound	22.6	23.7	24.5	24.5	25.0
Secondary recovery	506	552	641	693	698
Exports (crude and semicrude)	292	349	315	330	366
Imports for consumption (crude and semicrude)	466	453	620	679	539
Consumption, apparent	3,040	3,216	3,734	4,002	4,009
World: Production	5,862	6,531	6,929	7,561	8,285

DOMESTIC PRODUCTION

PRIMARY

Domestic primary aluminum output set a record high for the sixth successive year. Production for the fourth quarter was slightly more than reported capacity. Washington State led in total production with 746,321 tons valued at $370.3 million.

[1] Commodity specialist, Division of Mineral Studies.

Aluminum Company of America (Alcoa) increased annual primary reduction capacity at the following plants: Warrick (Evansville), Ind., from 75,000 at yearend 1965 to 175,000 tons; Badin, N.C., 50,000 to 100,000 tons; and Wenatchee, Wash., from 125,000 to 175,000 tons; thus, total annual capacity was up to 1,150,000 tons at yearend. Construction began on the addition of a seventh potline at the company's Rockdale, Tex., plant to increase annual capacity from 175,000 to 225,000 tons by fall 1968. Alcoa also started construction of a multimillion-dollar plant at Marshall, Tex., to suppy bare and covered aluminum conductor to the electrical industry. The company's wholly-owned subsidiary, Rome Cable Corporation, was sold to Cyprus Mines Corporation late in the year.

Intalco Aluminum Corp. started construction of a third 96,000-ton unit at its Ferndale plant near Bellingham, Wash. to bring annual capacity to 228,000 tons in 1968.

Anaconda Aluminum Co. began installation of two additional potlines at its Columbia Falls, Mont., aluminum reduction plant which will increase annual capacity from 100,000 to 170,000 tons in 1968. Construction of a new plant at Flora, Ill., to produce bare aluminum and Aluminum Cable Steel Reinforced (ACSR) conductors was announced by Anaconda Wire and Cable Company to coincide with the increase in primary aluminum output.

Modernization at the Mead, Wash., aluminum reduction plant of Kaiser Aluminum & Chemical Corp. and an additional 40,000-ton-per-year potline at its Tacoma, Wash., works was expected to increase total annual capacity to 710,000 tons in 1968. The company announced plans for a new aluminum forge plant at Oxnard, Calif., and a $55 million expansion program to include facilities to increase production of sheet and plate products at its Ravenswood, W. Va., and Trentwood, Wash., mills.

The capacity of the primary aluminum reduction plant of Consolidated Aluminum Corp. (Conalco) at New Johnsonville, Tenn., was increased to 106,000 tons per year late in 1966 by the addition of a potline comprised of 120 reduction cells (pots). Expansion to 140,000 tons per year was planned for early 1968 by addition of a fourth potline. The cold-rolling capacity of the company's fabricating complex at Jackson, Tenn., was also expanded.

Reynolds Metals Co. operating seven primary aluminum reduction plants increased annual capacity to 815,000 tons and announced plans for expansion to 975,000 tons in 1970. A 72-inch continuous coil heat treating line, largest in the industry, neared completion at the company's sheet and plate plant at McCook, Ill.

Technical improvements and a sixth potline put into operation in April, increased the annual capacity of the Ormet Corp.'s primary aluminum reduction plant at Hannibal, Ohio, to 240,000 tons. Revere Copper & Brass Corp., Inc., part owner of Ormet with Olin Mathieson Chemical Corp., announced plans for a 112,000-ton-per-year primary aluminum reduction plant at Scottsboro, Ala., the location of the company's new $55 million aluminum rolling mill. Olin Mathieson also announced plans for a multimillion-dollar aluminum electrical conductor and cable manufacturing plant at Sedalia, Mo.

Harvey Aluminum, Inc., the Nation's eighth primary aluminum producer, with an 88,000-ton-per-year plant at the Dalles, Oreg., dedicated its new $50

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

(Short tons)

Quarter	1966		1967	
	Production	Shipments	Production	Shipments
First	719,833	719,816	783,189	788,213
Second	737,983	739,679	817,445	777,440
Third	738,554	739,430	824,919	747,155
Fourth	771,996	759,349	843,706	823,328
Total	2,968,366	2,958,274	3,269,259	3,136,136

Table 3.—Aluminum production capacity in the United States, by companies

(Short tons per year)

Company and plant	Actual capacity end of 1967
Aluminum Company of America:	
Alcoa, Tenn	125,000
Badin, N.C	100,000
Evansville, Ind	175,000
Massena, N.Y	125,000
Point Comfort, Tex	175,000
Rockdale, Tex	175,000
Vancouver, Wash	100,000
Wenatchee, Wash	175,000
Total	1,150,000
Reynolds Metals Co.:	
Arkadelphia, Ark	55,000
Jones Mills, Ark	109,000
Listerhill, Ala	194,500
Longview, Wash	96,000
Massena, N.Y	115,000
San Patricio, Tex	105,500
Troutdale, Oreg	140,000
Total	815,000
Kaiser Aluminum & Chemical Corp.:	
Chalmette, La	260,000
Mead, Wash	206,000
Ravenswood, W. Va	163,000
Tacoma, Wash	41,000
Total	670,000
Anaconda Aluminum Co.: Columbia Falls, Mont	100,000
Consolidated Aluminum Corp.: New Johnsonville, Tenn	106,000
Harvey Aluminum, Inc.: The Dalles, Oreg	88,000
Ormet Corp.: Hannibal, Ohio	240,000
Intalco Aluminum Corp.: Bellingham, Wash	152,000
Grand total	3,321,000

million aluminum rolling mill at Lewisport, Ky. The plant has an annual capacity of 120 million pounds of aluminum sheet and plate. It was expected that Harvey Aluminum will build a second primary aluminum reduction plant with an annual capacity of 100,000 tons on the Washington side of the Columbia River across from its existing plant.

Southwire Co., a manufacturer of aluminum wire and cable at Carrollton, Ga., announced plans for a 90,000-ton-per-year primary aluminum reduction plant to be located at Hawesville, Ky. The proposed site of the alumina, 130,000-ton-per-year aluminum reduction facility, to be operated by Northwest Aluminum Co., Inc., was changed from Guemes Island, near Anacortes, Wash., to Warrenton, Oreg., near the mouth of the Columbia River. Noranda Mines, Ltd., announced plans for a primary aluminum reduction plant at New Madrid, Mo., with initial annual capacity of 75,000 tons, to begin production in 1970.

Ashland Oil & Refining Co. began production of petroleum pitch used in making electrodes for aluminum reduction at a 50,000-ton-per-year plant at the company's Catlettsburg, Ky., refinery.

A $10 million aluminum cable plant operated by General Cable Corp., near Hot Springs, Ark., began production using molten aluminum from Reynolds Metals Co.'s nearby Jones Mills reduction plant.

SECONDARY

Recovery of secondary aluminum was 698,000 tons, slightly higher than the record 693,000-tons set in 1966. Domestic recovery of aluminum alloys (including all constituents) from aluminum-base scrap totaled 747,000 tons. Metallic recovery from new scrap was 602,064 tons, an increase of 2 percent; however, metallic recovery from old scrap and sweated pig dropped 6 percent to 145,392 tons in 1967, following the 14-percent decrease registered in 1966. An additional 1,288 tons was recovered from copper-, zinc-, and magnesium-base scrap. The value of 696,463 tons of aluminum recovered from processed aluminum scrap was $358 million computed from the average price of primary aluminum ingot of 25 cents per pound.

The calculated consumption of purchased aluminum-base scrap and sweated pig, based on reports from consumers, totaled 882,795 tons. Independent secondary smelters used 617,145 tons, or 70 percent. Primary producers used 122,987 tons or 14 percent; fabricators used 70,505 tons or 8 percent; foundries used 67,053 tons and chemical plants used 5,105 tons.

The Bureau of Mines estimated that complete coverage of the industry would show a total scrap consumption of 1,050,000 tons and a secondary ingot production of 667,000 tons. Calculated aluminum recovery based on full coverage would total 820,000 tons and the metallic aluminum alloy recovery would total 878,000 tons. Secondary aluminum alloy-ingot production totaled 571,600 tons, 6 percent more than in 1966. Data on remelt ingot excluded alloys produced from purchased scrap by the primary producers. The increase in production of 97.0 percent aluminum (pure) alloy ingot and of AXS-679 and variations accounted for the increase in production of secondary aluminum.

Data obtained through a Bureau of Mines canvass were combined with data made available to the Bureau by the Aluminum Smelters Research Institute, which covered operations of its members. The combined coverage was estimated to represent about 85 percent of the secondary aluminum smelter industry.

Alloys & Chemical Corp., the controlling interest of which is owned by Rio Tinto-Zinc Corp. Ltd. (R.T.Z.), acquired the building and land of the

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

(Short tons)

Kind of scrap	1966	1967	Form of recovery	1966	1967
New scrap:			As metal	33,168	53,656
Aluminum-base	[1] 555,572	[2] 568,782	Aluminum alloys	642,928	628,848
Copper-base	103	81	In brass and bronze	578	643
Zinc-base	80	71	In zinc-base alloys	9,888	8,304
Magnesium-base	400	313	In magnesium alloys	1,340	1,195
			In chemical compounds	5,129	5,105
Total	556,155	569,247	Total	693,031	697,751
Old scrap:					
Aluminum-base	[1] 135,845	[2] 127,681			
Copper-base	87	70			
Zinc-base	738	569			
Magnesium-base	206	184			
Total	136,876	128,504			
Grand total	693,031	697,751			

[1] Aluminum alloys recovered from aluminum-base scrap in 1966, including all constituents, were 587,490 tons from new scrap and 154,920 tons from old scrap and sweated pig, a total of 742,410 tons.
[2] Aluminum alloys recovered from aluminum-base scrap in 1967, including all constituents, were 602,064 tons from new scrap and 145,392 tons from old scrap and sweated pig, a total of 747,456 tons.

Table 5.—Stocks, receipts and consumption of new and old aluminum scrap and sweated pig in the United States in 1967 [1]

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1 [r]	Receipts	Consumption [2]	Stocks Dec. 31
Secondary smelters: [3]				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4 percent)	3,715	79,734	78,386	5,063
Segregated high copper	627	16,819	15,771	1,675
Mixed low copper (Cu maximum, 0.4 percent)	2,690	53,228	53,944	1,974
High zinc (7000 series type)	294	7,749	7,511	532
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	1,408	20,652	21,711	349
Zinc, 0.5 to 1.0 percent	W	W	W	W
Other	1,507	56,524	56,466	1,565
Foil, dross, skimmings, and other	7,564	115,280	110,170	12,674
Total new scrap	22,966	476,863	470,931	28,898
Old scrap (solids)	6,007	103,877	103,773	6,111
Sweated pig (purchased for own use)	4,244	43,427	42,441	5,230
Total all classes	33,217	624,167	617,145	40,239

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 1967—Continued [1]

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1 [r]	Receipts	Consumption [2]	Stocks Dec. 31
Primary producers, foundries, fabricators, and chemical plants:				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4 percent)	3,670	129,013	129,971	2,712
Segregated high copper	166	13,970	14,001	135
Mixed low copper (Cu maximum, 0.4 percent)	1,000	33,033	30,904	3,129
High zinc (7000 series type)	138	7,234	7,090	282
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	------	-------	-------	------
Zinc, 0.5 to 1.0 percent	W	W	W	W
Other	------	12,941	12,679	262
Foil, dross, skimmings, and other	1,703	39,070	39,512	1,261
Total new scrap	6,897	241,611	240,468	8,040
Old scrap (solids)	486	3,832	4,019	299
Sweated pig (purchased for own use)	3,393	21,186	21,163	3,416
Total all classes	10,776	266,629	265,650	11,755
Total of all scrap consumed:				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4 percent)	7,385	208,747	208,357	7,775
Segregated high copper	793	30,789	29,772	1,810
Mixed low copper (Cu maximum, 0.4 percent)	3,690	86,261	84,848	5,103
High zinc (7000 series type)	432	14,983	14,601	814
Mixed clips	1,210	58,751	57,554	2,407
Borings and turnings:				
Low copper (Cu maximum, 0.4 percent)	826	15,541	15,655	712
Zinc, under 0.5 percent	1,408	20,652	21,711	349
Zinc, 0.5 to 1.0 percent	3,345	58,935	60,074	2,206
Other	1,507	69,465	69,145	1,827
Foil, dross, skimmings, and other	9,267	154,350	149,682	13,935
Total new scrap	29,863	718,474	711,399	36,938
Old scrap (solids)	6,493	107,709	107,792	6,410
Sweated pig (purchased for own use)	7,637	64,613	63,604	8,646
Total all classes	43,993	890,796	882,795	51,994

[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.

adjoining I. Schumann Co. in Cleveland, Ohio. The addition will enable Alloys & Chemicals to increase its production capacity to an estimated 200 million pounds per year of aluminum and zinc alloys and specialties.

Vulcan Materials Co., Birmingham, Ala., announced plans to build a $3.5 million secondary aluminum smelter at Oak Creek, Wis., to be in production early in 1969.

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

(Short tons)[1]

Alloy	1966		1967	
	Production [2]	Shipments [2]	Production [2]	Shipments [2]
Pure aluminum (Al minimum, 97.0 percent)	33,168	32,645	53,656	53,509
Aluminum-silicon:				
95/5 Al-Si, 356, etc. (maximum Cu, 0.6 percent)	20,296	20,429	20,310	20,256
13 percent Si, 360, etc. (maximum Cu, 0.6 percent)	39,293	40,087	42,679	42,224
Aluminum-silicon (Cu, 0.6 to 2 percent)	8,196	8,485	8,494	8,372
No. 12 and variations	8,664	8,628	7,504	7,448
Aluminum-copper (maximum Si, 1.5 percent)	578	557	643	683
No. 319 and variations	54,630	55,470	50,914	51,326
Nos. 122 and 138	395	609	956	991
AXS-679 and variations	267,756	275,003	285,535	287,316
Aluminum-silicon-copper-nickel	27,056	27,369	24,675	24,791
Deoxidizing and other destructive uses:				
Grades 1 and 2	12,398	12,476	14,323	14,391
Grades 3 and 4	15,648	14,944	13,118	13,964
Aluminum-base hardeners	7,932	8,272	6,818	6,722
Aluminum-magnesium	1,340	1,236	1,195	1,297
Aluminum-zinc	9,888	9,930	8,304	8,398
Miscellaneous	29,493	29,872	32,454	32,489
Total	536,731	546,012	571,578	574,177

[1] Gross weight, including copper, silicon, and other alloying elements. Secondary smelters used 18,368 and 21,134 tons of primary aluminum in 1966 and 1967, respectively, in producing secondary aluminum-base alloys.
[2] No allowance was made for consumption or receipts by producing plants.

CONSUMPTION

Apparent consumption of aluminum in 1966 was 7 percent higher than that in 1965. In 1967 net foreign trade was less than half of the record of 350,000 tons set in 1966 and apparent consumption leveled off with only a minor gain.

According to figures compiled by the Aluminum Association from industry estimates, the distribution of shipments of aluminum metal to various industries was as follows:

Industry	1966	1967
Building and construction	21.6	20.8
Transportation	23.0	21.4
Consumer durables	10.1	9.4
Electrical	14.4	13.9
Machinery and equipment	7.2	7.0
Containers and packaging	8.2	9.7
Exports	6.5	7.3
Other	9.0	10.5
Total	100.0	100.0

Net shipments of aluminum wrought and cast products by producers decreased in 1967 from the record 4 million tons set in 1966. Lower shipments of castings accounted for most of the decline. Shipments of powder, flake, and paste continued the sharply increasing trend of recent years and in 1967 were more than double the 1966 level.

Intense competition between aluminum and other metals and plastic continued to be a major market force. Despite a decline in overall electrical applications for aluminum in 1967, the metal reportedly was used in increasing quantities in place of copper, which continued to fluctuate in price and to be in short supply. Industry sources estimated that virtually all of the newly installed bare overhead electrical cable was made of aluminum. An estimated 20 percent of underground conductors for residential distribution systems was of aluminum.

Aluminum's use in containers and packaging also continued to make inroads in the use of other materials. Advantages of the light metal as a packaging material was demonstrated by a wide range of commercial packaging applications including the all-aluminum can, the composite can, easy opening tops, aluminum closures, flexible foil packaging, and the rigid foil container.

Expanding use of aluminum in rail transportation was reported in the extensive use of aluminum in unit trains placed in service in 1966 and 1967 to transport alumina and coal. The use of

Table 7.—Apparent consumption of aluminum in the United States

(Short tons)

Year	Primary sold or used by producers [1]	Imports (net) [2]	Recovery from old scrap [3]	Recovery from new scrap [3]	Total apparent consumption
1963	2,353,624	180,878	115,921	389,670	3,040,093
1964	2,554,898	109,901	123,677	428,014	3,216,490
1965	2,786,584	306,819	159,704	481,014	3,734,121
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

[1] Includes shipments to the Government: 1963, 24,293 tons; 1964–67, none.
[2] Crude and semicrude. Includes ingot equivalent of scrap imports and exports (weight multiplied by 0.9). Includes some shipments to Government stockpiles. Figures not available.
[3] Aluminum content.

aluminum in railroad freight and passenger cars increases the pay load, especially for bulk carrying freight cars of 100 tons or more capacity. For example, the pay load of a typical 4,750 cubic-foot-aluminum-covered copper car was 5 to 7 tons higher than a similar covered steel car.

Although the market for all screw machine parts and cold heading stocks reportedly declined in 1967, aluminum shipments for these applications reportedly remained at the 1966 levels, indicating that aluminum also was gaining in this market.[2]

Major markets for aluminum continued to be in the building and construction industry and in transportation.

[2] Metals Week. More Inroads in Screw Machine Parts. V. 38, No. 49, Dec. 4, 1967, p. 3.

Table 8.—Net shipments [1] of aluminum wrought and cast products [2] by producers

(Short tons)

	1966	1967 p
Wrought products:		
Sheet, plate, and foil	r 1,684,458	1,656,830
Rolled and continuous cast rod and bar; wire	r 463,920	460,536
Extruded rod, bar, pipe, shapes, drawn and welded tubing and rolled structural shapes	r 955,058	858,734
Powder, flake, paste	55,694	116,834
Forgings	r 69,608	82,097
Total	r 3,228,738	3,175,031
Castings:		
Sand	145,886	125,310
Permanent mold	202,351	191,284
Die	463,013	438,474
Others	8,724	12,288
Total	819,974	767,356
Grand total	r 4,048,712	3,942,387

p Preliminary r Revised.
[1] Derived by subtracting the sum of producer's domestic receipts of each mill shape from the domestic industry's gross shipments of that shape.
[2] 1966 figures derived from a new probability sample.

Table 9.—Distribution of wrought products

(Percent)

	1966 r	1967
Sheet, plate, and foil:		
Non-heat-treatable	38.8	39.4
Heat-treatable	6.6	5.7
Foil	6.7	7.1
Rolled and continuous cast rod and bar; wire:		
Rod, bar, etc	2.4	2.2
Bare wire, conductor and nonconductor	1.6	1.5
Bare cable (including steel-reinforced)	7.8	8.0
Wire and cable, insulated or covered	2.6	2.8
Extruded rod, bar, pipe, tube, and shapes:		
Alloys other than 2000 and 7000 series	[1] 24.7	22.4
Alloys in 2000 and 7000 series	2.0	1.8
Tubing:		
Drawn	1.5	1.4
Welded, nonheat-treatable	[2] 1.4	1.4
Powder, flake, and paste:		
Atomized	1.3	3.2
Flaked	.1	.1
Paste	.3	.3
Powder, n.e.c		.1
Forgings (including impact extrusions)	2.2	2.6
Total	100.0	100.0

r Revised.
[1] Includes a small amount of rolled structural shapes.
[2] Includes a small amount of heat-treatable welded tube.

The Sacal Borincano, which reportedly was the largest all-aluminum ship ever built, was put in service in 1967 between Miami and Puerto Rico. The vessel, measuring 226 feet long and displacing 1,570 tons, fully loaded, was capable of carrying nearly 500 tons more cargo than a similar sized vessel of steel.[3] The 380 tons of aluminum used in the craft was overshadowed by the planned use of some 1,100 tons of aluminum in the superstructure of the Q–4, the temporary designation of the transatlantic passenger craft, planned as a replacement for the Queen Mary.

An average of about 72 pounds of aluminum per automobile was reportedly used in the 1968 models compared with 71 pound per car used in 1967 models. Most of the gain was attributed to automobile air-conditioning equipment in which aluminum is extensively used.

STOCKS

Aluminum ingot stocks at primary reduction plants increased from 74,800 on January 1 to 218,900 on December 31, 1967. Although primary producer stocks were the largest since 1961, this quantity represented only 3.5 weeks production at the high level achieved in 1967. In addition to the primary aluminum stocks reported, reduction plants also had inventories of ingot and aluminum in process.

Inventories of secondary aluminum alloy ingot decreased 9 percent to 25,100 tons, equivalent to a 16-day supply based on shipments for the entire year. Consumers' yearend inventories of purchased aluminum scrap increased 18 percent to 51,994 tons, equivalent to about a 3-week supply based on the total quantity melted or consumed during the year.

PRICES

The published domestic price for unalloyed primary aluminum ingot, which had remained at 24.5 cents per pound throughout 1966, was increased to 25 cents per pound in mid-January 1967 and was unchanged by yearend. Concurrently, prices on major producer alloys and most semi-fabricated products were increased from 0.5 to 1.0 cent per pound. The price quoted for super pure aluminum (99.99 percent aluminum) advanced in January from 40.0 to 40.5 cents per pound and remained unchanged through December.

The average prices quoted by the American Metal Market for clippings, old sheet, castings, and borings and turnings of scrap aluminum decreased about 1 cent per pound during the year. There was no change in the quoted prices for smelter alloys nor for steel-deoxidizing grades.

Prices quoted at the end of 1967 for various grades of aluminum scrap clippings ranged from 10.25 to 11.25 cents per pound for 7075 (75s) to 15.50 to 16 cents per pound for 1100 (2s). Mixed aluminum clippings were quoted at 13.75 to 14.25 cents per pound. Old aluminum sheets and castings were quoted at 11 to 11.75 cents per pound, and aluminum borings and turnings were quoted at 11.75 to 12.25 cents per pound.

Effective at the end of the year, quoted delivery prices for 10-ton lots of various grades of smelter's alloy delivered to the buyers plant ranged from 24 to 24.5 cents per pound for 380 (AXS–679) alloy containing 3 percent zinc to 31.25 to 31.75 cents per pound for 218 alloy grades. Steel-deoxidizing grades ranged from 22 cents per pound for 85 percent aluminum (No. 4 grade) to 25.75 cents per pound for 95 percent aluminum (No. 1 grade).

FOREIGN TRADE

The quantity of crude and semicrude aluminum exported was 11 percent more than in 1966; the value increased 8 percent. Japan became the principal destination of aluminum ingots, slabs, and crude, accounting for 18 percent of the total. Belgium-Luxembourg was second with 11 percent, and the United Kingdom, the leading market for export of

[3] Materials in Design Engineering. All-Aluminum Vessels, Ship Freight Faster, Cheaper. V. 65, No. 5, May 1967, pp. 16–17.

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

Class	1966 Short tons	1966 Value (thousands)	1967 Short tons	1967 Value (thousands)
Crude and semicrude:				
Ingots, slabs, and crude	188,240	$90,012	209,009	$99,961
Scrap	48,666	16,239	54,531	17,686
Plates, sheets, bars, etc	86,396	71,272	96,275	70,757
Castings and forgings	2,524	8,592	2,816	11,173
Semifabricated forms, n.e.c	3,939	6,352	3,596	7,524
Total	329,765	192,467	366,227	207,101
Manufactures:				
Foil and leaf	3,092	5,730	3,612	5,940
Powders and pastes (aluminum and aluminum bronze) (aluminum content)	908	1,235	1,130	1,550
Cooking, kitchen, and hospital utensils	1,164	3,001	1,082	3,268
Sash, sections, frames, (door and window)	4,134	8,132	7,894	10,840
Venetian blinds and parts	548	773	318	437
Wire and cable	8,364	6,451	11,143	8,560
Total	18,210	25,322	25,179	30,595
Grand total	347,975	217,789	391,406	237,696

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

(Short tons)

Country	1966 Ingots, slabs, and crude	1966 Plates, sheets, bars, etc.[1]	1966 Scrap	1967 Ingots, slabs, and crude	1967 Plates sheets, bars, etc.[1]	1967 Scrap
Argentina	6,487	54	---------	9,037	58	---------
Australia	230	902	98	105	1,083	366
Belgium-Luxembourg	1,032	427	146	22,604	261	264
Brazil	22,977	892	---------	12,762	42	---------
Canada	5,432	57,713	2,117	3,966	72,472	589
Chile	936	170	8	782	1,082	8
Colombia	3,888	150	5	3,144	50	---------
El Salvador	1,103	92	---------	738	322	14
France	20,673	520	46	14,346	295	34
Germany, West	15,681	2,148	15,255	14,976	1,827	15,835
Ghana	2,978	1,182	---------	25	60	---------
Hong Kong	2,939	122	5	1,325	87	44
India	8,282	5,449	---------	12,736	1,326	---------
Iran	2,412	154	---------	2,174	207	---------
Israel	1,738	110	---------	1,177	1,008	---------
Italy	3,858	3,905	10,405	2,373	2,660	13,214
Jamaica	72	661	3	45	251	2
Japan	23,472	1,621	16,850	37,073	2,964	18,456
Korea, South	3,726	226	140	8,098	43	28
Mexico	90	804	21	224	3,859	2
Netherlands	4,405	1,961	1,582	3,062	1,033	488
New Zealand	673	84	---------	831	141	---------
Pakistan	1,827	29	---------	7,249	825	---------
Panama	738	240	---------	662	611	---------
Peru	1,013	149	1	1,136	93	320
Philippines	5,218	91	6	4,657	49	50
South Africa, Republic of	1,668	1,969	---------	1,742	921	---------
Spain	1,369	308	435	1,379	439	361
Sweden	4,377	318	15	6,652	114	29
Switzerland	1,630	59	291	1,037	95	63
Taiwan	884	89	908	3,079	147	2,172
United Kingdom	27,622	1,269	177	20,754	1,948	2,111
Venezuela	2,361	1,251	7	1,721	1,760	15
Viet-Nam, South	43	3,121	---------	---------	2,372	---------
Other	6,406	4,619	145	7,338	2,182	66
Total	188,240	92,859	48,666	209,009	102,687	54,531
Value, thousands	$90,012	$86,216	$16,239	$99,961	$89,454	$17,686

[1] Includes plates, sheets, bars, extrusions, forgings and unclassified semifabricated forms.

aluminum since 1957, dropped to third with 10 percent of the total. Exports of aluminum scrap increased 12 percent. Japan received about one-third of the total with shipments to West Germany and Italy accounting for most of the remainder.

Total net imports of aluminum in all forms declined to less than half the record high of 350,000 tons established in 1966.

The total quantity of crude and semicrude aluminum imported was 21 percent less than in 1966, largely because of drops in receipts of crude aluminum and alloys from Canada, Cameroon, Japan, Norway, and France.

Presidential Proclamation 3822 authorizing reductions in tariffs in accordance with the Kennedy Round trade agreements was signed in December 1967. The first stage of tariff reductions applying to calendar year 1968 and becoming effective January 1, 1968, included certain wrought and unwrought aluminum products.

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

Class	1966		1967	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	r 521,021	r $217,013	449,716	$194,995
Circles and disks	12,724	8,071	6,196	4,019
Plates, sheets, etc. n.e.c	r 96,592	r 57,937	38,770	25,809
Rods and bars	14,707	10,844	13,375	10,415
Scrap	33,616	10,782	30,489	10,040
Total	678,660	r 304,647	538,546	245,278
Manufacturers:				
Foil	2,968	4,505	1,939	3,587
Folding rules	(1)	1	(1)	1
Leaf (5.5 by 5.5 inches)	(2)	23	(2)	17
Flakes and powders	492	420	496	388
Wire	1,220	857	571	610
Table, kitchen, and hospital utensils, etc	2,699	5,592	3,457	6,658
Other manufactures	(1)	3,299	(1)	2,777
Total	(1)	14,697	(1)	14,038
Grand total	(1)	319,344	(1)	259,316

r Revised.
[1] Quantity not recorded.
[2] 1966, 2,355,500 leaves and 36,163,566 square inches of leaf; 1967, 1,542,500 leaves and 17,540,245 square inches of leaf.

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

(Short tons)

Country	1966 Metal, and alloys, crude	1966 Plates, sheets, bars, etc.[1]	1966 Scrap	1967 Metal, and alloys, crude	1967 Plates, sheets, bars, etc.[1]	1967 Scrap
Australia	1,189	3,053			1,466	
Austria		2,206			1,815	
Belgium-Luxembourg		46,795		34	17,381	
Cameroon	r 18,490	r 276		83		
Canada	386,355	8,364	21,628	356,209	6,474	29,164
Denmark			469		3	
France	10,184	10,944		2,918	2,971	
Germany, West	318	5,325	121	117	2,401	
Greece	6,779	24		11,942	100	
Italy	(2)	12,695		1	9,453	
Japan	14,758	19,933	978	1,876	5,090	
Norway	78,721	2,019		60,165	686	
Spain		1,011	7	4,707	2,087	
Sweden	1,000	415	136		131	399
Switzerland	1,017	266			140	
Taiwan	220	461			88	
United Kingdom	1,956	4,720	5,526	5,207	1,168	378
Yugoslavia		5,309			6,598	
Other	34	207	4,751	6,457	289	548
Total	r 521,021	r 124,023	33,616	449,716	58,341	30,489
Value, thousands	r $217,013	r $76,852	$10,782	$194,995	$40,243	$10,040

r Revised.
1 Includes circles, disks, bars, rods, plates, sheets, etc.
2 Less than ½ unit.

WORLD REVIEW

Production of primary aluminum continued to increase at a rate of about 10 percent per year. The United States accounted for 42 percent of the 721,300 ton increase in 1967; the estimated Soviet increase accounted for 12 percent, Canada 10 percent, Japan 7 percent, and the new production from Ghana, 6 percent.

Estimated world consumption remained at 8.3 million tons with Asia showing a 25-percent increase and Europe, the Americas, and the Soviet bloc a slight decrease.

New primary aluminum reduction plants were scheduled in Argentina, West Germany, Greece, Italy, Norway, Yugoslavia, Angola, Republic of South Africa, United Arab Republic, India, Japan, Iran, Turkey, and New Zealand.

NORTH AMERICA

Canada.—Production of 963,400 tons represented 89 percent of the installed capacity of the two primary aluminum producers. An increase of 8 percent over 1966 figures was achieved in the face of voluntary cutbacks by Aluminum Company of Canada, Ltd. (ALCAN), a subsidiary of Alcan Aluminium Limited, for inventory control and a 5-week strike at the Baie Comeau, Quebec, plant of Canadian British Aluminium Company, Ltd. (C.B.A.), which reduced production to 85,700 tons.

Pilot plant research by Alcan at Arvida, Quebec, on the development of a process for direct reduction of aluminum from bauxite, was indefinitely postponed. During 10 years of research the technical feasibility of the monochloride process was demonstrated through the small-scale pilot plant stage.

Jamaica.—Amax Aluminum Co., a division of American Metal Climax, Inc., announced plans to construct a plant in the Kingston area to produce aluminum building products as a joint venture with Jamaican business interests.

Iceland.—Construction began on a 33,000-short-ton-per-year aluminum smelter by Icelandic Aluminum Co., Ltd. (ISAL), a wholly owned subsidiary of Swiss Aluminum, Ltd. The plant, located at Hafnarfjördur in southwestern Iceland, is scheduled to begin production in mid-1969 with capacity increases to

Table 14.—World production of aluminum by countries [1]

(Short tons)

Country	1963	1964	1965	1966	1967 [p]
North America:					
Canada	719,390	842,640	[r] 830,505	[r] 890,600	963,400
Mexico	6,100	19,487	21,041	23,040	23,714
United States	2,312,528	2,552,747	2,754,478	2,968,366	3,269,259
South America:					
Brazil	19,412	29,366	[r] 33,518	[e] [r] 42,000	[e] 40,000
Surinam	---	---	[r] 1,381	[2] 28,330	[2] 34,279
Venezuela	---	---	---	---	3,407
Europe:					
Austria	84,287	85,646	[r] 86,880	87,002	[e] 86,500
Czechoslovakia [e]	65,000	65,000	68,000	68,000	72,000
France	328,891	348,319	375,367	400,701	398,000
Germany:					
East [e]	50,000	50,000	55,000	55,000	55,000
West	230,142	242,418	258,407	268,839	278,770
Greece	---	---	---	[r] 40,000	79,000
Hungary	61,174	62,693	64,043	66,685	[e] 67,000
Italy	100,782	127,422	136,660	140,704	[e] 140,000
Netherlands	---	---	---	22,422	35,000
Norway	[r] 248,400	287,724	303,804	[r] 356,809	399,211
Poland [3]	51,365	52,639	52,146	60,816	101,700
Rumania	---	---	25,127	51,644	58,187
Spain	50,142	54,723	[r] 57,217	[r] 66,914	[e] 77,600
Sweden (includes alloys)	[r] 18,812	[r] 33,589	[r] 34,959	[r] 32,500	[e] 34,300
Switzerland	66,260	70,805	74,020	[r] 75,756	79,697
U.S.S.R. [e]	[r] 840,000	[r] 900,000	[r] 930,000	[r] 980,000	1,064,000
United Kingdom	34,243	35,516	39,911	40,934	43,051
Yugoslavia	39,567	38,320	45,545	46,321	49,134
Africa:					
Cameroon	58,327	56,777	55,652	[r] 53,681	53,253
Ghana	---	---	---	---	43,752
Asia:					
China, mainland [e]	110,000	110,000	110,000	110,000	90,000
India	60,881	62,465	74,041	91,803	106,210
Japan [4]	246,854	292,950	323,972	371,778	421,123
Taiwan	13,148	21,354	20,847	18,978	17,020
Oceania: Australia	46,214	88,194	96,744	[r] 101,262	101,848
Total [5]	[r] 5,861,919	[r] 6,530,794	[r] 6,929,265	[r] 7,560,885	8,285,415

[e] Estimate. [p] Preliminary. [r] Revised.
[1] Compiled from data available May 1968.
[2] Exports.
[3] Includes secondary.
[4] Includes super-purity; 1963, 2,060; 1964, 2,136; 1965, 2,023; 1966, 2,278; and 1967, 3,057.
[5] Totals are of listed figures only; no undisclosed data included.

66,000 tons by 1973. At full capacity the plant will require 120,000 kilowatts of power to be obtained from a 210,000-kilowatt hydroelectric powerplant under construction at Burfell on the Thjorsa River. Total estimated cost of the powerplant and smelter at full capacity is $100 million, part of which was financed by a World Bank loan of $18 million.

Mexico.—Construction began to increase aluminum ingot capacity at the Veracruz plant of Aluminio Mexicano S. A. de C. V. to 33,000 tons by 1968 and to 44,000 tons by 1970 at an estimated cost of $20 million. The company is owned 35 percent by Aluminum Company of America, 14 percent by American Foreign Power Co., and 51 percent by Mexican interests.

SOUTH AMERICA

Argentina.—Construction of a 44,000-ton-per-year aluminum reduction plant at Puerto Madryn and a 225,000-kilowatt hydroelectric powerplant about 300 miles to the west near Esquel was recommended as a result of a feasibility study conducted for the Argentine Air Force. The plant would depend on foreign sources of bauxite since Argentina has no known reserves.

Brazil.—Construction began, with completion scheduled for mid-1970, on an aluminum mining, refining, and smelting complex in Poços de Caldas, State of Minas Gerais. The operating company, Companhia Mineira de Alumínio (ALCOMINAS) owned by Aluminum

Company of America, The Hanna Mining Company, and Brazilian interests, announced initial capacity at 27,500 tons per year to be expanded if market conditions warrant. Large reserves of high-grade bauxite, discovered by The Hanna Mining Company geologists, occur within a 5-mile radius of the alumina refining plant site. Capital requirement for the complex is estimated at $55 million of which $22 million was financed by a World Bank loan.

Combined capacity of the two primary aluminum producers was 45,700 short tons at yearend.

Surinam.—Production at the new 58,000-ton-per-year aluminum reduction plant of Suriname Aluminum Co. (SURALCO) reached only about 65 percent of capacity primarily because of a shortage of water for the hydroelectric facility at Afobaka.

Venezuela.—The 11,000-ton-per-year primary aluminum plant of Aluminio del Caroní, S. A. (ALCASA), owned 50 percent by Reynolds International, Inc., and 50 percent by the Venezuelan Government, was officially dedicated in October. Capacity will be doubled by 1969 with the installation of 70 additional cells. Alumina was imported from the United States and Jamaica.

EUROPE

Consumption of primary aluminum dropped 3 percent from the record high set in 1966. Only Austria and Italy showed marked improvement. New production capacities in Greece and the Netherlands, a 67-percent production increase in Poland, and a 12-percent increase in Norway, were largely responsible for an overall primary production increase of about 9 percent.

Belgium.—Reynolds International, Inc., became full owner of Aluminium—Europe, S. A., operator of an aluminum extrusion and foil plant near Mons, by acquiring the 50 percent interest held by Societé Générale de Belgique.

Negotiations were held between Kaiser Aluminum & Chemical Corp. and the Belgian government for the possible construction of a 110,000-ton-per-year aluminum reduction plant near Liége. Belgium is the only sizable European country without primary aluminum capacity.

France.—Production and consumption of aluminum leveled off in 1967 after recording a steady growth for 10 years, during which time production doubled.

A 27,500-ton-per-year secondary aluminum smelter operated by Ste' Affinerie de l'Ile de France (Affifrance), a subsidiary of Péchiney, started production, increasing the secondary aluminum production capacity of France by 50 percent.

Germany, West.—Following the United States and the U.S.S.R., West Germany became the world's third largest consumer of aluminum. About 655,000 tons were consumed in 1966, derived from the following sources: Local primary, 265,000;

Table 15.—Non-Communist Europe: Consumption of primary aluminum

(Thousand short tons)

Country	1963	1964	1965 r	1966	1967
United Kingdom	351.1	401.4	400.6	407.1	397.3
Germany, West	334.4	390.2	400.2	439.5	455.5
France	267.3	274.8	274.0	328.7	324.0
Italy	141.1	132.3	141.1	188.4	202.8
Belgium-Luxembourg	98.0	124.1	129.0	168.1	144.3
Switzerland	(1)	56.2	68.3	65.8	65.3
Sweden	55.9	56.4	48.7	65.7	51.1
Austria	46.0	50.7	53.1	48.6	66.7
Spain	24.3	50.7	70.5	93.3	86.2
Norway	23.7	40.8	33.6	43.0	37.5
Other countries [2]	46.8	50.9	58.2	67.9	67.8
Total	1,440.0	1,628.5	1,677.3	1,916.1	1,898.5

r Revised.
[1] Data not available. Estimate included in total.
[2] Netherlands, Greece, Denmark, Portugal, Ireland, Finland, and Turkey. Includes Bureau of Mines estimates.
Source: Organization for Economic Cooperation and Development (OECD).

local secondary, 195,000; and primary imports, 195,000.

Kaiser Aluminum Kabel-Werk G. m. b.H., a subsidiary of Kaiser Aluminum & Chemical Corp., negotiated for a plant site at Voerde near Dinslaken on the Rhine for construction of a 65,000-ton-per-year aluminum smelter. A joint venture formed by Metallgesellschaft A. G., Frankfort, and Schweizerische Aluminum A. G., Switzerland, announced plans for a comparable aluminum capacity in the same area.

The VAW-Alcan aluminum fabricating plant at Nort, near Neuss, a joint venture of Vereinigte Aluminium Werke A. G. (VAW) and Alcan Aluminium Limited began production. The plant's hot and cold mills with an annual capacity of 200,000 tons is expected to increase the country's fabricating capacity by about 50 percent when full production is attained in 1968.

Greece.—The 80,000-ton-per-year aluminum reduction plant of Aluminium de Gréce, S. A., reached full capacity in 1967. Plans were announced for construction of a second unit in the same area at Distomon on the Gulf of Corinth which will double annual capacities to 400,000 tons of alumina and 160,000 tons of aluminum.

Italy.—Aluminio Sarda, a consortium of Italian and Belgian companies, announced that its plans for a 110,000-ton-per-year aluminum reduction plant on the island of Sardinia had reached an advanced stage. The plant is reportedly scheduled for completion in 1970. Production in 1967 of 140,000 tons represented near capacity.

Netherlands.—The capacity of the 35,000-ton-per-year aluminum reduction plant at Delfzijl, which went into operation as this country's first primary aluminum plant in mid-1966, will be increased to 80,000 tons per year. The plant used natural gas for fuel and is operated by Aluminium Delfzijl N. V. (ALDEL), a joint venture of the Swiss company, Schweizerische Aluminium A. G. (Alusuisse) and the Dutch enterprises, N. V. Billiton Maatschappij and Royal Netherlands Blast Furnaces & Steel Works (Hoogovens). The alumina is supplied by Suriname Aluminum Co. (SURALCO), a subsidiary of Aluminum Company of America.

Norway.—An agreement was reached for the integration of the Government owned A/S Aardal Og Sunndal Verk (ASV), Norway's largest primary aluminum producer, with Aluminum Company of Canada, Ltd. (Alcan), a subsidiary of Alcan Aluminium Ltd. The new Alcan/ASV Company will have an annual capacity of about 265,000 tons when expansions are completed and will also own the Nordisk Aluminium Industrl fabricating plant near Oslo.

A/S Alnor Aluminum owned jointly by Norsk Hydro-Elektrisk, A/S and Harvey Aluminum, Inc., started production at its 88,000-ton-per-year aluminum reduction plant at Haavik on the island of Karmoy. An integrated 66,000-ton-per-year fabrication plant was scheduled for completion in early 1968.

Construction was started on a 33,000-ton-per-year aluminum reduction plant by Alcoa and Elektrokemish, A/S (Elken) at Lista. Startup is scheduled for early 1970 with expansions to 110,000 tons planned when power is available.

Poland.—The new Konin Aluminum works in the Posaan district reached full capacity of 52,500 tons per year. The older plant at Skawina also operated at capacity and will be expanded to 66,000 tons per year.

Construction of an alumina-from-clay plant near Kielce was announced. Although Poland is now totally reliant on bauxite imports, large clay deposits containing over 25 percent alumina form the overburden of brown coal deposits being exploited by strip mining.

Rumania.—Primary aluminum annual capacity at the Slatina reduction plant was expanded to 82,500 tons and construction was started to further expand to 120,000 tons by 1969. Expansion of the associated alumina works to 200,000 tons will be completed in 1968. Anode plant capacity was 24,000 tons per year, sufficient to cover the requirements of the full expansion.

Spain.—The four primary aluminum reduction plants (two Government-controlled and two privately owned) expanded annual capacity to 96,000 tons at yearend with additional expansions planned to 142,000 by 1970. Consumption, however, was equal to production in 1967 and planned expansions are not expected to make Spain a net exporter.

Sweden.—Svenska Metallverken and its subsidiary Svenska Aluminiumkompaniet (Sako) increased productive capacity for both primary and worked aluminum. The rolling mill at Finspong increased annual capacity from 39,000 to 78,000 tons and the reduction plant at Sundsvall, Sweden's only primary producer, will attain a 55,000-ton-per-year capacity in 1968.

United Kingdom.—The Foyers Works of British Aluminium Co., Ltd. (BACO), producer of super pure (99.99 percent) aluminum ceased operations in 1967.

Negotiations were underway throughout the last half of 1967 among Government officials and representatives of Alcan, BACO and Rio Tinto-Zinc Corp., Ltd. (RTZ), for competitive bids on the construction of two 120,000-ton-per-year primary aluminum reduction plants in the British Isles—one to be in production by 1970 and the other by 1974. Cost studies were conducted on nuclear versus coal-fired powerplants as a source of electricity.

U.S.S.R.—Estimated annual production of aluminum was revised downward by 200,000 tons to 480,000 tons for the past 4 years to eliminate secondary production and to report estimated primary production only—about 1 million tons in 1967.

As the world's second largest primary aluminum producer, the U.S.S.R. exported about 325,000 tons; imports were negligible.

Yugoslavia.—Announcement was made of the formation of a bauxite-aluminum-power complex near Titograd in Montenegro, to be financed by Yugoslav Investment Bank funds. Primary aluminum capacity is planned for 55,000 tons per year with startup scheduled for 1971.

AFRICA

Angola.—Aluminio Portugues (SARL) secured the necessary financing to complete the company's aluminum reduction plant at Dondo with Péchiney participation. Startup is scheduled for 1970 with initial annual capacity of 27,500 tons which will later be doubled.

Cameroon.—A water shortage again curtailed production of primary aluminum at the Edea plant of Compagnie Camerounaise de l'Aluminium (ALUCAM), Africa's first aluminum reduction facility.

Construction was started on a third dam on the Sanaga River which when completed in 1971 is expected to make available sufficient hydroelectric power to attain full capacity of 66,000 tons per year.

An aluminum rolling mill to produce roofing and semi-finished corrugated sheeting was dedicated at a site adjacent to the ALUCAM plant.

Ghana.—Africa's second primary aluminum producer, Volta Aluminum Co. Ltd. (VAICO), made its first shipment in March and reached full capacity of 115,000 tons per year by yearend. The $122 million facility is owned 90 percent by Kaiser and 10 percent by Reynolds.

Libya.—Alcoa International, in a joint venture with Libyan investors, formed Aluminium Co. of Libya, Ltd. (Alcolib) to fabricate aluminum windows, doors, shopfronts, etc., for Libya's construction market.

Mozambique.—A group of industrialists applied for a license to establish a complex for the production of caustic soda, alumina, and aluminum to use bauxite from Malawi and from local deposits.

South Africa, Republic of.—It was announced that Richards Bay, about 100 miles north of Durban in Zululand, was selected as the site for a 55,000 tons per year aluminum reduction plant to startup in 1970. The $56 million joint venture of the Industrial Development Corp. (IDC) of South Africa and Allusuisse will reportedly use bauxite from Malawi. Constuction was scheduled to begin in May 1968.

United Arab Republic.—Agreement was reached for Poland to assist in the construction of a $35 million, 40,000-ton-per-year-capacity aluminum plant at Suez to process alumina from India. Completion was scheduled to coincide with that of the Aswan High Dam.

ASIA

India.—The Government-owned Bharat Aluminium Co., Ltd., announced plans to proceed with the Korba project which includes a 220,000-ton-per-year alumina plant to be built with Hungarian assistance, and a 110,000-ton aluminum reduction plant and allied manufacturing facility to be constructed with Soviet assistance. An agreement was also concluded with Vereinigte Aluminium-Werke, A. G. (VAW), for technical assistance in establishing a 27,500-ton-per-year aluminum reduction plant at Koyna, Maharashtra. Both plants were scheduled to be in production by 1971.

Action was taken by the Indian Aluminium Co. to establish an integrated bauxite mining-alumina refining-aluminum reduction plant in Mysore State to begin production in 1970 with initial annual capacity of 33,000 tons of primary aluminum.

Hindustan Aluminium Corp. Ltd., raised annual capacity at its aluminum reduction plant at Mettur, Madras, to 14,000 tons and announced plans to double capacity to 28,000 tons by late 1968.

Total expansions and new construction announced in 1967 will increase primary aluminum annual capacity in India to 365,000 tons by 1971.

Iran.—Negotiations for construction of a 55,000-ton-per-year aluminum reduction plant to be located in the western part of Iran were completed. The $44.5 million plant, scheduled for production by 1971, will be operated by Iran Aluminum Co. (IRALCO), owned 65 percent by Iran, 10 percent by Pakistan, and 25 percent by Reynolds Metals Co.

Japan.—Japan became the world's fourth largest producer of primary aluminum and advanced to third place in world consumption, producing and consuming 421,000 and 562,000 tons, respectively.

The aluminum shortage predicted early in the year failed to materialize and a surplus was reported by mid year, caused by an increase in net imports of primary aluminum from 28,900 tons in 1966 to 132,800 in 1967.

The fifth primary aluminum production company in Japan, The Mitsui Aluminum Industry Co., composed of six Mitsui Group companies, was organized. A 33,000-ton-per-year aluminum reduction plant on the island of Kyushu is scheduled for completion in late 1969 with expansion to 66,000 tons by 1972. Alumina will be imported from Australia.

Japan Light Metals Co. Ltd. (50-percent owned by Alcan) announced plans for construction of a new 55,000-ton-per-year aluminum reduction plant at Tomakomai, Hokkaido, scheduled to be in production by 1971. The new plant will increase the annual aluminum capacity of the company to about 300,000 tons by 1972.

The 19,000-ton-per-year aluminum reduction plant of Sumitomo Chemical Co. Ltd. began operation in June. Expansions are underway to increase capacity to 75,000 tons per year, which when completed by 1971 will increase the company's total capacity to 163,500 tons.

The aluminum melting and casting facility (hot mill) of Sky Aluminium Co. Ltd. was commissioned in April. The 148-inch mill is the largest of its kind in Japan.

Taiwan.—The Taiwan Aluminum Corp., the only producer of aluminum in Taiwan, began installation of equipment to increase annual capacity from 22,000 to 35,000 tons. The expansion is scheduled for completion in 1968.

Turkey.—An agreement was signed between Turkey and the Soviet Union for construction of a $110 million aluminum reduction plant at Seydisehir, about 180 miles south of Ankara. Scheduled for startup in 1972, the plant will have an annual capacity of 66,000 tons.

OCEANIA

Australia.—Comalco Aluminum, Ltd. (capacity 72,000 tons per year); Alcoa of Australia, Pty. Ltd. (capacity 45,000 tons per year), and, Alcan Australia, Ltd., with a 40,000 ton per year aluminum reduction plant under construction at Kurri Kurri, near Sydney, formed the Aluminum Association of Australia and an Aluminum Development Council for market development and sales promotion, compilation of statistics, and the establishment of industrial standards.

New Zealand.—Negotiations reached an advanced stage among two Japanese aluminum producers, Sumitomo Chemical Co. Ltd. and Shoua Electro-Chemical Industry Co. Ltd., and Comalco Industries, Pty., Ltd. (50-percent owned by Kaiser) for construction of a 100,000-ton-per-year aluminum reduction plant at Bluff, South Island, to utilize alumina from Gladstone, Australia. Electric power will be available from Manapouri hydroelectric project at an estimated cost of 0.2 cent per kilowatt-hour, reportedly the lowest rate in the world.

TECHNOLOGY

Direct operating costs and electric energy consumption at the Intalco Aluminum Corp., 152,000-ton-per-year alumina reduction plant at Bellingham, Wash., which began operation in 1966, reportedly were the lowest in the industry.[4] Utilization of large reduction cells (15 feet wide, 25 feet long, and 4 feet deep) and high current densities (120,000 amperes) reportedly resulted in lower heat losses and electric energy consumption. Additional efficiency was achieved through extensive use of mechanization in feeding alumina and fluoride compounds to the cells, removal of molten aluminum from the cell, and in mixing electrode ingredients to achieve optimum and uniform properties.

Fluorine-containing vapors, other gases, and small particles of alumina and other materials that emanate from the reduction cells during operation are removed from the air at the Intalco plant by a system of fiber-glass-reinforced plastic scrubbers installed in the roof of the potrooms. Although the $9 million cost of the system reportedly was somewhat higher than for other systems used in the industry, the firm expected to achieve savings in operating and maintenance costs using the plastic scrubbers. Each of the 120 plastic scrubbers in use at the plant weigh 18,000 pounds and employ 80 horizontal water sprays. The system uses more than 3 million gallons of water per day.[5]

Aluminum metal is produced commercially in up to 200 individual reduction cells, electrically connected in series to make up the potline. The rate at which aluminum is produced in each of the cells is proportional to the product of the total line current and the current efficiency prevailing in the cell. Hence, changes in the operating conditions in an individual cell affect the rate of production in all of the cells in the line. The factors affecting the operating of the cell such as the chemical composition and electrical properties of the cell bath, the bath temperature, the distance between the electrodes in the cell, and the effects of these factors on the efficiency of the production process have been investigated for many years. A series of reports presented at the 1966 annual meeting of American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) reflected the increasing trend in the aluminum industry toward the use of computers and automatic devices to measure and control the production process and achieve maximum current efficiencies consistent with economic considerations.[6]

The addition of lithium salts to the alumina reduction cell electrolyte was found to increase aluminum output by 10 to 12 percent, with simultaneous reduction in power, anode carbon, and electrolyte consumption.[7] Extensive use of lithium in commercial operations may be achieved in the future if an assured supply can be developed and the initial cost of the lithium can be reduced. Development of suitable methods to recover lithium from used pot linings and plant fumes also would improve the economics of its use in aluminum production.

Although aluminum was first prepared by electrolysis of aluminum chloride in a sodium chloride electrolyte in 1854, the literature subsequent to the introduction of the Hall-Heroult process which has been used commercially since 1896, shows little published data on chloride processes. This chloride electrodeposition process carries a potential economic advantage over the commercial Hall-Heroult method, because nonconsumable anodes may be used with a significant saving in cost and because its lower temperatures are more economical to maintain. Research resulted in the establishment of conditions for small-scale deposition of aluminum from a molten chloride bath in two different cell designs and systems, one using a solid titanium diboride cathode. It was con-

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[4] Chemical Engineering. New Techniques in Auminum Production. V. 74, No. 12, June 5, 1967, pp. 102–104.
Modern Metals. France's Pechiney "Invades" U.S. Primary Aluminum Business. V. 22, No. 9, October 1966, pp. 55–58.

[5] Steel. Intalco Puts Lid on Air Pollution. V. 159, No. 10, Sept. 5, 1966, p. 42.

[6] Kojima, T., and S. Ichihara. Prospects for Automation of the Aluminum Reduction Process. J. Metals, v. 8, No. 3, March 1966, pp. 312–316.
McMahon, T. K., and G. P. Dirth. Computer Control of Alum'num Reduction Cells. J. Metals, v. 18, No. 3, March 1966, pp. 317–319.
McMinn, C. J. Status of Gas Analysis Control of Aluminum Reduction Cells. J. Metals, v. 18, No. 3, March 1966, pp. 308–311.

[7] Lewis, R. A. Aluminum Reduction: Evaluating 5 Percent Lif-Modified Hall Bath in 10KA Experimental Reduction Cells. J. Metals, v. 19, No. 5, May 1967, pp. 30–36.

cluded that the results were favorable enough to warrant further research in cells of increased capacity.[8]

During 1967 interest continued in direct reduction processes for aluminum. However, research was abruptly terminated on the Alcan Aluminum, Ltd., subhalide process which had excited the most interest and about which the most information had been released. Technical reasons for the decision were not given but it was known that severe temperature conditions, problems of handling the hot metal, and the corrosive nature of the gases made it difficult to scale up the process from laboratory to semiworks.[9] By postponing revamping the 8,000-ton-per-year experimental plant indefinitely the company stated that total research-and-development expenditures were reduced by 15 to 20 percent, or by approximately $2 to $3 million.[10]

Reynolds Metals Co. has a direct-reduction pilot plant in operation at Richmond, Va. The Reynolds process reportedly uses a raw material which is half alumina and half low-grade bauxite or clay. It is a single-step electrolytic process that eliminates the alumina stage in the present bauxite-alumina-metal process. It produces aluminum of less purity than the present process. However, plant equipment investment is considerably reduced. The company predicted that in 10 years it could be producing 20 percent of its aluminum by this process.[11]

High-purity aluminum (99.99 percent Al) was produced for many years by refining commercial-purity aluminum in the Hoopes cell. Since 1960 lower cost precipitation-crystallization methods have been developed. One of the most recently developed methods includes treatment of the molten aluminum with boron to precipitate high melting point impurities. After separation the liquid phase is partially crystallized, the crystals separated and partially remelted. The unremelted crystals, which are the high-purity metal, are then recovered.[12]

A new die casting process, Acurad, developed by General Motors Corp., was reported as likely to increase the use of aluminum in the automobile industry as well as in other consuming industries. This process results in castings 3 to 5 percent denser than those from conventional methods, and which are more uniform and dimensionally accurate and have a better surface finish. Undersurface defects from trapped air bubbles are said to be virtually eliminated.

The claimed improvements result largely from use of a double-plunger system in which the second plunger is smaller in radius and is a concentric part of the first plunger. The second plunger forces more molten metal into the die cavity at just the proper moment of solidification, filling the voids and eliminating air bubbles. Other modifications include lower velocity of injection of the molten metal into the die, use of a wider gate on the die, and better cooling of the die.[13]

Development of the Acurad die casting equipment was likely to advance the use of aluminum engine blocks. Studies were conducted to eliminate the need for cast iron sleeves in the cylinder bores of an aluminum engine block to make it economically competitive with the cast iron block. It appeared that an aluminum alloy containing 14 to 19 percent silicon would be used and a method called silicon-lap finishing was developed, whereby a controlled amount of softer aluminum alloy components is removed leaving the harder silicon particles slightly raised on the bore surface. This preconditions the surface of the bore so that wear is minimized when starting the engine in cold weather.[14]

Master alloys or hardeners have been used in the aluminum industry for many years. Such alloys, which combine aluminum with such metals as titanium, zirconium, manganese, and chromium, pro-

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[8] Good, P. C., M. O. Butler, and L. A. Yerkes. Electrodeposition of Aluminum From Fused-Salt Electrolytes Containing Aluminum Chloride. BuMines Rept. of Inv. 6785, 1966, 13 pp.

[9] Chemical Week. Go Directly to Aluminum. V. 101, No. 12, Sept. 16, 1967, pp. 89–91, 94, 96.

[10] Chemical Week. Aluminum by Direct Reduction Has Been Shelved. V. 101, No. 14, Sept. 30, 1967, p. 54.

Work cited in footnote 9.

[11] Light Metal Age. Reynolds Expands Pacific Northwest Production. V. 24 Nos. 9–10, October 1966, pp. 6–8.

Wall Street Journal. Alcan Aluminum Delays Bid To Find New Process. V. 170, No. 58, Sept. 22, 1967, p. 10.

[12] Russell, Allen S., Stanley C. Jacobs, Noel Jarrett, and Bernard M. Starner. A New Process To Produce High-Purity Aluminum. Trans. AIME v. 239 (Metallurgy), No. 10, October 1967, pp. 1630–1633.

[13] Light Metal Age. New Low Pressure Double-Plunger System for Aluminum. V. 24, Nos. 7–8, August 1966, pp. 6–9.

Parker, Bill. Aluminum Use Given Sizeable Lift by GM's New "Acurad" Technique. Am. Metal Market, v. 73, No. 150, Aug. 4, 1966, pp. 2, 15.

[14] Murray R. W. Aluminum Engine Technology: Where Is It Now? Iron Age, v. 199, No. 5, Feb. 2, 1967, pp. 70–71.

vide a convenient and efficient means for introducing and dispersing alloying ingredients into the molten metal in the furnace. The result is an aluminum alloy with greater castability, better physical properties, and improved electrical conductivity. The development of high-purity master alloys and effective methods of adding them to the product have made an important contribution to the versatility of aluminum. Methods of producing master alloys, new developments, and the future of the industry were discussed.[15]

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[15] Hoff, J. C. Master Alloys Aid Aluminum Industry Growth. J. Metals, v. 18, No. 12, December 1966, pp. 1275–1277, 1285.

Antimony

By Donald E. Moulds [1]

In 1967, for the first time since 1964, activity in the antimony industry was below that of the previous year. The 12-percent decrease in consumption of primary antimony was reflected in a 14-percent decrease in output of primary antimony and a reduction in imports of ore, metal, and oxide. Output of byproduct antimony was adversely affected by the strike shutdown of lead smelters and refineries operated by American Smelting and Refining Company and International Smelting & Refining Co. Secondary production also continued the downward trend from the 1965 record level.

The price of imported chemical-grade ore increased approximately 50 cents per unit in the second and third quarters of the year owing to uncertainties of deliveries from mainland China and military requirements. The market eased in the fourth quarter with a resulting yearend price appoximately 30 cents per unit above the January quotation.

Legislation and Government Programs.—Under authorization of Public Law 88–615 enacted in 1964, the General Services Administration disposed of 60 tons and delivered 62 tons of surplus Government stocks of antimony, compared with the 66 tons sold and 58 tons delivered in 1966. After June 1, 1966, sales were off-the-shelf with a minimum acceptable order of 5 short tons of metal, 500 short-ton units of antimony as liquated antimony, or 2,500 short-ton units of antimony in ore. Sale price was based on the American Metal Market quotation, f.o.b. storage locations. Of the initial disposal authorization of 5,000 tons, 2,623 tons remained for sale at yearend. Total government inventory at the close of the year was 49,371 tons, of which 23,871 tons was surplus. In addition to the antimony inventory, the stockpile contained 10,500 tons of surplus antimonial lead, about 9,000 tons of which was available for disposal at the close of 1967.

Effective September 12, 1967, the Government participation in the allowable costs of exploring for antimony was increased from 50 percent to 75 percent, under the program administered by the Office of Minerals Exploration, Geological Survey, of the Department of the Interior.

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Table 1.—Salient antimony statistics

(Short tons)

	1963	1964	1965	1966	1967
United States:					
Production:					
Primary:					
Mine	645	632	845	927	892
Smelter [1]	12,117	13,358	12,389	14,539	12,466
Secondary	20,803	22,339	24,321	24,258	23,664
Exports of ore, metal and alloys	143	807	14	29	82
Imports, general (antimony content)	17,781	16,718	14,879	19,712	17,419
Consumption	[2] 16,532	15,839	16,919	19,681	17,350
Price: New York, average cents per pound	34.75	42.22	45.75	45.75	45.75
World: Production	63,882	70,816	70,541	68,513	64,402

[1] Includes primary content of antimonial lead produced at primary lead smelters.
[2] Includes primary content of antimonial lead produced at primary lead smelters and antimony content of imported alloys (not available after 1963).

DOMESTIC PRODUCTION

MINE PRODUCTION

Antimony produced as identified antimony ore and concentrates at domestic mines declined 4 percent to 892 tons. Lead-silver ores of the Coeur d'Alene district of Idaho accounted for 823 tons, slightly below the 834 tons registered in 1966, reflecting the strike-curtailed mining operations in the district. The antimony concentrates from Sunshine Mining Co., Hecla Mining Co., and Silver Dollar Mining Co. were processed into cathode metal, 96 percent antimony, at the Sunshine Mining Co. electrolytic plant.

Antimony concentrates containing about 10 tons of antimony were produced at the Stampede mine in Alaska. Antimony concentrates produced in 1966–67 at the Stibnite mine in Sanders County, Mont., and milled in the Raven flotation mill were shipped to the Laredo smelter. Approximately 53 tons of antimony, contained in concentrates and selected ore, was shipped from mines in Nevada to the Laredo, Tex., smelter.

Antimony Refining Company was reportedly constructing a 25-ton-per-day pilot oxidizing plant at Panaca, Nev., to process ores from Nevada, Utah, and Mexico.

SMELTER PRODUCTION

Primary.—The production of antimony in metal, oxide, and other products totaled 12,500 tons, a decrease of approximately 2,000 tons compared with the 1966 total. Foreign antimony ore and concentrates or byproduct antimony from foreign lead ores supplied 84 percent of the material for smelter production. Domestic sources supplied 16 percent, 7 percent from mine ore and 9 percent as a byproduct of domestic lead ores. Byproduct antimony recovered at primary lead refineries was mainly consumed at the refinery in manufacturing antimonial lead. A small amount was processed to oxide or recycled in residues. Smelter output of primary products, in ratios essentially the same as those of 1966, was divided as follows: Metal, 32 percent; oxide, 53 percent; antimonial lead, 12 percent; and sulfide and residues, 3 percent.

The National Lead Co. smelter at Laredo, Tex., and the Sunshine Mining Co. electrolytic plant produced antimony metal. American Smelting and Refining Company, Harshaw Chemical Co., McGean Chemical Co., M & T Chemicals, Inc., and National Lead Co. produced antimony oxide. Foote Mineral Co., Hummel Chemical Co., and McGean Chemical Co. processed ore for consumption as a sulfide. American Smelting and Refining Company was the major producer of byproduct antimony.

Secondary.—The processing of lead scrap at primary lead plants was sharply reduced owing to the strike during the second half of the year. Secondary antimony recovery decreased from 286 tons in 1966 to 185 tons in 1967. Secondary lead plants maintained about the same level of lead output, but antimony recovery decreased about 300 tons to 22,900 tons. Manufacturers and foundries recovered 840 tons of antimony while reprocessing manufacturing scrap, compared with 1,070 tons in 1966. Sources of old scrap, which contributed 89 percent of the secondary antimony, consisted of the following: Batteries, 66 percent; type metal, 22 percent; babbitt, 5 percent; and miscellaneous articles, 7 percent. Scrapped batteries continued to be an increasingly large source of secondary lead and antimony. New scrap consisting of residues and drosses from manufacturing and casting, amounted to 2,600 tons, or 11 percent of the total. Because the antimony recovered at secondary lead plants is normally insufficient to meet the commercial specifications of antimonial lead alloys, 3,350 tons of primary antimony was required to supplement the secondary antimony during 1967, compared with 3,830 tons in 1966.

Table 2.—Antimony mine production and shipments in the United States

(Short tons)

Year	Antimony concentrate		Antimony	
	Quantity	Antimony content, percent	Produced	Shipped
1963	3,540	18.2	645	503
1964	3,296	19.2	632	789
1965	4,711	17.9	845	848
1966	5,582	16.6	927	930
1967	5,402	16.5	892	828

Table 3.—Primary antimony produced in the United States

(Short tons, antimony content)

Year	Class of material produced					
	Metal	Oxide	Sulfide	Residues	By-product antimonial lead	Total
1963	4,160	5,983	76	392	1,506	12,117
1964	4,418	6,748	53	447	1,692	13,358
1965	4,216	6,485	94	205	1,389	12,389
1966	4,567	7,794	126	219	1,833	14,539
1967	4,002	6,612	71	249	1,532	12,466

Table 4.—Secondary antimony produced in the United States, by kind of scrap and form of recovery

(Short tons, antimony content)

Kind of scrap	1966	1967	Form of recovery	1966	1967
New scrap:					
Lead-base	2,786	2,516	In antimonial lead [1]	16,895	16,783
Tin-base	80	91	In other lead alloys	7,340	6,865
Total	2,866	2,607	In tin-base alloys	23	16
			Total	24,258	23,664
Old scrap:			Value (millions)	$22.2	$21.7
Lead-base	21,361	21,031			
Tin-base	31	26			
Total	21,392	21,057			
Grand total	24,258	23,664			

[1] Includes 286 tons of antimony recovered in antimonial lead from secondary sources at primary plants in 1966 and 185 tons in 1967.

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
1963	18,818	836	670	384	1,890	10.0
1964	24,023	997	695	303	1,995	8.3
1965	27,895	998	391	595	1,984	7.1
1966	24,059	1,417	416	286	2,119	8.8
1967	18,608	983	549	185	1,717	9.2

[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 requirements for antimony in various end products were derived from both primary and secondary sources. Total consumption decreased from 43,950 tons in 1966 to 41,010 tons in 1967. Primary antimony comprised 17,350 tons, 42 percent of the total, and secondary antimony, 23,660 tons. Secondary antimony was essentially all consumed in manufacture of antimonial lead and other hard-lead alloys. Consumption of secondary lead was not reported to the Bureau of Mines and industrial consumption by products is therefore confined to primary antimony.

Consumption of primary antimony decreased 12 percent compared with the record use attained in 1966. Antimony metal requirements continued the downward trend of recent years, especially in the manufacture of antimonial lead, owing to the increased availability of secondary antimony and, more importantly, the continued reduction in the antimony content of antimonial lead used for battery plates. Decreasing requirements for primary antimony in bearing metal and type metal was again evident. A major increase for ammunition reflected rising military requirements. Sheet and pipe requirements continued to rise and antimony used in solder was substantially above that used in 1966.

The use of antimony in nonmetal products, primarly as antimony oxide, represents 57 percent of the primary antimony consumed. The major use was in fire retardant compounds for textiles and plastics. To a large degree, the increase in recent years reflects major military requirements but, also, an increasing public demand for fireproofed materials. Pigment consumption continued to decline. Other uses of antimony, mainly as chemical compounds, ranged from fur processing to opacifying agents. Two compounds, antimony trichloride, with a wide range of applications, and sodium antimonate, predominantly an opacifying agent in enamels and glass, made up 75 percent of the 1,007 tons consumed in other nonmetal products The major decrease in 1967 was for sodium antimonate with requirements approximating one-third of the 1966 consumption.

The 1967 consumption data indicate a return to the normal level that existed prior to the sharp increase in industrial activity in 1966. The growth potential for primary antimony is indicated to be in the area of nonmetal products, although obscured by the current influence of military needs and other compensating trends. A decreasing demand for primary antimony for metal products is indicated by the trend toward the lower antimony content of alloys and the reduced requirements for type metal, bearing metal, and collapsible tubes because of new techniques and materials. The supply of primary and secondary antimony appears adequate to support the recent consumption level and indicate growth potential.

Table 6.—Industrial consumption of primary antimony in the United States

(Short tons, antimony content)

Year	Class of material consumed						
	Ore and concentrate	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	Total
1963 [1]	266	7,124	7,173	71	392	1,506	16,532
1964	252	6,050	7,325	73	447	1,692	15,839
1965	404	6,992	7,847	81	206	1,389	16,919
1966	450	6,269	10,829	81	219	1,833	19,681
1967	312	5,666	9,514	77	249	1,532	17,350

[1] Includes antimony content of imported alloys (not available after 1963).

Table 7.—Industrial consumption of primary antimony in the United States, by class of material produced

(Short tons, antimony content)

Product	1963	1964	1965	1966	1967
Metal products:					
Ammunition	W	15	36	154	209
Antimonial lead	[1] 6,462	5,952	6,382	6,285	5,539
Bearing metal and bearings	992	804	821	731	653
Cable covering	101	49	68	164	141
Castings	49	50	76	62	54
Collapsible tubes and foil	72	53	49	44	31
Sheet and pipe	81	99	104	107	118
Solder	188	149	244	155	184
Type metal	[1] 652	513	642	515	382
Other	199	167	214	219	223
Total	[1] 8,796	7,851	8,636	8,436	7,534
Nonmetal products:					
Ammunition primers	15	17	16	27	30
Fireworks	36	47	46	50	43
Flameproofing chemicals and compounds	1,601	1,626	1,971	3,188	3,454
Ceramics and glass	1,465	1,649	1,853	2,074	1,884
Matches	5	W	W	------	------
Pigments	1,009	1,173	855	832	665
Plastics	1,352	1,289	1,469	2,224	1,785
Rubber products	597	492	477	870	948
Other	1,656	1,695	1,596	1,980	1,007
Total	7,736	7,988	8,283	11,245	9,816
Grand total	16,532	15,839	16,919	19,681	17,350

W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1] Includes antimony content of imported alloys (not available after 1963).

STOCKS

Industrial stocks of antimony that were reported to the Bureau of Mines during the year reflected the favorable supply-demand balance. Stocks of ore and oxide, drawn down in the first quarter of 1967 to a total of 7,400 tons of antimony content were rebuilt in the second quarter to 8,600 tons and then declined in the third and fourth quarters to a yearend total of 8,350 tons. Metal stocks were somewhat above usual levels but other materials on hand were in the normal range.

Table 8.—Industry stocks of primary antimony in the United States, December 31

(Short tons, antimony content)

Stocks	1963	1964	1965	1966	1967
Ore and concentrate	1,970	1,647	2,735	2,720	2,469
Metal	1,420	1,433	1,585	1,572	1,719
Oxide	1,861	2,895	2,705	3,093	2,704
Sulfide	81	81	98	131	80
Residues and slags	1,081	935	1,088	519	916
Antimonial lead [1]	651	309	411	531	462
Total	7,064	7,300	8,622	8,566	8,350

[1] Inventories from primary sources at primary lead smelters only.

PRICES

The domestic prices of antimony metal, 99.5 percent, continued unchanged at 44 cents per pound, in bulk, f.o.b. Laredo, Tex. (45.75 cents at New York). The dealer price for imported metal, duty paid, New York, also continued in the range of 40 to 42 cents per pound, dependent on quality. The domestic price of oxide continued unchanged at 47.5 cents per pound in carload lots, freight allowed, east of the Rocky Mountains.

At the beginning of the year, the quoted price for prime 65 percent antimony ores at New York was $5.60 per short-ton unit of contained antimony. The price began to rise in April due to supply uncertainties relating to deliveries of metal to Europe from mainland China, blockage of the Suez Canal, and military requirements in Viet-Nam. From April through October, quotations were 40 to 50 cents per short-ton unit higher than earlier in the year. Prices eased late in the year and at yearend the quotation ranged from $5.90 to $5.95 per short-ton unit.

Table 9.—Antimony price ranges in 1967

		Price
Domestic metal [1]	per pound	$0.44
Foreign metal [2]	do	.40–.42
Antimony trioxide [3]	do	.475
Antimony ore, [3] 50–55 percent	per short-ton unit	4.70–5.30
Antimony ore, minimum 60 percent	do	5.50–6.10
Antimony ore, minimum 65 percent	do	5.60–6.20

[1] RMM brand, f.o.b.,Laredo, Tex.
[2] Duty-paid delivery, New York.
[3] Quoted in Metals Week.

FOREIGN TRADE

The export of antimony in metallic form—metal, alloys, waste, and scrap—amounted to 82 tons in 1967 valued at $75,000. Shipments were consigned to 13 countries with the leading importers Canada and Taiwan, receiving 44 tons and 29 tons, respectively. Export of antimony oxide amounted to 166 tons valued at $197,200. The Netherlands received 85 tons; India, 34 tons; Canada, 23 tons; and West Germany, 12 tons. The remaining 12 tons was divided among seven other countries.

General imports of antimony in all forms decreased from 20,600 tons in 1966 to 18,300 tons in 1967, all of which was entered for consumption except 27 tons of metal. The decrease brought receipts of ore and metal back to the 1965 level, but oxide imports remained more than double the 1965 total. The Republic of South Africa, Mexico, and Bolivia continued to supply most of the ore (91 percent). Yugoslavia and Belgium-Luxembourg were the principal suppliers of metal, and the United Kingdom and Belgium-Luxembourg supplied 82 percent of the oxide.

In addition to the imports of ore, metal, and oxide, 356 tons of alloy containing 83 percent or more of antimony by weight was imported, principally from the United Kingdom and Mexico; 73 tons of antimony tartrate was received from Italy and Japan; 32 tons of antimony sulfide came from France; and 7 tons of other antimony compounds came from the United Kingdom and West Germany. The value of these materials totaled $342,900.

Table 10.—U.S. imports [1] of antimony, by countries

Year and country	Antimony ore: Short tons (gross weight)	Antimony ore: Antimony content: Short tons	Antimony ore: Antimony content: Value (thousands)	Antimony metal [2]: Short tons (gross weight)	Antimony metal [2]: Value (thousands)	Antimony oxide: Short tons (gross weight)	Antimony oxide: Value (thousands)
1965	22,886	10,360	$4,310	2,719	$2,165	2,178	$1,802
1966:							
Australia	148	98	49	-----	-----	-----	-----
Belgium-Luxembourg	-----	-----	-----	518	390	1,751	1,323
Bolivia	5,627	3,470	1,559	19	17	-----	-----
Brazil	181	112	20	-----	-----	-----	-----
Canada	-----	-----	-----	(3)	18	11	9
Chile	1,154	723	334	6	5	-----	-----
France	-----	-----	-----	-----	-----	663	496
Germany, West	-----	-----	-----	(3)	1	261	189
Honduras	30	17	5	-----	-----	-----	-----
Ireland	-----	-----	-----	(3)	1	-----	-----
Italy	141	85	40	-----	-----	-----	-----
Japan	-----	-----	-----	-----	-----	5	4
Mexico	12,288	3,868	723	382	248	-----	-----
Morocco	138	65	15	-----	-----	-----	-----
Netherlands	-----	-----	-----	-----	-----	27	21
Peru	-----	-----	-----	187	126	-----	-----
South Africa, Republic of	6,496	4,006	2,001	-----	-----	-----	-----
Spain	-----	-----	-----	22	17	-----	-----
Turkey	26	16	8	17	10	-----	-----
United Kingdom	-----	-----	-----	288	216	2,648	1,946
Yugoslavia	-----	-----	-----	1,366	1,003	17	10
Total	26,229	12,460	4,754	2,805	2,052	5,383	3,998
1967:							
Belgium-Luxembourg	-----	-----	-----	807	585	1,928	1,461
Bolivia	3,946	2,439	1,155	5	3	-----	-----
Canada	-----	-----	-----	(3)	17	-----	-----
Chile	831	507	220	-----	-----	-----	-----
France	-----	-----	-----	-----	-----	699	514
Germany, West	-----	-----	-----	11	9	170	124
Mexico	10,369	3,018	570	204	101	-----	-----
Morocco	334	164	42	-----	-----	-----	-----
Mozambique	112	69	33	-----	-----	-----	-----
Netherlands	-----	-----	-----	-----	-----	39	30
Peru	198	131	52	58	34	-----	-----
South Africa, Republic of	6,751	4,117	2,003	-----	-----	-----	-----
Thailand	106	72	15	94	42	-----	-----
Turkey	-----	-----	-----	11	7	-----	-----
United Kingdom	-----	-----	-----	283	200	2,262	1,633
Yugoslavia	-----	-----	-----	1,208	868	-----	-----
Total	22,647	10,517	4,090	2,681	1,866	5,098	3,762

[1] Data are general imports: that is, they include antimony imported for immediate consumption plus material entering the country under bond. Table does not include antimony contained in lead-silver ores.
[2] Includes data for needle or liquated antimony for the following countries (value in thousand dollars): 1965: United Kingdom, 20 tons ($16); 1966: 28 tons ($21); 1967: 5 tons ($4); 1965: Belgium-Luxembourg, 3 tons ($2); 1966: 35 tons ($21); 1967: 24 tons ($14).
[3] Less than ½ unit.

Table 11.—U.S. imports for consumption of antimony [1]

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: Short tons	Antimony metal: Value (thousands)	Antimony oxide: Short tons (gross weight)	Antimony oxide: Value (thousands)
1965	22,886	10,360	$4,310	23	$18	2,650	$2,112	2,173	$1,798
1966	26,229	12,460	4,754	63	42	2,767	2,031	5,383	3,998
1967	22,647	10,517	4,090	29	18	2,654	1,849	5,098	3,762

[1] Does not include antimony contained in lead-silver ore.

WORLD REVIEW

The world supply-demand situation for antimony remained relatively balanced through 1967 even though demand continued at a high level, especially for high-quality ores and concentrates. The market was easy early in the year but uncertainties concerning delivery of metal purchased at the Canton, China, business fairs during 1966 had strengthened the foreign price of metal and ore early in April. Blockage of the Suez Canal and the Israel–Arab conflict in June increased the uncertainties of antimony supply and demand in Europe and the prices of metal and ores continued strong into October. Delivery of Chinese metal and ore to European and Japanese ports during the second half of 1967, together with easing of the political situation and a declining consumption, resulted in a downward movement of metal and ore prices in the fourth quarter of the year.

The Republic of South Africa and Bolivia, the main sources of premium-quality oxide ores, responded to the strong demand with an increase in output. Consolidated Murchison Goldfields and Development Co., Ltd., South Africa, increased their milling rate to capacity in the second half of the year, producing 14,200 tons of antimony in concentrates and cobbed ore, compared with 12,600 tons in 1966. Ore reserves were increased slightly by extensive exploration and development work.[2] Bolivian production exceeded 12,000 tons, principally from the medium mines, and exports were about 12,600 tons, compared with 11,800 tons in 1966. Mexican production, principally as ore for smelting at Laredo, Tex., declined from 4,900 tons in

[2] Consolidated Murchison Goldfields and Development Co., Ltd. Annual Report (Transvaal). 1967, pp. 14–15.

Table 12.—World production of antimony (content of ore except as indicated) by countries[1]

(Short tons)

Country	1963	1964	1965	1966	1967 p
North America:					
Canada [2]	801	796	651	r 703	622
Guatemala	[3] 31	------	------	15	33
Mexico	r 5,331	r 5,111	r 4,917	r 4,868	4,199
United States	645	632	945	927	892
South America:					
Bolivia [4]	r 8,321	r 10,604	r 10,606	r 11,729	12,421
Peru (recoverable)[4]	674	752	713	741	699
Europe:					
Austria (recoverable)	548	585	434	250	212
Czechoslovakia e	2,200	2,200	2,200	2,200	2,200
France	110	119	133	r 308	NA
Italy	266	592	293	r 292	e 480
Portugal	7	13	12	r 4	e 8
Spain	65	60	95	100	e 130
U.S.S.R. e	6,700	6,700	6,800	r 6,900	7,100
Yugoslavia (metal)	2,933	3,008	3,051	2,916	2,533
Africa:					
Algeria	------	------	71	e 70	e 70
Morocco	744	1,720	2,425	1,480	1,753
Rhodesia, Southern	66	49	e 200	NA	NA
South Africa, Republic of	12,410	14,200	13,901	12,534	14,216
Asia:					
Burma e [4]	165	165	165	r 165	165
China, mainland e	16,500	16,500	16,500	16,500	13,200
Japan	212	554	202	85	64
Pakistan	9	90	67	NA	NA
Sarawak	------	86	61	65	34
Thailand	676	1,399	r 1,246	1,177	1,131
Turkey	r 3,340	r 3,631	r 3,896	r 3,396	e 2,240
Oceania: Australia [5]	r 1,128	r 1,250	r 1,057	r 1,088	NA
Total [6]	r 63,882	r 70,816	r 70,541	r 68,513	64,402

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Compiled mostly from data available May 1968.
[2] Antimony content of smelter products.
[3] U.S. imports.
[4] Includes antimony content of smelter products derived from mixed ores.
[5] Includes antimony in lead concentrates.
[6] Total is of listed figures only; no undisclosed data included.

1966 to 4,200 tons. Moroccan and Spanish output increased, but that of Austria, Japan, Peru, Thailand, and Turkey declined.

About 50 percent of the output of Peruvian antimony is derived as a byproduct at the Cerro de Pasco lead refinery. A planned change in the antimony extraction process, which will increase byproduct output to 1,800 tons annually within the next 2 years, has been announced.

TECHNOLOGY

The increasing production of antimony as a byproduct of recycling antimonial lead scrap continues to focus research in this area with the objective of improved recovery and improved tailoring of antimonial alloys to the desired alloy performance. The development of oxygen-enriched smelting has promise in achieving greater smelting efficiency. The depletions of high-grade oxide ores necessitate greater attention to improvement of concentration methods at the mines and in operating techniques at the oxide smelters.

Increasing public attention toward fire hazards inherent in plastics and textiles, with possible expansion of fire-retardant standards and markets, has stimulated research to devise new formulations.[3] A new development is a boric acid-antimony trioxide agent added to the constituents of wood-based materials with a resultant ability to withstand very high temperature without ignition.

A development in the catalyst field was a process for recovering antimony trifluoride from spent complex hydrocarbon compounds.[4] Research has also developed in commerical quantities a semiconductor-grade antimony trisulfide with purity higher than 99.999 percent.

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[3] Modern Plastics. Flame Retardance—Key to New Plastics Markets. October 1964, pp. 84–89, 168–172

[4] Oelderik, Jan M. (assigned to Shell Oil Company, New York). Process for Recovering SbF_3 from Spent $HSbF_6$ Catalyst. U.S. Pat. 3,278,259, Oct. 11, 1966.

Asbestos

By Timothy C. May[1]

The market for asbestos was off in 1967 as a result of reduced construction activity. Because of lower levels of residential commercial water and sewer system construction, sales volume of asbestos was less than in the previous year. United States production in 1967 dropped 2 percent, and output in Canada, the largest producer, was almost 3 percent less than in 1966. Imports of amosite and crocidolite from the Republic of South Africa, the principal source, was reduced drastically, while exports of asbestos manufactured products increased in 1967.

Table 1.—Salient asbestos statistics

	1963	1964	1965	1966	1967
United States:					
Production (sales) short tons	66,396	101,092	118,275	125,928	123,189
Value thousands	$5,108	$8,143	$10,162	$11,056	$11,102
Exports and reexports (unmanufactured) short tons	10,044	27,147	43,126	46,996	47,718
Value thousands	$1,304	$3,199	$5,294	$5,763	$6,025
Exports and reexports of asbestos products (value) thousands	$16,267	$16,288	$19,139	$21,963	$23,767
Imports for consumption (unmanufactured) short tons	667,860	739,361	719,559	726,459	645,112
Value thousands	$61,739	$72,973	$70,457	$73,100	$65,743
Consumption, apparent [1] short tons	724,212	813,306	794,708	805,391	720,583
World: Production do	2,762,000	3,051,000	3,146,000	3,359,000	NA

NA Not available.
[1] Measured by quantity produced, plus imports, minus exports.

Legislation and Government Programs.—The U.S. Department of Agriculture invited U.S. firms to submit barter offers to deliver chrysotile asbestos valued at approximately $4.5 million to India for the Agency for International Development (AID). Successful offerors furnished asbestos to India and received payment in agricultural commodities from Commodity Credit Corporation (CCC) stocks. The agricultural commodities will be exported to eligible barter destinations. The barter arrangements helped reduce the outflow of U.S. dollars because the proceeds from the sale of the agricultural commodities abroad were used to pay for the asbestos while AID dollars were paid to CCC.[2]

The General Services Administration in 1967 disposed of 110.44 short tons of subspecification chrysotile from the Defense Production Act inventory. Also sold were 300 tons of amosite and 150 tons of crocidolite obtained under the barter program.

The stockpile position for asbestos as of December 31, 1967, is shown in table 2.

[1] Commodity specialist, Division of Mineral Studies.
[2] U.S. Department of Agriculture. Press Release 2932–67, Washington, D.C., Sept. 14, 1967.

Table 2.—Stockpile objective and Government inventories as of December 31, 1967

(Short tons)

	Stockpile objective	National	Supplemental	Commodity Credit Corporation	Defense Production Act	Total
Amosite	40,000	11,705	54,100	--------	--------	65,805
Chrysotile	13,700	6,073	4,383	--------	--------	10,456
(Subspecification)	------	152	3,193	--------	1,883	5,228
Crocidolite	------	1,565	46,696	--------	--------	48,261

Under Presidential action asbestos imports from Southern Rhodesia were barred after December 16, 1966. The decree also bans dealings abroad in these products by Americans and Rhodesian subsidiaries of U.S. firms.[3]

DOMESTIC PRODUCTION

Asbestos production in the United States in 1967 declined 2 percent in volume, but the value was slightly higher than in 1966. Arizona volume was 14 percent below that of 1966, although the value was 5 percent more, owing to sales of better quality material. Production in California, the largest producer was 6 percent lower in volume and 3 percent less in value than in 1966. North Carolina, the smallest producer, dropped 5 percent in volume and 8 percent in value compared with 1966 level. Production in Vermont, the only State to show an increase, was 6 percent higher in volume and 7 percent more in value. Nearly all U.S. production was short fiber. U.S. production supplied approximately 17 percent of domestic requirements for asbestos. Producers of asbestos in the United States are listed in the following tabulation:

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 Minerals 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.
Vermont:			
General Aniline & Film Corp The Ruberoid Division.	Orleans	Lowell	Chrysotile.

The Ruberoid Co., operator of Vermont Asbestos Mines, merged with General Aniline & Film Corp. (GAF), a diversified producer of dyestuffs, chemicals, photographic products, and copying equipment. According to the merger agreement, GAF was the surviving corporation and Ruberoid operated as a division.[4]

CONSUMPTION AND USES

The principal markets for asbestos were in the building and construction industries, largely in the manufacture of asbestos cement products. Because of lower levels of activity in the construction industry in 1967, fiber shipments to this consuming sector decreased.

Asbestos is also used in the manufacture of friction materials, gaskets, textiles,

[3] Federal Register. Relating to Trade and Other Transaction Involving Southern Rhodesia. V. 32, Jan. 17, 1967, pp. 119–120.

[4] Asbestos. V. 48, No. 12, June 1967, p. 12.

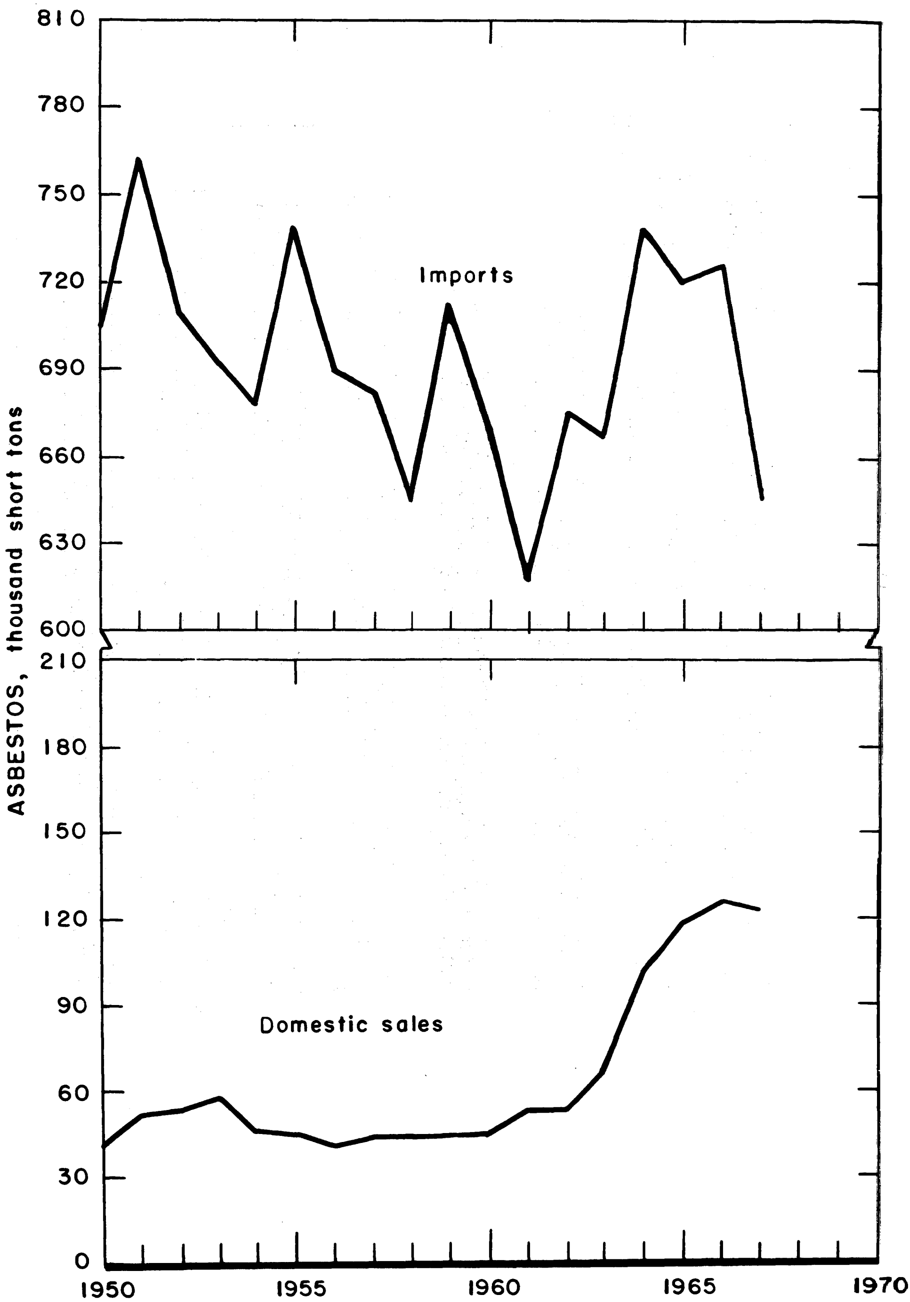

Figure 1.—United States production (sales) and imports of asbestos.

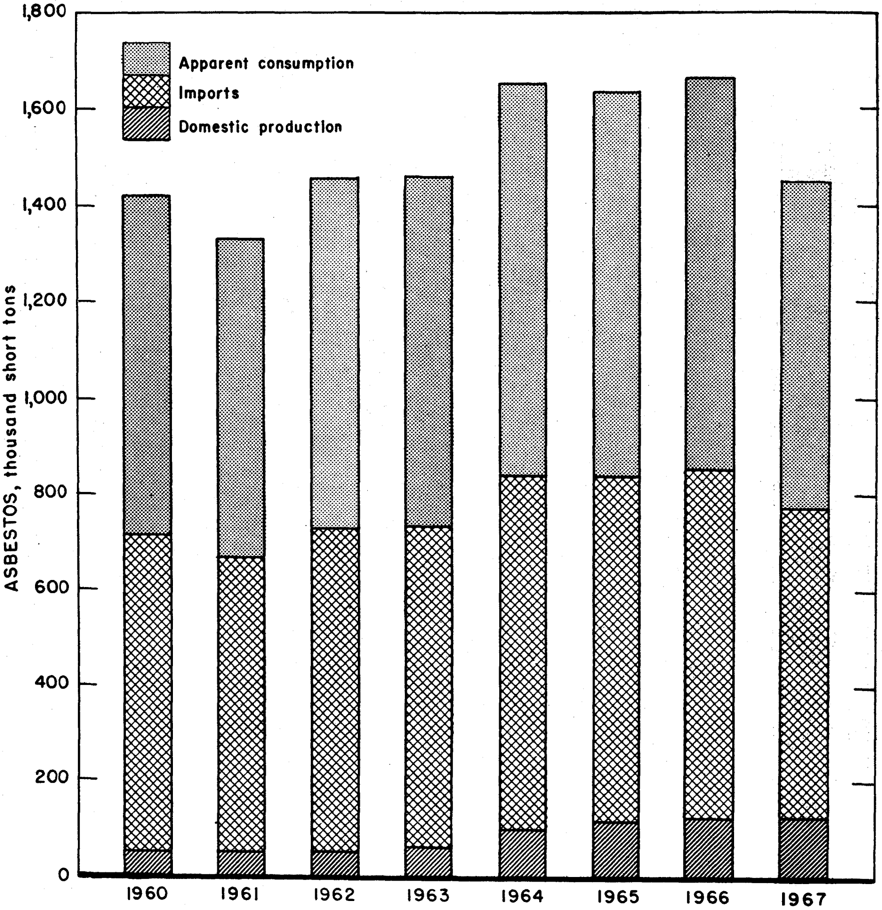

Figure 2.—Domestic supply and consumption of asbestos.

plastics, paints, roof coating, caulking, and numerous miscellaneous items. Nearly 17 percent of the asbestos consumed was from domestic mines. Chrysotile asbestos accounted for 96 percent of the total amount consumed, crocidolite 2 percent, and amosite 2 percent.

Automatic transmissions get their drive from metal transmission disks that are covered with a super-tough paper containing crocidolite asbestos fiber. The average automobile with power shift contains from eight to 12 of the paper-lined disks. The output of more than 6 million automatic transmissions annually requires disk paper in hundreds of tons.[5]

PRICES [6]

Prices for Vermont, Quebec and British Columbia, Canada, asbestos increased approximately 5 percent effective April 1, 1967. It was reported that the increase was needed to help offset higher costs, particularly labor and materials.

Prices were not published for California and North Carolina asbestos.

[5] North American Asbestos Corp. Asbestos News. V. 2, No. 7, July 1967, p. 1.
[6] Asbestos. V. 48, No. 10, April 1967, p. 54.

Quotations for Canadian (Quebec) chrysotile f.o.b. mine were as follows:

Grade	Description	Per short ton	
		March 31, 1967	April 1, 1967
Group No. 1	Crude	Can $1,410	Can $1,410
Group No. 2	do	640 to 875	760
Group No. 3	Spinning fiber	345 to 565	360 to 588
Group No. 4	Shingle fiber	190 to 320	198 to 335
Group No. 5	Paper fiber	115 to 156	140 to 165
Group No. 6	Waste, stucco	95	101
Group No. 7	Refuse or shorts	40 to 80	47 to 85

Prices for British Columbia, Canada, chrysotile asbestos, f.o.b. Vancouver, were as follows:

Grade	Description	Per short ton	
		March 31, 1967	April 1, 1967
AAA	Nonferrous spinning fiber	Can $787	Can $810
AA	do	625	643
A	do	470	484
AC	Asbestos-cement fiber	325	345
AD	Shingle fiber	273	284
AK	do	231	241
AS	do	190	200
AX	do	168	177
AY	do	126	126

Prices for Arizona chrysotile asbestos have remained unchanged since July 10, 1964. Quotations f.o.b. Globe, were listed as follows:

Grade	Description	Per short ton
Group No. 1	Crude	$1,410 to $1,650
Group No. 2	do	610 to 900
AAA		800
Group No. 3	Nonferrous filtering and spinning	425 to 750
Group No. 4	Nonferrous plastic and filtering	385 to 500
Group No. 5	Plastic and filtering	250 to 400
Group No. 7	Refuse or shorts	58 to 90

Prices for Vermont chrysotile asbestos, f.o.b. Hyde Park or Morrisville, were as follows:

Grade	Description	Per short ton	
		March 31, 1967	April 1, 1967
Group No. 3	Spinning and filtering	$319 to $370	$319 to $342
Group No. 4	Shingle fiber	176 to 296	183 to 296
Group No. 5	Paper fiber	121 to 144	129 to 153
Group No. 6	Waste, stucco or plaster fiber	88	93
Group No. 7	Shorts and floats	40.50 to 75	40.50 to 75

Market quotations were not available for African and Australian asbestos because sales were negotiated privately. The following average values were calculated from U.S. Department of Commerce import data:

Imports	Per short ton	
	1966	1967
Amosite: South Africa, Republic of	$152	$152
Chrysotile:		
Rhodesia, Southern	190	160
South Africa, Republic of	180	187
Crocidolite:		
Australia	203	----
South Africa, Republic of	191	191

FOREIGN TRADE

Exports of asbestos manufactured products in 1967 increased 8 percent over those of 1966. Canada accounted for 36 percent of the total value. The products consisted of brake linings, gaskets and packings, clutch facings, including linings, shingles and clapboard, and asbestos-cement articles.

A 10 percent increase in the ocean freight rates for amosite and crocidolite asbestos from South Africa to U.S. ports was announced by the U.S./South and East Africa Shipping Conference, effective August 7, 1967. The rate was raised from $27.75 to $30.50 per long ton.[7]

[7] North American Asbestos Corp. Asbestos News. V. 2, No. 6, June 1967, p. 1.

Table 3.—U.S. exports and reexports of asbestos and asbestos products

Product	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
Exports:				
Unmanufactured:				
Crude and spinning fibers short tons	1,455	$325	860	$238
Nonspinning fibers do	28,017	3,973	26,603	4,021
Waste and refuse do	17,218	1,414	19,893	1,692
Total do	46,690	5,712	47,356	5,951
Products:				
Gaskets and packing do	2,678	5,261	2,326	5,253
Brake linings do	3,630	5,236	4,249	5,819
Clutch facings, including linings number	2,246,986	1,897	2,765,868	2,328
Textiles and yarn short tons	900	1,326	2,215	1,790
Shingles and clapboard do	10,010	1,797	10,729	1,996
Articles of asbestos-cement do	4,742	1,332	11,020	2,159
Manufactures, n.e.c.	NA	5,058	NA	4,358
Total	---------	21,907	-----------	23,703
Reexports:				
Unmanufactured:				
Crude and spinning fibers short tons	176	30	256	52
Nonspinning fibers do	130	21	106	22
Total do	306	51	362	74
Products:				
Gaskets and packing do	(1)	1	-----------	--------
Brake linings do	1	2	(1)	1
Clutch facings, including linings number	117	1	6,800	5
Shingles and clapboard short tons	231	41	85	16
Manufactures, n.e.c.	NA	11	NA	42
Total	---------	56	-----------	64

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

In 1967 total imports for consumption of asbestos was 11 percent less than in 1966. Imports of amosite and crocidolite from Republic of South Africa, however, decreased 48 percent and 45 percent respectively. Low-iron spinning-length chrysotile imports from British Columbia increased to 9,274 tons from 8,278 tons in 1966, and imports of all grades from this source increased to 24,487 tons from 23,216 tons in 1966. Of all of the chrysotile imported, approximately 94 percent was fiber of less than spinning length.

Table 4.—U.S. imports for consumption of asbestos (unmanufactured), by classes and countries

Year and country	Crude (including blue fiber)		Textile fiber		All other		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1966:								
Australia	300	$61	------	------	-------	-------	300	$61
Bolivia	3	2	------	------	-------	-------	3	2
Canada	151	59	16,309	$6,132	637,648	$55,248	654,108	61,439
Finland	98	4	------	------	2,465	139	2,563	143
India	2	(1)	------	------	-------	-------	2	(1)
Italy	------	------	------	------	4	5	4	5
Mozambique	308	57	25	21	122	25	455	103
Portugal	------	------	------	------	10	1	10	1
Rhodesia	445	69	------	------	135	69	580	138
South Africa, Republic of	56,929	9,844	530	131	5,111	801	62,570	10,776
U.S.S.R	------	------	------	------	98	20	98	20
Yugoslavia	3,629	153	813	35	-------	-------	4,442	188
Zambia	1,324	224	------	------	-------	-------	1,324	224
Total	63,189	10,473	17,677	6,319	645,593	56,308	726,459	73,100
1967:								
Bolivia	------	------	------	------	3	3	3	3
Canada	6,966	1,246	15,063	5,745	579,953	52,174	601,982	59,165
Finland	662	26	------	------	2,585	166	3,247	192
France	15	2	------	------	-------	-------	15	2
Italy	1	1	------	------	6	7	7	8
Mozambique	250	32	------	------	-------	-------	250	32
Portugal	------	------	------	------	59	6	59	6
Rhodesia	420	68	75	26	4,956	775	5,451	869
South Africa, Republic of	29,318	5,081	17	3	1,280	255	30,615	5,339
Yugoslavia	------	------	827	30	2,656	97	3,483	127
Total	37,632	6,456	15,982	5,804	591,498	53,483	645,112	65,743

[1] Less than ½ unit.

Table 5.—U.S. imports for consumption of asbestos from specified countries, by grades

(Short tons)

Grade	1966			1967		
	Canada	Rhodesia	Republic of South Africa	Canada	Rhodesia	Republic of South Africa
Chrysotile:						
Crudes	151	445	6,000	6,966	420	1,843
Spinning and textile	16,309	---------	530	15,063	75	17
All other	637,648	135	5,111	579,953	4,956	1,280
Crocidolite (blue)	-------	---------	26,995	---------	---------	14,917
Amosite	-------	---------	23,934	---------	---------	12,558
Total	654,108	580	62,570	601,982	5,451	30,615

WORLD REVIEW

Australia.—The asbestos mine at Wittenoum, 700 miles north of Perth in Western Australia, ceased operations in December 1966.

Production of asbestos in 1966 was 13,467 tons, an increase of 16 percent over 1965 output, and consisted of 12,840 tons of crocidolite and 627 tons of chrysotile. Asbestos imports in 1966 totaled 55,152 tons consisting of 43,108 tons of chrysotile, 9,950 tons of amosite, and 2,094 tons of other grades. Exports of asbestos in 1966 was 4,644 tons with the larger amounts going to Malaysia, 838 tons, Singapore, 672 tons, and Japan 485 tons.[8]

[8] Bureau of Mineral Resources, Geology and Geophysics (Canberra). Australian Mineral Industry. 1966 review, pp. 54–57.

Table 6.—World production of asbestos, by countries [1] [2]

(Short tons)

Country	1963	1964	1965	1966	1967 p
North America:					
Canada (sales)	1,275,530	r 1,419,851	r 1,388,212	1,479,281	1,443,011
United States (sold or used by producers)	66,396	101,092	118,275	125,928	123,189
South America:					
Argentina	365	542	243	r 53	NA
Bolivia (exports)	10	7	3	4	4
Brazil [3]	1,440	e 1,430	1,204	1,820	NA
Europe:					
Austria	638	----------	----------	----------	----------
Bulgaria	1,323	1,433	1,433	e 1,430	e 1,430
Finland [4]	10,201	11,611	[5] 13,307	13,250	e 13,000
France	26,094	24,289	r 11,179	NA	NA
Greece	74	r 69	NA	NA	NA
Italy	63,016	75,573	79,214	90,464	e 110,000
Portugal	29	----------	53	r 11	e 40
U.S.S.R.	e 755,000	810,000	e 865,000	e 925,000	e 980,000
Yugoslavia	9,074	9,280	10,585	8,411	9,944
Africa:					
Botswana	2,368	2,161	888	(r)	NA
Kenya	78	204	136	73	NA
Mozambique	----------	----------	----------	r 535	NA
Rhodesia, Southern	142,254	153,450	176,149	e 175,000	NA
South Africa, Republic of	r 205,773	215,592	240,752	276,597	e 270,000
Swaziland	33,350	39,862	40,884	36,142	e 42,000
United Arab Republic	192	1,739	3,225	[6] 2,057	NA
Asia:					
China, mainland e	110,000	130,000	140,000	r 150,000	170,000
Cyprus	19,962	13,755	17,622	24,449	e 24,000
India	3,038	3,710	r 5,264	7,646	NA
Japan	18,210	17,979	16,451	r 21,428	NA
Korea, South	2,120	1,402	1,710	687	2,388
Philippines	421	586	----------	551	NA
Taiwan	604	526	883	721	NA
Turkey	408	1,291	1,376	r 4,001	e 4,000
Oceania:					
Australia	13,374	13,545	r 11,567	r 13,467	589
New Zealand	439	----------	----------	----------	NA
Total [7]	r 2,761,781	r 3,050,979	r 3,145,615	r 3,359,006	NA

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Asbestos also is produced in Czechoslovakia, Eritrea, Malagasy, North Korea, and Rumania.
[2] Compiled from data available April 1968.
[3] Bahia only.
[4] Includes asbestos flour.
[5] Data represents fiber.
[6] Includes vermiculite.
[7] Total is of listed figures only; no undisclosed data included.

Canada.—The recent growth of the asbestos industry came to a halt in 1967. Production in 1967 was 1,443,011 tons, down almost 3 percent from the 1,479,281 tons produced in 1966.

Canadian Johns-Manville Co., Ltd., the leading asbestos fiber producer entered its 50th year of operations in 1967. A historical report traces the development of mining practices and equipment at the firm's Jeffrey Mine, at Asbestos, Quebec, the largest asbestos mine and mill in the free world. The report covers statistics of the mine from 1881 to 1966, and contains many photographs including the open pits during 1890 and 1895. The mine was operated as an open pit until 1950 when a change to underground mining was made because the required horizontal expansion of the pit and the equipment then available made open pit mining not economically feasible. By 1958 there was great improvement in all types of open pit mining equipment, and this coupled with other factors such as increased wage rates, contamination of the fiber by overburden, and lower quality fibers due to additional handling favored a return to open pit procedures.[9]

[9] Canadian Mining Journal (Quebec). The Free World's Largest Asbestos Producer. V. 88, No. 5, May 1967, pp. 45–64.
Northern Miner (Toronto). Canadian Johns-Manville Reaches Half Century Mark This Year. No. 18, July 27, 1967, p. 2.

Table 7.—Canada: Shipments of asbestos, by grades

(Short tons)

	1963 r	1964	1965	1966	1967
Quebec:					
Crude No. 1, 2, and other	217	218	(1)	(1)	(1)
Milled group:					
3 (spinning)	28,987	31,376	21,356	28,716	25,391
4 (shingle)	380,900	319,629	322,772	371,837	336,568
5 (paper)	169,198	188,672	168,759	190,278	185,450
6 (stucco)	234,371	232,382	208,682	229,426	244,021
7 (refuse)	453,821	507,003	506,497	512,030	490,087
8 (sand)	8,036	5,602	6,088	8,706	7,149
Newfoundland, Ontario, and British Columbia	(2)	135,887	153,401	138,288	154,345
Total of all grades	1,275,530	1,420,769	1,387,555	1,479,281	1,443,011

r Revised.
1 Included with group 3.
2 Included with Quebec.

Source: Dominion Bureau of Statistics.

Advocate Mines, sole producer of asbestos in Newfoundland in 1966, milled 2,006,738 tons of ore and produced 65,201 tons of asbestos fiber for a recovered grade of 3.25 percent. This represents a considerable increase over the 1965 figure of 2.94 percent.[10]

Johns-Manville also manages Advocate Mines at Baie Verte, Newfoundland, and is developing a third asbestos mine at Reeves Township, near Timmins, Ontario.[11]

It was announced that the aerial skyline spanning the Yukon River at Dawson has been completed. The 1,500-foot-long skyline is designed to haul freight across the Yukon River during freeze-up and spring breakup so that Cassiar Asbestos Corp. Ltd., can operate its new mine at Clinton Creek and ship fiber on a year-round basis. The Cassiar asbestos mine is 60 miles northeast of Dawson.[12]

Operating data including mining methods, equipment, ore preparation and storage, bagging and shipping, and ventilation were summarized for ten mines operating in the Eastern Townships of Quebec. These mines were operated by Canadian Johns-Manville Co.; Asbestos Corp., Ltd.; Bell Asbestos Mines; Flintkote Mines; National Asbestos Mines; Carey-Canadian Mines; and Nicolet Asbestos Mines.[13]

As a result of the continuing program of ore reserve evaluation at Asbestos Corporation Limited properties, and after allowing for ore consumed by operations during the year, reserves at the end of 1967 were calculated to be 161,163,000 tons compared with 167,012,000 tons at the end of 1966. Asbestos Corporation Limited, Canada's only major independent asbestos producer, is one of the few asbestos firms to publicly provide information on reserves.[14]

It was reported that Asbestos Corporation Limited, suspended development work on the Asbestos Hill project in Ungava, northeastern Quebec because of enormous escaluation of costs. The corporation spent about $25 million on the Ungava property, including the cost of acquisition. Of this amount nearly $14 million was spent on actual development.[15]

Asbestos fiber shipments for the year 1967 from the Black Lake mine, jointly owned by United Asbestos and Lake Asbestos of Quebec (a subsidiary of American Smelting and Refining Co.) was expected to reach 123,000 tons, an increase of 7 percent more than 1966 production of 115,000 tons.[16]

Germany, West.—In response to the United Nations Security Council Resolution of December 16, 1966, on economic sanctions against Rhodesia, licenses to

10 Northern Miner (Toronto). Successful Year Advocate As Profits Higher, No. 3, Apr. 13, 1967, p. 3.
11 Canadian Mining and Metallurgical Bulletin (Montreal). Canadian Johns-Manville—Half A Century Of Growth. V. 60, No. 664, August 1967, p. 865.
12 Engineering and Mining Journal. An Aerial Skyline. V. 168, No. 3, March 1967, p. 156.
13 Mining in Canada (Ontario). Quebec Is Main Centre of Asbestos Industry. October 1967, pp. 22–30.
14 Asbestos Corporation Limited. Annual Report. Montreal, 1967, p. 4.
15 Engineering and Mining Journal. Quebec, V. 168, No. 5, May 1967, p. 178.
Northern Miner (Toronto). Studying New Plans For Asbestos Hill of Asbestos Corporation. No. 6, May 4, 1967, p. 17.
16 Northern Miner (Toronto). United Asbestos Net Up Sharply First Nine Months No. 33, Nov. 9, 1967, pp. 1, 12.

import asbestos from Rhodesia were no longer granted.[17]

India.—Production of asbestos in India during the first 9 months of 1967 was 6,071 tons. This represents an increase of 6 percent over the same period in 1966. Exports of asbestos in 1967 were 76 tons, more than twice the exports in 1966. Imports of asbestos in 1967 were 32,500 tons compared with 33,019 tons in 1966.[18]

Italy.—Production of asbestos in 1966 was 90,464 short tons, an increase of 14 percent above 1965 output. Because of greater local requirements in 1966 imports increased about 13 percent. The country of origin of imports were as follows: Republic of South Africa, 21,098 tons; Canada, 13,622 tons; U.S.S.R. 7,644 tons; and other countries, 1,943 tons. Exports of asbestos in 1966 were 39,613 tons compared with 28,295 tons in 1965, an increase of 40 percent. The destination of the exports were as follows: West Germany, 15,070 tons; France, 8,842 tons; Poland, 5,100 tons; Spain, 1,659 tons; Cuba, 457 tons; and other countries, 8,485 tons.[19]

Korea, South.—Production of chrysotile amounted to 687 tons in 1966, of which the Kwangchon mine accounted for 558 tons and the Kwihang mine produced 129 tons.

South Africa, Republic of.—Production of asbestos during the first 9 months of 1967 was 202,470 tons or about 2 percent less than during the same period in 1966. Exports amounted to 165,254 tons during the same period and local sales were 17,565 tons. Production of amosite during January–September 1967 was 71,632 tons; chrysotile, 29,084 tons; and crocidolite, 101,754 tons. Exports for the same period for amosite were 63,777 tons; chrysotile, 12,498 tons; and crocidolite, 88,979 tons.

A new deposit of crocidolite was recently discovered at the Pomfret mine, and exploration continued to uncover deep-seated deposits. The Pomfret mine is located in an isolated area in the northern part of the Cape Province on the Molopo River.[20]

The new $6.5 million amosite milling complex at Penge, now in full production, is a highly automated unit that compares favorably with the most modern asbestos milling facilities elsewhere in the world. This technically sophisticated plant—located in one of the most remote parts of South Africa, 300 miles from Johannesburg—had to be designed to deal with the hardest and toughest of all asbestos bearing ores. The banded ironstone, in which amosite and crocidolite asbestos both occur, is so hard that only the heaviest and most durable crushing and reducing equipment can cope with it on a continuous basis. Fully mechanized pressure-packing units of unusual design, to overcome the high resiliency of amosite, are now in operation for all of the standard gradings of amosite. Also, newly developed motor transportation units for moving amosite from mine to railhead—28 miles—and extensive new railhead facilities for storage, palletizing, and mechanical loading of rail cars are in full operation to complete the new amosite production complex.[21]

A member of the Cape Asbestos group of companies, released information on ocean freight rates to the United States for amosite and crocidolite from South Africa. To Eastern and gulf coast ports, on non-pressure-packed fiber the rate is $30.50 per long ton (2,240 pounds); for pressure-packed fiber, $27.75 per long ton. The rates from South Africa to the West Coast are $40.50 per long ton for non-pressure-packed fiber and $37.75 per long tons for pressure-packed shipments.[22]

The Ethel asbestos mine at Mtoroshanga ceased operations. Marginal recovery, leading to technical difficulties and increasing costs were given as reasons for the shutdown. The mine was operated by Ethel Asbestos Mine, Ltd., a subsidiary of Skandinaviska Eternit Aktiebolaget and A. B. Ifoverken, Stockholm, Sweden.

The Thornwood asbestos mine, 7 miles south of Gwanda, was reactivated by A. D. Theron & Sons (Pvt.) Ltd. Reserves are reported to be 300,000 tons of ore.[23]

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[17] U.S. Embassy, Bonn. State Department Airgram A-1064, Mar. 6, 1967, p. 2.

[18] U.S. Embassy, New Delhi, India. State Department Airgram A-932, Apr. 4, 1968, 4 pp.

[19] Bureau of Mines. Mineral Trade Notes. V. 64, No. 11, November 1967, p. 6.

[20] North American Asbestos Corp. Asbestos News. New Blue Deposit At Pomfret. V. 2, No. 4, May 1967, p. 1.

[21] North American Asbestos Corp. Asbestos News. V. 2, No. 10, October 1967, p. 1.

[22] North American Asbestos Corp. Asbestos News. V. 2, No. 11, November 1967, p. 1.

[23] U.S. Embassy, Johannesburg, Republic of South Africa. State Department Airgram A-385, Apr. 27, 1967, p. 7.

U.S.S.R.—Exports of asbestos continued to increase. Exports in 1966 were 283,070 tons compared with 273,810 tons in 1965. France, Bulgaria, and Hungary received the larger amounts.[24]

TECHNOLOGY

There are two kinds of distinctly fibrous silicates, one manmade, the other occurring naturally. Glass fibers, silica, and aluminosilicate fibers and those mineral fibers known as rock-wool and slag-wool constitute the group of artificial fibrous silicates, all of which, with the possible exception of certain quartz fibers, have a random noncrystalline structure. In contradistinction to glass fibers, the naturally occurring fibers possess true crystallinity of structure, which in turn predetermines and contributes to their range of unusual chemical and physical properties. Structural and chemical properties, chemical reactions, synthesis, tensile strengths, bond strengths, surface area, and other physical properties of asbestos are discussed.[25]

High-strength asbestos fibers can economically upgrade the environmental resistance of plastic moldings and laminates. Available asbestos reinforcements, the plastics they can be used with, and important properties and recommended uses are described.[26]

The largest overhead eccentric jaw crusher was put in operation by Cassiar Asbestos Corp. Ltd., at its Clinton Creek, Yukon Territory, Canada, operation. The crusher is capable of reducing asbestos ore to minus 6-inch size, at the rate of 350 tons per hour. Reason for the new crusher's record size is that asbestos, a fibrous mineral, requires extraction from the mine in large chunks so as to avoid destroying the fibers, thus tending to optimize the quality of end products. Details and operations of the crusher are described.[27]

An epidemiological survey is being carried on throughout the Quebec asbestos industry by the Quebec Asbestos Mining Association as a part of a planned international effort. Fact-finding medical research on the effect of asbestos on human health was centered in the Thetford Mines and Asbestos districts. The work undertaken is similar in design and purpose to other surveys being conducted in the United States, Finland, the U.S.S.R., Republic of South Africa, Italy, and other countries. Because of the universal use of asbestos and asbestos products, national and international authorities are pressing for careful investigations so that if there are dangers they can be identified and controlled.[28] Dust control is very important in the asbestos industry and much has been done to develop effective control methods and to safeguard the workers in mining and milling operations. Steps taken by the asbestos industry in creating better working conditions and as a safeguard against industrial diseases through ventilation engineering is described.[29]

It was announced that new legislation will be introduced in the United Kingdom describing measures to be taken to avoid exposure to asbestos in occupations not covered by the present Asbestos Regulations. Exposure to relatively small and occasional amounts of some forms of asbestos dust might result in a disease called mesothelioma, a malignant growth of the pleura (the lining membrane of the lung) or of the peritoneum (the lining membrane of the abdominal organs).[30]

The United Kingdom asbestos industry has formed an information committee charged with making the facts about health hazards in the producing and handling industries known to the public. The two diseases involved are asbestosis—a fibrosis of the lungs—and mesothelioma.[31]

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24 Metal Bulletin (London). U.S.S.R.'s 1966 Foreign Trade. No. 5268, Jan. 26, 1968, pp. 24–25.

25 Hodgson, A. A. Fibrous Silicates. The Royal Institute of Chemistry, Lecture Series Number 4, Russell Square, London, W. C. 1, pp. 46.

26 Cryor, Robert E. Asbestos Reinforced Plastics Resist Heat and Chemicals. Materials in Design Eng., April 1966, pp. 92–96.

27 Western Miner (Vancouver). Largest Overhead Eccentric Jaw Crusher. V. 40, No. 1, January 1967, p. 45.

28 Mining in Canada (Ontario). Epidemiological Survey. January 1967, p. 7.

29 Mining in Canada (Ontario). Health Controls Are Advanced in the Asbestos Industry. October 1967, pp. 35–36.

30 Chemical Age (London). Legislation Expected Shortly On Asbestos. V. 97, No. 2493, Apr. 22, 1967, p. 11.

31 Mining Journal (London). Health Hazard Committee. V. 268, No. 6877, June 9, 1967, p. 466.

Barite

By Donald E. Eilertsen [1]

United States output and consumption of barite continued at high levels in 1967. Barite producers sold or used almost 1 million short tons of crude domestic barite, the most since 1957, while imports for consumption were the least since 1958.

Table 1.—Salient barite and barium-chemical statistics

(Thousand short tons and thousand dollars)

	1963	1964	1965	1966	1967
United States:					
Primary:					
Mine or plant production	803	817	846	1,007	944
Sold or used by producers	824	830	852	947	962
Value	$9,402	$9,796	$10,192	$11,259	$11,604
Imports for consumption	578	600	712	699	532
Value	$4,637	$4,796	$5,553	$5,764	$4,655
Consumption [1]	1,230	1,277	1,388	1,417	1,371
Ground and crushed sold by producers	1,030	1,077	1,169	1,209	1,171
Value	$25,517	$26,948	$29,444	$30,641	$29,382
Barium chemicals sold by producers	109	117	125	133	113
Value	$15,837	$17,101	$17,935	$19,109	$16,283
World: Production	3,218	3,451	3,877	4,023	2,447

[1] Includes some witherite.

DOMESTIC PRODUCTION

Forty-four mines in nine States produced crude barite in 1967 and almost 88 percent of this production was from Arkansas, Georgia, Missouri, and Nevada. Although the output was somewhat smaller than in 1966, producers sold or used the most barite since 1957. Yearend stocks of crude barite at mining operations totaled 67,500 tons compared with 85,100 tons (revised) in 1966.

[1] Commodity specialist, Division of Mineral Studies.

Table 2.—Domestic barite sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	1963		1964		1965		1966		1967	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Arkansas	236	$2,161	233	$2,202	249	$2,379	233	$2,266	229	$2,266
California	5	31	6	45	4	21	15	104	10	71
Georgia	117	2,013	109	2,022	W	W	W	W	W	W
Kentucky	6	85	6	96	---	---	---	---	---	---
Missouri	287	3,680	267	3,451	329	4,219	337	4,280	332	4,444
Nevada	120	760	149	1,261	91	583	139	933	154	923
New Mexico	1	6	W	W	(1)	2	---	---	---	---
North Carolina	---	---	---	---	---	---	---	---	1	6
Tennessee	24	404	39	519	31	442	29	412	15	235
Washington	---	---	---	---	(1)	1	---	---	(1)	1
Other States [2]	28	262	21	200	148	2,545	194	3,264	221	3,658
Total	824	9,402	830	9,796	852	10,192	947	11,259	962	11,604

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Less than ½ unit.
[2] Alaska (1966–67), Idaho (1963–64), South Caroiina (1963–66), and Texas (1963–66).

Three firms in three States produced crushed barite while 17 firms in nine States produced ground barite, some firms producing from more than one plant. The output of these materials continued at a high level.

The following firms produced barium chemicals from barite, except where indicated: Chemical Products Corp., Cartersville, Ga.; Chicago Copper & Chemical Co., Blue Island, Ill.; The Great Western Sugar Co., Johnstown, Colo. (also used witherite); Holland-Suco Color Co., Huntington, W. Va.; Inorganic Chemicals Division, FMC Corp., Modesto, Calif.; Mallinckrodt Chemical Works, St. Louis, Mo.; Ozark Smelting & Mining Co., Coffeyville, Kans.; and Pittsburgh Plate Glass Co., Chemical Division, New Martinsville, W. Va.

The following firms used various barium chemicals to make other barium chemicals:

J. T. Baker Chemical Co., Phillipsburg, N.J.; Barium & Chemicals Inc., Steubenville, Ohio; Eastman Kodak Co., Rochester, N.Y.; Inorganic Chemicals Division, FMC Corp., Carteret, N.J.

CONSUMPTION AND USES

The greatest use of barite continued to be as a weighting agent in oil-and gas-well drilling muds for lubricating and cooling drill bits, sealing the walls of holes to prevent caving and loss of drilling fluid, and confining high pressures to the rock formations to prevent blowouts. Barite was also used by the glass, paint, and rubber industries and in making barium chemicals for many uses such as glass, television picture tubes, ceramics, lubricating oil additives, paper coating, lithol colors, steel hardening, permanent magnets, vinyl stabilizers, brick, tile, railroad flares, fireworks, and sugar refining.

In contrast to 1966, the producers of ground and crushed domestic barite (table 5) reported smaller sales of these materials to the well-drilling, paint, and rubber industries, and larger sales to the glass and undistributed industries, the latter mostly for chemicals. Consumption of domestic and imported barite for chemicals (table 4) decreased 16 percent in 1967 over 1966.

Table 3.—Ground and crushed barite produced and sold by producers in the United States

(Thousand short tons and thousand dollars)

Year	Plants	Production (quantity)	Sales	
			Quantity	Value
1963	34	1,027	1,030	$25,517
1964	33	1,079	1,077	26,948
1965	31	1,169	1,169	29,444
1966	30	1,203	1,209	30,641
1967	29	1,174	1,171	29,382

Table 4.—Crude barite (domestic and imported) used in the manufacture of ground barite and barium chemicals in the United States [1]

(Thousand short tons)

Year	In manufacture of—		Total
	Ground barite [2]	Barium chemicals and lithopone	
1963	1,048	182	1,230
1964	1,103	174	1,277
1965	1,199	189	1,388
1966	1,215	202	1,417
1967	1,201	170	1,371

[1] Includes some witherite in the manufacture of barium chemicals.
[2] Includes some crushed barite.

Table 5.—Ground and crushed barite sold by producers, by consuming industries [1]

Industry	1963 Short tons	1963 Percent of total	1964 Short tons	1964 Percent of total	1965 Short tons	1965 Percent of total	1966 Short tons	1966 Percent of total	1967 Short tons	1967 Percent of total
Well drilling	907,134	89	930,965	87	986,889	84	1,022,106	85	949,982	81
Glass	56,362	5	56,866	5	70,158	6	73,660	6	91,220	8
Paint	34,611	3	58,396	6	68,827	6	69,895	6	59,698	5
Rubber	28,479	3	26,675	2	29,992	3	38,249	3	31,039	3
Undistributed	3,121	---	3,787	---	12,718	1	4,605	---	[2] 39,166	3
Total	1,029,707	100	1,076,689	100	1,168,584	100	1,208,515	100	1,171,105	100

[1] Designated uses as reported by the producers of ground and crushed barite.
[2] Includes chemicals not separately reported.

Table 6.—Barium chemicals produced and used or sold by producers in the United States

(Short tons)

Chemical and year	Plants	Produced	Used [1] by producers [2] in other barium chemicals	Sold by producers [3] Short tons	Sold by producers [3] Value
Black ash:[4]					
1963	8	112,953	102,945	3,374	$322,941
1964	9	114,421	110,676	3,605	344,295
1965	7	124,279	118,805	3,954	375,815
1966	7	131,671	128,886	4,691	465,116
1967	6	111,019	109,803	2,690	273,997
Carbonate (synthetic):					
1963	7	78,411	25,688	52,026	5,685,281
1964	7	81,018	28,088	53,897	6,021,728
1965	6	85,609	28,734	57,264	6,206,303
1966	6	94,369	30,669	63,697	7,197,090
1967	6	82,281	26,782	55,625	6,307,246
Chloride (100 percent $BaCl_2$):					
1963	4	11,100	---------	11,299	1,842,105
1964	5	11,425	---------	11,590	1,926,885
1965	3	11,214	---------	10,975	1,892,909
1966	3	12,373	---------	12,213	2,182,917
1967	3	11,180	---------	10,692	1,942,283
Hydroxide:					
1963	4	18,746	---------	18,436	3,018,482
1964	5	23,384	W	23,313	3,688,060
1965	5	30,211	W	30,459	4,662,887
1966	5	29,604	W	28,664	4,123,893
1967	4	25,172	W	25,250	3,729,658
Other barium chemicals:[5]					
1963	----	26,555	W	23,462	4,967,844
1964	----	28,365	W	24,598	5,120,053
1965	----	29,006	W	21,926	4,796,988
1966	----	30,054	W	23,763	5,140,246
1967	([6])	30,229	W	18,269	4,029,904
Total:[7]					
1963	14	---------	---------	108,597	15,836,653
1964	14	---------	---------	117,003	17,101,021
1965	12	---------	---------	124,578	17,934,902
1966	12	---------	---------	133,028	19,109,262
1967	12	---------	---------	112,526	16,283,088

W Withheld to avoid disclosing individual company confidential data.
[1] Includes purchased material.
[2] Of any barium chemical.
[3] Exclusive of purchased material and exclusive of sales by 1 producer to another.
[4] Black-ash data include lithopone plants.
[5] Includes barium acetate, nitrate, oxide, peroxide, sulfate, and other compounds for which separate data may not be revealed.
[6] Barium acetate, 1 plant; nitrate, 3; oxide, 2; peroxide, 1; sulfate (synthetic) 5.
[7] A plant producing more than 1 product is counted only once in arriving at total.

PRICES

Prices of barite and barium chemicals are negotiated between the buyer and seller. The published prices, which follow, only serve as a general guide to prices and do not necessarily reflect prices at which transactions occurred.

The quoted prices of two varieties of chemical-grade barite and of three barium chemicals increased.

Table 7.—Price quotations for crude and ground barite in 1967

(Per short ton)

Item	1967
Chemical grade, f.o.b. shipping points, carlots:	
Hand picked, 95 percent $BaSO_4$, 1 percent iron [1]	$18.50 to $20.50
Flotation or magnetic separation, 96–97.5 percent $BaSO_4$, 0.3–0.7 percent iron (add $3 for 100-pound bags)[2]	19 to 24.50
Water ground, 99.5 percent $BaSO_4$, 325 mesh, 50-pound bags	45 to 49
Drilling-mud grade, f.o.b. shipping point, carlots: 83–93 percent $BaSO_4$, 3–12 percent, iron, specific gravity 4.20–4.30:	
Crude, bulk	12 to 16
Some restricted sales	11.50
Ground	23 to 26
Imported, bulk, c.i.f. gulf ports	10 to 14

[1] $18.50 until September 18, and afterward at $20 to $20.50.
[2] $19 to $23.50 until September 18, and afterward at $24.50.
Source: Metals Week.

Table 8.—Price quotations for barium chemicals in 1967

(Per short ton, except as noted)

Item	1967
Barium carbonate, calcined, bags, carlots, works	[1] $117.00 to $122.50
Barium chlorate, drums, works ... per pound	.32 to .41
Barium chloride, anhydrous, bags, carlots, works	[2] 185.00 to 194.00
Barium dioxide (peroxide), drums, freight equalized ... per pound	.30
Barium hydrate, crystalline, bags, carlots, truckloads, delivered	224.00
Barium monohydrate, 99 percent, bags, carlots, delivered ... per 100 pounds	12.00
Barium nitrate, barrels, carlots, truckloads, delivered ... per pound	.16
Barrels, less carlots, less truckloads, delivered ... do	.17
Barium oxide, ground, drums, carlots, truckloads, freight equalized	288.00
Blanc fixe, direct process, bags, carlots, works	[3] 175.00 to 235.00

[1] $117 to Dec. 3.
[2] $185 to Dec. 3.
[3] $156 to $175 to Dec. 3.
Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE

Exports of lithopone declined sharply in 1967 from those of 1966; the latter were the highest since 1953.

Table 9.—U.S. exports of lithopone

Year	Short tons	Value (thousands)
1965	609	$187
1966	3,017	644
1967	735	267

Imports for consumption of crude barite were 24 percent lower in 1967 compared with those in 1966. The average declared value of imports for consumption of crude barite at foreign ports, for all countries, in 1967 was $8.75 per short ton. The large decrease in barite imports in 1967 may be attributed to smaller demand by the chemical and well-drilling industries. Declared values of crude barite at foreign ports were as follows for the indicated countries:

	Per ton
Canada	$8.49
Greece	8.26
Ireland	7.56
Mexico	7.93
Morocco	10.06
Peru	10.32

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

(Thousand short tons and thousand dollars)

Type and source	1966 Quantity	1966 Value	1967 Quantity	1967 Value
Crude barite:				
Algeria	11	$111	17	$163
Canada	181	1,541	134	1,141
Germany, West	-----	-----------	(1)	1
Greece	11	85	37	306
Ireland	116	874	58	437
Italy	8	80	8	99
Mexico	212	1,501	133	1,055
Morocco	45	444	49	497
Peru	95	969	71	729
Turkey	10	83	25	227
United Kingdom	10	76	-------	---------
Total	699	5,764	532	4,655
Ground barite:				
Canada	(1)	1	(1)	2
France	-----	-----------	(1)	2
Germany, West	(1)	1	-------	----------
Total	(1)	2	(1)	4

[1] Less than ½ unit.

Table 11.—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)
1965	190	$34	1,624	$181	890	$80	6	$1
1966	182	33	2,705	304	1,237	128	11	2
1967	116	22	2,249	282	979	120	-----	--------

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)
1965	568	$84	826	$53	291	$165
1966	1,005	170	1,150	74	444	249
1967	1,046	153	813	54	156	73

Table 12.—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)
1965	2,569	$112	25	$2
1966	2,138	100	90	8
1967	1,260	53	25	3

WORLD REVIEW

Rhodesia, Southern.—The proved reserve of barite at the Dodge mine of the Dodge Mineral Development Co. in the Shamva district was reported to be more than 1 million tons.[2]

Thailand.—During a recent study sponsored by the United Nations, U.S. Geological Survey geologists working closely with the Royal Thai Department of Mineral Resources investigated 58 mineral prospects in the Mekong River basin, about 400 miles northeast of Bangkok, for a number of minerals and metals. One of the deposits, a limestone replacement deposit, was found to contain 2.5 million tons of proven and probable reserves of barite and possibly as much as 3 million tons.[3]

[2] Bureau of Mines. Mineral Trade Notes. V. 64, No. 9, September 1967, p. 5.
[3] U.S. Geological Survey. Mineral Investigations in Northeastern Thailand. Open file report, 1967, 276 pp.

Table 13.—World production of barite, by countries [1] [2]

(Short tons)

Country	1963	1964	1965	1966	1967 p
North America:					
Canada	173,503	169,149	203,025	r 221,376	199,576
Mexico	283,246	368,220	406,027	321,306	NA
United States	803,106	816,706	845,656	1,006,965	944,082
South America:					
Argentina	25,350	15,989	r 21,843	r 23,700	NA
Brazil	37,601	36,968	70,945	44,344	60,073
Chile	r 1,124	1,203	r 3,132	r 2,345	NA
Colombia	11,574	11,244	9,700	e 9,900	NA
Peru	137,557	138,252	122,104	128,579	NA
Europe:					
Austria (marketable)	2,395	1,390	2,573	r 3,086	e 2,900
France	82,078	92,397	114,733	e 110,200	NA
Germany, West (marketable)	r 503,430	r 515,290	r 517,374	r 497,418	NA
Greece	r 94,000	r 75,000	132,000	r 143,000	NA
Ireland	14,918	45,232	92,581	r 137,789	NA
Italy	114,229	115,461	156,412	190,411	e 171,000
Poland	50,376	e 50,376	e 50,376	e 51,800	e 51,800
Portugal	1,828	384	r 1,199	1,054	e 180
Rumania	NA	NA	r 50,000	e r 55,000	e 61,000
Spain	r 53,312	65,183	r 61,140	NA	NA
U.S.S.R. e	220,000	r 243,000	r 254,000	r 276,000	287,000
United Kingdom [3]	61,066	68,343	67,241	34,172	NA
Yugoslavia	115,176	112,072	107,045	r 88,393	e 99,000
Africa:					
Algeria	32,421	32,665	47,142	e 82,700	e 88,000
Kenya	----------	----------	40	108	NA
Morocco	104,228	99,036	114,508	117,126	99,779
Rhodesia, Southern	1,953	1,561	e 1,500	NA	NA
South Africa, Republic of	2,704	2,835	1,477	6,815	e 1,700
Swaziland	93	17	541	1,150	e 700
United Arab Republic	4,545	r 5,017	16,924	e 16,500	NA
Asia:					
Burma	r 2,127	NA	r 1,940	e r 8,800	NA
China, mainland e	r 88,000	110,000	110,000	r 121,000	110,000
India	41,752	r 51,763	r 53,223	56,949	NA
Iran [4]	e 16,500	47,399	e r 68,000	e r 68,000	e 68,000
Japan	41,360	43,810	46,606	r 44,396	41,417
Korea:					
North e	r 77,000	r 77,000	r 88,000	r 110,000	110,000
South	3,040	3,024	1,419	40	----------
Pakistan	5,422	13,235	9,740	r 8,624	NA
Philippines	1,008	1,627	----------	2	NA
Turkey	1,081	6,669	13,206	e 18,700	34,822
Oceania: Australia	9,206	13,778	r 13,413	r 15,370	16,017
Total [5]	r 3,218,309	r 3,451,295	r 3,876,785	r 4,023,118	2,447,046

e Estimate. p Preliminary. r Revised. NA Not Available.
[1] Barite is produced in Bulgaria, Czechoslovakia, and East Germany, but data on production are not available.
[2] Compiled mostly from data available May 1968.
[3] Includes witherite.
[4] Year ended March 20 of year following that stated.
[5] Total is of listed figures only; no undisclosed data included.

TECHNOLOGY

Discovery of a belt of barite deposits in Nevada may add appreciably to the domestic barite reserve. Additional exploration will be needed to evaluate the economic potential of the deposits. The three principal barite beds usually range from 5 to 30 feet in thickness, but one exceeds 50 feet in some places. The barite is mostly dark gray, contains 71 to 94 percent $BaSO_4$, and is interlayered in black chert. Outcrops indicate that the beds may extend 10,000 feet along the strike.[4]

[4] Shawe, D. R., F. G. Poole, and D. A. Brobst. Bedded Barite in East Northumberland Canyon, Nye County, Nevada. U.S. Geol. Survey Circ. 555, 1967, 8 pp.

Bauxite

By Robert F. Griffith [1]

Bauxite and alumina in 1966 and 1967 were featured by worldwide alumina plant capacity expansions, the increasing trend to convert bauxite to alumina at the bauxite source, and continued research to develop nonbauxitic sources of alumina. Imports of alumina for the production of aluminum doubled each year from 1965 to 1967 reaching almost 1 million short tons.

Legislation and Government Programs—Public Law 89–364 (April 14, 1966), provided for disposal of 126,300 long tons of calcined refractory-grade bauxite from the national stockpile, which was reduced to its objective of 173,000 tons by sales of 49,000 tons in 1967. No acceptable bids were received by the General Services Administration on the offering for sale of 1,000 short dry tons of fused crude aluminum oxide used in abrasives.

Table 1.—Salient bauxite statistics

(Thousand long tons and thousand dollars)

	1963	1964	1965	1966	1967
United States:					
Production, crude ore (dry equivalent)	1,525	1,601	1,654	1,796	1,654
Value	$17,234	$17,875	$18,632	$20,095	$19,079
Imports for consumption [1]	9,212	10,180	11,199	11,529	11,673
Exports (as shipped)	203	279	147	62	2
Consumption (dry equivalent)	11,318	12,546	13,534	14,084	14,503
World: Production	30,206	32,826	36,854	38,766	43,612

[1] Includes bauxite imported for Government account. Import figures for Jamaican, Haitian, and Dominican Republic bauxite included were adjusted by Bureau of Mines to dry equivalent. Other imports, which are virtually all dried, are on an as-shipped basis.

DOMESTIC PRODUCTION

Output of crude bauxite remained at the 1965 level but decreased 8 percent from 1966 production. Cessation of production during the first quarter at the American Cyanamid mine in Pulaski County, Ark., accounted for a large part of this decrease.

Arkansas continued to produce 96 percent of the U.S. total from mines operated by three companies in Saline County. The two leading producers, Aluminum Company of America (Alcoa) and Reynolds Metals Co., shipped crude ore to their own alumina plants. American Cyanamid Co. continued to operate its Saline County mine for the production of calcined bauxite. Activated bauxite was produced by Porocel Corp. and Stauffer Chemical Co. Reserves of bauxite in Arkansas, comparable with the grade now being mined, are estimated to be sufficient to last for 25 years at the current rate of production.[2]

Harbinson-Walker Refractories Co., National Properties Mining Co., and Wilson-Snead Mining Co. mined bauxite in Barbour and Henry Counties, Ala., and American Cyanamid Co. mined bauxite in Sumter and Floyd Countries, Ga. Together they produced 70,500 long dry tons, a 9-percent decrease from the 1966 total. Harbinson-Walker Refractories Co.

[1] Commodity specialist, Division of Mineral Studies.

[2] Patterson, Sam H. Bauxite Reserves and Potential Aluminum Resources of the World. U.S. Geol. Survey Bull. 1228, 1967, 176 pp.

produced calcined bauxite; the other companies produced dried bauxite.

Reynolds Metal Co. began production of sodium aluminate at its Hurricane Creek, Ark., alumina plant. Reynolds is the first primary aluminum producer to make and market this basic chemical. Alcoa and Kaiser Aluminum & Chemical Corp. doubled their tabular aluminum production capacities at their plants in Bauxite, Ark., and Baton Rouge, La., respectively.

The gross weight of all aluminum oxide produced in 1967 was 6.51 million short tons of which 6.15 million short tons was calcined alumina, 254,000 tons was trihydrate alumina, and the remainder was tabular and activated alumina and light hydrate. Shipments of alumina and aluminum oxide products totaled 6.9 million tons of which 5.91 million tons went to the aluminum industry; the remainder was shipped to the refractory, ceramic, chemical, and abrasive industries.

Harvey Aluminum, Inc., began production of alumina from Australian bauxite at its 350,000-ton-per-year capacity plant at St. Croix, Virgin Islands. The alumina was shipped to Harvey's aluminum reduction plant at The Dalles, Oreg. In 1967, 52,576 short tons of alumina were shipped to the United States from the Virgin Islands. This operation, and the eight alumina plants in the continental United States operated by four aluminum companies accounted for the entire calcined alumina output.

CONSUMPTION AND USES

The production of aluminum accounted for 90.0 percent of U.S. bauxite consumption in 1967, of which over 87 percent was imported. The refractory, chemical, and abrasive industries in that order accounted for most of the remainder. Minor quantities of bauxite were consumed by the cement, oil and gas, and steel industries and by municipal water works.

Shipments of domestic bauxite (an index of the grade of ore consumed) containing less than 8 percent silica decreased to 4 percent of the total, the 8- to 15-percent silica class increased to 73 percent, and the plus 15-percent silica category decreased to 23 percent. A 5-year comparison of the grades shipped follows:

SiO_2, percent	1963	1964	1965	1966	1967
Less than 8	8	6	5	10	4
8 to 15	52	63	64	60	73
More than 15	40	31	31	30	23

The aluminum industry received 94 percent of total alumina shipments. The chemical, refractory, and ceramic and abrasive industries received most of the remainder.

Calcined alumina consumed by the primary aluminum reduction plants totaled 6.14 million tons. The amount of bauxite and alumina consumed to produce 1 ton of aluminum since 1963 was as follows:

	1963	1964	1965	1966	1967
Bauxite long dry tons	3.929	4.074	4.136	4.088	3.993
Alumina short tons	1.849	1.901	1.891	1.904	1.878
Aluminum do	1.000	1.000	1.000	1.000	1.000

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:						
1963	60	47	$533	54	62	$747
1964	51	39	444	57	57	809
1965	79	61	658	57	56	792
1966	102	78	656	85	82	1,108
1967	108	83	810	85	84	1,236
Arkansas:						
1963	1,771	1,478	16,701	1,725	1,483	17,543
1964	1,864	1,562	17,431	1,773	1,531	17,859
1965	1,911	1,593	17,974	2,008	1,729	20,293
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
Total United States:						
1963	1,831	1,525	17,234	1,779	1,545	18,290
1964	1,915	1,601	17,875	1,830	1,588	18,668
1965	1,990	1,654	18,632	2,065	1,785	21,085
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

[1] Computed from selling prices and values assigned by producers and estimates of the Bureau of Mines.

Table 3.—Recovery of dried, calcined, and activated bauxite in the United States

(Long tons)

Year	Crude ore treated	Processed bauxite recovered			
		Dried	Calcined or activated	Total	
				As recovered	Dry equivalent
1963	170,641	35,727	61,853	97,580	137,946
1964	166,884	W	W	93,235	128,347
1965	193,076	W	W	99,765	140,713
1966	202,443	W	W	117,326	157,206
1967	223,174	W	W	123,200	166,696

W Withheld to avoid disclosing individual company confidential data.

Tabular alumina was used in the manufacture of spark plugs, refractory brick, casting molds, industrial crucibles, high tension insulators, and thermocouple tubes where resistance to high temperatures, chemical attack, and general erosion was necessary. Sodium aluminate and hydrated alumina powder were consumed by the paper, paint, chemical and rubber industries.

Aluminum sulfate (alum), by far the largest item in the category of selected aluminum salts, was consumed by the pulp and paper, clay, and textile industries, and by municipal water works as a purifier. A plant was constructed by the Tennessee Corp. at Augusta, Ga., to supply this commodity to markets in the Augusta area.

STOCKS

Bauxite stocks, crude and processed, increased about 680,000 long tons in 1966 and decreased about 140,000 tons in 1967.

Table 4.—Bauxite consumed in the United States, by industries

(Long tons, dry equivalent)

Year and industry	Domestic	Foreign	Total
1966:			
Alumina	1,687,643	11,420,670	13,108,313
Abrasive [1]	W	296,369	[2] 296,369
Chemical	104,738	189,539	294,277
Refractory	39,802	272,979	312,781
Other	28,259	43,942	72,201
Total [1]	1,860,442	12,223,499	14,083,941
1967:			
Alumina	1,633,289	11,936,473	13,569,762
Abrasive [1]	W	246,163	[2] 246,163
Chemical	130,292	175,727	306,019
Refractory	32,666	282,014	314,680
Other	23,214	43,100	66,314
Total [1]	1,819,461	12,683,477	14,502,938

W Withheld to avoid disclosing individual company confidential data; included with "Other".
[1] Includes consumption by Canadian abrasive industry.
[2] Excludes domestic.

Table 5.—Bauxite consumed in the United States in 1967, by grades

(Long tons, dry equivalent)

Grade	Domestic origin	Foreign origin	Total
Crude	1,655,393	375,414	2,030,807
Dried	32,342	11,780,703	11,813,045
Activated	31,268	----------	31,268
Calcined	100,458	527,360	627,818
Total	1,819,461	12,683,477	14,502,938

Table 6.—Capacities of domestic alumina plants

Company and plant	Capacity as of Dec. 31, 1967 (short tons per year)
Aluminum Company of America:	
Mobile, Ala	950,000
Bauxite, Ark	400,000
Point Comfort, Tex	900,000
Total	2,250,000
Reynolds Metals Co.:	
Hurricane Creek, Ark	820,000
La Quinta, Tex	[1] 1,080,000
Total	1,900,000
Kaiser Aluminum & Chemical Corp.:	
Baton Rouge, La	1,042,000
Gramercy, La	720,000
Total	1,762,000
Ormet Corp.: Burnside La	520,000
Harvey Aluminum, Inc.: St. Croix, Virgin Islands	350,000
Grand total	6,782,000

[1] A 100,000-short-ton-per-year expansion is under construction.

Table 7.—Production and shipment of selected aluminum salts in the United States in 1966

Type of salt	Number of plants producing	Production (short tons)	Total shipments including interplant transfers: Short tons	Total shipments including interplant transfers: Value (thousands)
Aluminum sulfate:				
Commercial (17 percent Al_2O_3)	56	1,112,180	1,072,654	$42,212
Municipal (17 percent Al_2O_3)	3	3,738	XX	XX
Iron-free (17 percent Al_2O_3)	16	64,929	38,798	2,210
Aluminum chloride:				
Liquid (32° Be) } Crystal (32° Be)	8	24,649	14,462	1,071
Anhydrous (100 percent $AlCl_3$)	7	36,659	36,807	9,736
Aluminum floride, technical	6	124,843	125,526	29,667
Aluminum hydroxide, trihydrate (100 percent $Al_2O_33H_2O$)	8	270,529	243,716	18,307
Other inorganic aluminum compounds [1]	XX	XX	XX	15,809
Total	XX	XX	XX	119,012

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.

Table 8.—Stocks of bauxite in the United States [1]

(Long tons)

Year	Producers and processors: Crude	Producers and processors: Processed [2]	Consumers: Crude	Consumers: Processed [2]
1963	1,143,893	8,967	499,526	1,696,700
1964	1,163,770	10,264	402,394	1,399,509
1965	1,007,020	8,689	419,525	1,609,104
1966	1,129,759	10,424	414,446	2,167,741
1967	1,091,926	9,975	405,870	2,078,018

[1] Excludes strategic stockpile.
[2] Dried, calcined, and activated.

PRICES

No open market price was in effect for bauxite mined in the United States because the output was consumed mainly by the producing companies. The average value of imported bauxite consumed by domestic alumina plants was $15.68 per long dry ton.

Prices per long ton quoted in Metals Week for imported bauxite at yearend 1966 and 1967 follow:

	Atlantic ports, f.o.b. cars: Dec. 26, 1966	Atlantic ports, f.o.b. cars: Dec. 25, 1967
Calcined, crushed (abrasive grade)[1]	[2] $27.05–$28.80	$35.00
Refractory grade [3]	36.25	42.00
Dried bauxite, crushed chemical grade (60 percent Al_2O_3, 6 percent SiO_2, 1.25 percent Fe	13.95	15.50– 16.50

[1] 87 percent minimum Al_2O_3.
[2] Penalties for SiO_2 content more than 7 percent.
[3] 88 percent minimum Al_2O_3.

The average value of calcined alumina, as determined from producer reports, was $0.0333 per pound. The value of imported calcined alumina classified as aluminum oxide for use in producing aluminum was $0.0263 per pound.

Table 9.—Average value of domestic bauxite in the United States [1]

(Per long ton)

Type	Shipments f.o.b. mines or plants 1966	1967
Crude (undried)	$9.70	$9.70
Dried	W	W
Calcined	21.20	W
Activated	W	W

W Withheld to avoid disclosing individual company confidential data.
[1] Calculated from reports to the Bureau of Mines by bauxite producers.

Table 10.—Average value of U.S. exports and imports of bauxite

(Per long ton)

Type and country	Average value port of shipment 1966	1967
Exports: Bauxite and bauxite concentrate	$69.27	$100.33
Imports:		
Crude and dried:		
Australia	------	7.75
Brazil	17.98	------
Dominican Republic [1]	12.49	15.26
Greece	14.00	7.85
Guyana	9.88	9.49
Haiti [1]	9.40	10.87
Jamaica [1]	12.45	14.52
Surinam	9.67	9.62
Trinidad and Tobago	10.68	------
United Kingdom	13.70	------
Venezuela	------	9.13
Average	11.54	12.97
Calcined: [2]		
Canada	39.39	38.22
Guyana	29.90	31.11
Surinam	26.17	23.10
Trinidad and Tobago	32.32	31.16
Average	29.41	29.32

[1] Dry equivalent tons adjusted by the Bureau of Mines used in computation.
[2] 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, etc. Consequently the data do not necessarily reflect market values in the country of origin.

Table 11.—Market quotations on alumina and aluminum compounds

Compound	Dec. 26, 1966	Dec. 18, 1967
Alumina, calcined, bags, carlots, works ... pound	$0.0530	$0.0530
Aluminum hydrate, heavy bags, carlots, freight equalized ... do	.0370	.0370 to .0400
Aluminum sulfate, commercial, ground, bulk, carlots, work, freight equalized ... ton	48.25	52.75 to 56.25
Aluminum sulfate, iron-free, bags, carlots, works, freight equalized 100 pounds	3.80	3.95 to 4.0525

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE

The decline in exports of bauxite and bauxite concentrate from 147,000 long tons in 1965 to 2,168 tons in 1967 was caused in part by the development of the Australian bauxite industry and by exports of alumina rather than bauxite to Canada and Mexico. Exports of alumina increased from 320,000 short tons in 1965 and in 1966 to 550,000 tons valued at $41.5 million in 1967. Canada received 32, Ghana 21; U.S.S.R. 15, Norway 13, and Mexico 9 percent. Small quantities were shipped to over 30 other countries.

Exports of aluminum sulfate dropped from 22,000 tons in 1966 to 16,200 tons. Venezuela received 52, Canada 18, and Guatemala 12 percent. About 10,600 tons of aluminum hydroxide was exported; Mexico, India, and West Germany received 32, 15, and 14 percent, respectively. Approximately 19,600 tons of artificial corundum valued at $5.6 million was exported;

Canada received 53, the United Kingdom 9, and Sweden 8 percent. Of the 19,650 tons of other aluminum compounds exported, 20 percent was shipped to Canada, Norway and Australia each 15 percent, and Colombia 14 percent.

Table 12.—U.S. exports of bauxite (including bauxite concentrates), by countries

(Thousand long tons)

Destination	1965	1966	1967
Australia	16	(1)	(1)
Canada	85	9	2
France	7	7	(1)
India	(1)	11	----
Mexico	39	35	(1)
Other countries	(1)	(1)	(1)
Total as reported	147	62	2
Dried bauxite equivalent	228	96	----
Value thousands	$10,736	$4,275	$218

[1] Less than ½ unit.

Imports of bauxite have remained at about the same level of 11.5 million long tons since 1965, but imports of alumina increased from 226,500 short tons in 1965 to 489,000 in 1966, and 952,000 in 1967. Of the bauxite imported, 60 percent came from Jamaica and 26 percent from Surinam. The Dominican Republic, Guyana, and Haiti accounted for most of the remaining imports. Aluminum oxide imports came chiefly from Surinam, 42 percent; Australia, 32 percent; and Jamaica, 14 percent. Imports of aluminum hydroxide totaled 24,044 tons of which 55 percent came from France, 32 percent from Canada, 8 percent from Surinam, and 3 percent from Austria.

Bauxite import data do not include shipments to the Virgin Islands.

Tariff.—The duties on crude bauxite, calcined bauxite, and alumina imported for making aluminum continued to be suspended until July 15, 1968. Duties on aluminum hydroxide and alumina not used for aluminum production remained at 0.25 cent per pound. Presidential Proclamation 3822 authorizing reductions in tariffs in accordance with the Kennedy Round trade agreements was signed in December 1967. The first stage of tariff reductions applying to calendar year 1968 and becoming effective January 1, 1968, included crude and calcined bauxite and alumina.

Table 13.—U.S. imports for consumption of bauxite (crude and dried) by countries [1]

(Thousand long tons and thousand dollars)

Country	1965	1966	1967
Dominican Republic	775	653	824
Guyana	87	326	380
Haiti	330	283	313
Jamaica	6,602	6,665	6,968
Surinam	2,962	3,500	3,069
Trinidad and Tobago [2]	407	63	-------
Other countries	36	39	119
Total:			
Quantity	11,199	11,529	11,673
Value	$142,989	$147,335	$151,418

[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. Other imports, which are virtually all dried, are on as-shipped basis.

[2] Bauxite imports from Trinidad and Tobago originated in Guyana and Surinam, bauxite is not produced in Trinidad and Tobago.

Table 14.—U.S. imports for consumption of alumina for use in producing aluminum, by countries

(Thousand short tons and thousand dollars)

Country	1966	1967
Australia	19	309
France	14	7
Guinea	66	22
Guyana	42	26
Jamaica	86	130
Japan	57	60
Surinam	197	398
Other countries	8	-------
Total:		
Quantity	489	952
Value	$27,383	$50,173

WORLD REVIEW

World bauxite production increased 12 percent in 1967. Of the total world advance, Australia accounted for 86 percent with an individual increase of 132 percent and became the third largest producer in the free world behind Jamaica and Surinam, whose outputs increased 2 percent and 15 percent, respectively. Guyana's production increased 16 percent while that of Republic of Guinea remained at the 1966 level, which was revised downward to 1,583,000 tons from an estimated 3,150,000 tons.

Worldwide the ratio of bauxite to aluminum production continued to decline slightly as follows:

1963	5.6
1964	5.5
1965	5.5
1966	5.4
1967	5.4

Alumina productive capacity in the free world was an estimated 16.21 million tons at yearend as follows:

	(Thousand short tons)
North America, including Jamaica and Virgin Islands	8,972
South America	1,517
Europe	2,629
Africa	800
Asia	1,112
Oceania	1,180
Total	16,210

Table 15.—World production of bauxite by countries [1]

(Thousand long tons)

Country	1963	1964	1965	1966	1967 p
North America (dried equivalent of crude ore):					
Dominican Republic (shipments)	761	748	927	820	e 830
Haiti	r 378	430	377	356	453
Jamaica	6,903	[2] 7,811	[2] 8,514	[2] 8,929	[2] 9,121
United States	1,525	1,601	1,654	1,796	1,654
South America:					
Brazil	167	130	154	r 246	e 257
Guyana	2,342	2,468	2,873	e 2,863	3,328
Surinam	3,384	3,930	r 4,258	4,513	e 5,200
Europe:					
Austria	18	4	-------	-------	-------
France	1,997	2,394	2,620	r 2,766	e 2,745
Germany, West	4	4	4	r 4	e 3
Greece	1,256	r 1,030	r 1,250	e 1,300	1,500
Hungary	1,341	1,454	1,455	1,406	e 1,600
Italy	264	248	241	r 238	e 249
Rumania	10	7	e 80	e 200	e 220
Spain	12	7	r 4	NA	NA
U.S.S.R. e [3]	r 4,200	r 4,200	r 4,600	r 4,700	5,000
Yugoslavia	1,265	1,273	1,549	1,857	2,097
Africa:					
Ghana	309	246	314	318	e 315
Guinea, Republic of	1,638	1,652	1,840	r 1,583	1,639
Mozambique	6	6	6	e 5	e 5
Rhodesia, Southern	2	2	2	NA	NA
Sierra Leone	e 30	151	204	268	336
Asia:					
China, mainland (diasporic) e	400	400	400	400	340
India	r 556	582	695	738	747
Indonesia	485	638	677	r 690	898
Malaysia:					
Malaya	444	464	843	940	885
Sarawak	155	158	135	(r)	-------
Turkey	-------	4	10	r 32	21
Oceania: Australia	354	r 784	r 1,168	r 1,798	4,169
World total [4]	r 30,206	r 32,826	r 36,854	r 38,766	43,612

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

[1] Compiled mostly from data available May 1968.

[2] Bone dry equivalent of bauxite shipments and bauxite converted into alumina.

[3] Excludes nepheline concentrates and alunite ores.

[4] Totals are of listed figures only, no undisclosed data included.

Table 16.—Production and trade of bauxite in 1966, by major countries

(Thousand long tons)

Country	Production	Total	North America: Canada	North America: United States	Europe: France	Europe: Germany, West	Europe: Italy	Europe: Spain	Europe: U.S.S.R.[1]	Europe: United Kingdom	Europe: Other Europe	Asia (Japan)	All other countries
North America:													
Dominican Republic	820	985	--	985	--	--	--	--	--	--	--	--	--
Haiti	356	[2] 328	--	[2] 328	--	--	--	--	--	--	--	--	--
Jamaica	[3] 8,929	7,020	--	7,020	--	--	--	--	--	--	--	--	--
United States	1,796	62	9	--	7	--	--	--	--	--	--	--	46
South America:													
Brazil	246	2	--	--	--	--	--	--	--	--	--	--	2
Guyana	[e] 2,863	2,023	1,040	750	[4] 43	[4] 51	23	--	--	41	8	21	46
Surinam	4,513	4,507	540	3,921	--	--	--	29	--	--	8	--	9
Europe:													
France	2,766	276	--	--	--	120	5	([5])	--	60	85	--	6
Germany, West	4	4	--	--	--	--	--	--	--	--	4	--	--
Greece	[e] 1,200	1,151	--	40	86	369	35	48	419	68	86	--	--
Hungary	1,406	611	--	--	--	59	--	--	552	--	--	--	--
Italy	238	2	--	--	--	--	--	--	--	--	2	--	--
Rumania	[e] 200	NA	--	--	--	--	--	--	--	--	--	--	--
U.S.S.R.	[6] [e] 4,700	NA	--	--	--	--	--	--	--	--	--	--	--
Yugoslavia	1,857	1,456	--	--	--	640	244	--	559	5	4	--	4
Africa:													
Ghana	318	306	--	10	--	--	--	--	--	296	--	--	--
Guinea, Republic of	1,583	NA	--	--	--	--	--	--	--	--	--	--	--
Mozambique	[e] 5	6	--	--	--	--	--	--	--	--	--	--	6
Sierra Leone	268	241	--	--	--	[4] 154	[4] 74	--	--	--	13	--	--
Asia:													
China (diasporic)	[e] 400	NA	--	--	--	--	--	--	--	--	--	--	--
India	738	77	--	--	--	29	[4] 17	--	--	9	3	9	10
Indonesia	690	672	--	--	--	[4] 27	[4] 29	--	--	--	--	[4] 594	22
Malaysia	940	1,007	90	--	--	--	--	--	--	--	--	590	327
Turkey	32	--	--	--	--	--	--	--	--	--	--	--	--
Oceania: Australia	1,798	389	--	--	--	147	--	--	--	--	--	210	32
World total [7]	38,666	21,125	1,679	13,054	136	1,596	427	77	1,530	479	213	1,424	510

[e] Estimate. NA Not available.
[1] U.S.S.R. and other Communist nations of East Europe.
[2] U.S. imports.
[3] Bone dry equivalent of bauxite shipments and bauxite converted to alumina.
[4] Imports.
[5] Less than ½ unit.
[6] Excludes nepheline concentrates and alunite ore.
[7] Totals are listed figures only; no undisclosed data included.

NORTH AMERICA

Canada.—Pyrominerals, Ltd., began production of fused alumina abrasives (synthetic corundum) at its 4.5 million metallurgical and chemical plant at Point Edward, Nova Scotia. The material, which is produced from Australian and South American bauxite, is sold worldwide to secondary processors.

Inland Chemicals awarded a construction contract for a 5,000-ton-per-year aluminum sulfate plant at Prince George, British Columbia, with startup scheduled for mid 1968.

Costa Rica.—A large low- to medium-grade lateritic bauxite deposit covering 250 square kilometers was under investigation by Alcoa under a 25-year contract.

Jamaica.—Jamaica continued to be the world's largest producer of bauxite accounting for 22 percent of total production. About 76 percent was shipped to the United States. The remainder was converted to alumina which was exported to Canada and the U.S.

Construction of a 950,000-ton-per-year alumina plant by Alumina Partners of Jamaica (Alpart) was about 20 percent complete. Alpart is a partnership of Anaconda Jamaica, Inc., Kaiser Jamaica Corp., and Reynolds Jamaica Alumina, Ltd. Total investment was estimated at $185 million.

Kaiser Bauxite Co. dedicated its new $35 million bauxite operation, which includes a loading facility at Discovery Bay to accommodate 37,500-ton ore-carrying ships and a 125,000-ton-capacity bauxite storage dome.

An agreement between Revere Copper & Brass Corp., Inc., and the Government of Jamaica was announced under which an alumina plant with an ultimate annual capacity of 660,000 tons will be built at a cost of $125 million. The first stage, 220,000-ton-capacity, is scheduled to be completed by 1970.

SOUTH AMERICA

Brazil.—The World Bank confirmed a $22 million loan to help finance aluminum facilities in Brazil, including a 50,000-ton-annual-capacity alumina plant. Companhia Mineria de Alumino (Alcominas), a joint venture of Brazilian capital, Alcoa, and Hanna Mining Co., will obtain bauxite from extensive reserves in the Poços de Caldas area to be mined by a subsidiary, Companhia Geral de Minas.

Guyana.—The new plant of Reynolds Metal Co. at Everton started production of calcined bauxite for refractory and abrasive use. Rated capacity is 400 long tons per day. Additional mining, transportation, and drying facilities were installed to increase production of metallurgical grade bauxite to 1 million tons per year. The $50 million, 3-year expansion program by Demerara Bauxite Co. Ltd. (Demba) a subsidiary of Alcan Aluminum, Ltd., and Reynold's $15 million investment program resulted in a record bauxite production of 3.3 million tons.

Surinam.—The decrease in exports of bauxite from 4.5 million long tons in 1966 to 3.8 million was more than offset by an increase in alumina exports from 340,000 to over 750,000 short tons. Thus, exports of bauxite equivalent totaled a record 5.3 million tons.

Productive capacity of Surinam Aluminum Co.'s (Suralco) alumina plant was increased to 800,000 tons per year and construction started on a fifth 200,000-ton-per-year unit. Facilities are shared with Billiton Co. (Dutch) which participated in the financing.

Negotiations continued between a group of primary aluminum producers and Surinam Government officials regarding the development of the large bauxite deposits discovered at Kabalebo in Western Surinam.

Venezuela.—Construction of an aluminum sulfate plant at Moron in the state of Carabobo having an annual capacity of 22,000 metric tons was announced by Aliada Quimica de Venezuela C.A., a subsidiary of Allied Chemical Corp. For the period 1964–67 Venezuela has received over 50 percent of U.S. exports of aluminum sulfate, averaging about 9,000 tons per year.

EUROPE

France.—Bauxite production was maintained at over 2.7 million long tons per year by the 12 mining operations in Herault and Var despite increasing mining costs. Plant expansions by Péchiney, Compagnie de Produits Chimiques et Eléctrometallurgiques at Gardanne and by Ugine-Kuhlmann Société at La Barasse increased alumina production capacity to an estimated 1.1 million short tons per year.

Germany, West.—Full alumina annual production capacity of 700,000 tons was attained in 1967. Vereinigte Aluminum-Werke, A.G. announced plans to increase capacity at its Lippewark plant at Lunen by 70,000 tons to 240,000 tons per year.

Greece.—Plans were drawn by Aluminum de Grece S.A. to double the capacity of its alumina plant at St. Nicholas to 500,000 tons per year. This capacity will be equivalent to most of the estimated 1.5 million tons of bauxite produced in Greece.

Hungary.—Existing annual capacity at the Ajaka alumina work in western Hungary was increased from 95,000 to 130,000 tons and plans were announced for a second 240,000-ton-per-year plant to be completed in 1972 and later doubled in capacity. The plant at Almatuzito was being expanded from 155,000 tons to 288,000 tons per year by 1969.

Italy.—Societa Salento Industrie Chemiche SpA announced plans for a plant to produce aluminum sulfate from bauxite mined at Montevergine, Poggiardo, and Palmariggi.

Netherlands.—Zuid Chimie NV, a subsidiary of Pechiney-Saint-Gobain, began construction of a 20,000-ton-per-year aluminum sulfate plant at Sas Van Gert to be on stream in early 1968, with plans to later double capacity.

U.S.S.R.—A pilot plant for production of alumina from kaolin mined near the town of Angra , was under construction at Almslyk, Uzbekistan.

United Kingdom.—A chemical division was formed by the British Aluminum Co. Ltd. (BACO), to include BACO's alumina plants at Buratisland, Fife, and Newport, and the aluminum sulfate plant of the Alumina Co. Ltd. at Widnes, among other interests.

Yugoslavia.—The capacity of the largest of Yugoslavia's three alumina plants at Kidricero was expanded to 90,000 short tons per year, to be increased to 140,000 tons by 1971. The country's other two alumina plants at Moste and Sibenik are comparatively small.

AFRICA

Ghana.—The bauxite operation of the British Aluminum Co. at Awaso was expanded by the addition of conveying, crushing, and screening equipment to handle 450 tons per hour. Of the four known bauxite deposits in Ghana, only those at Awaso are being mined.

Guinea.—Bauxite production, practically all of which was converted to alumina by, Compagnie Internationale pour la Production d'Alumine (Fria) and exported, remained at the same level. A small quantity of bauxite was mined by Harvey Aluminum, Inc., from its new operation on Tamara Island for shipment to St. Croix and production of alumina.

Negotiations continued on the development of the Boké bauxite fields, which are located about 90 miles inland. Compagnie des Bauxites de Guinee was formed in 1964 to develop these deposits. Halco (Mining) Inc., a subsidiary of Harvey Aluminum, Inc., owned 51 percent; the remaining 49 percent is owned by the Government of Guinea. In 1967, negotiations were underway for division of Halco's 51 percent interest as follows: Alcoa, 17.5 percent; Alcan Aluminum Ltd., 17.5 percent; Pechiney of France, 6 percent; Vereinigte Alumininum-Werke of West Germany, 5 percent; and Montecatini Edison of Italy, 3 percent. Thus, Halco would retain 51 percent of its original 51 percent ownership, or slightly over 26 percent of the whole.

ASIA

India.—The bauxite export monopoly of the Government-owned Minerals and Metals Trading Corp. (MMTC) was abolished effective February 2, 1967. Bauxite exporters may negotiate their own contracts, under Government-approved applications, or continue to utilize the services of MMTC.

Reserves of bauxite containing more than 50 percent Al_2O_3 were reported in 1967, in millions of metric tons by States, as follows: Bihar, 12.9; Gujarat, 12.7; Jammv and Kashmir, 13.0; Madhya Pradesh, 17.5; Madras, 4.0; Maharashtra, 10.6; Mysore, 1.2; Orissa, 0.7.

A $5.5 million loan from Canada's contribution to the World Bank will be used by the Indian Aluminum Co., Ltd., to purchase Canadian equipment and services to be supplied by Alcan, for constructing an alumina plant, smelter, and allied bauxite facilities, near Belgaum, Mysore State.

Indonesia.—One mine on the island of Bintan accounted for the total bauxite production of 900,000 tons containing 55 percent alumina, all of which was shipped to

Japan. Negotiations continued between Alcoa and the Indonesian Government for exclusive bauxite exploration rights to all of Indonesia except the Island of Bintan.

Japan.—Alumina production totaled 782,200 short tons from bauxite imported principally from Australia, Indonesia, and Malaysia.

Turkey.—A 200,000-ton-per-year alumina plant at Seydisehir will reportedly be financed by the U.S.S.R.

OCEANIA

Australia.—In addition to the three major known bauxite reserves located at Weipa, at Gove, and in the Darling Ranges containing at least 3.2 billion tons, a 50- to 75-million-ton reserve was developed by American Metal Climax, Inc. (AMAX), on the Mitchell Plateau in the Kimberly area of northwest Western Australia. Exploration work continued aimed at increasing reserves to 200 million tons to justify an alumina plant at Port Warrender. Broken Hill Associated Smelters, Pty. Ltd. reportedly applied for thirty-five 300-acre claims adjacent to the area under exploration by AMAX.

Initial geological surveys indicated a potential 500-million-ton bauxite reserve contained in a new discovery about 10 miles north of Perth in Western Australia. The Darling Range deposits, which are being mined by Alcoa of Australia Pty., Ltd., at the expanded rate of 29,000 tons per week, are located about 28 miles northeast of Perth.

Bauxite production from the Weipa field, located on the west coast of Cape York peninsula in Queensland, was increased to a rate of 2.5 million tons per year by Commonwealth Aluminum Corp., Pty., Ltd., a wholly owned subsidiary of Comalco Industries Pty., Ltd. Comalco is equally owned by Conzinc Riotinto of Australia, Ltd., and Kaiser Aluminum & Chemical Corp. The town of Weipa, constructed and designed specifically for the development of the bauxite deposits, was officially opened in June.

Bauxite production by Nabalco Pty., Ltd., from the Gove deposits located near the northeast tip of the Northern Territory is scheduled to begin in 1970 at a rate of 1 million tons per year. Nabalco, which is equally owned by Swiss Aluminum Ltd., and Australian Capital, tentatively chose a site for a 500,000-ton-per-year alumina plant and port facilities at Dundas Point on the entrance to Melville Bay.

Two-thirds of the bauxite mined in Australia is converted to alumina in Australia by three companies. Alumina productive capacity at yearend was 1,053,000 long tons, including the 50,000-ton-capacity of the oldest plant at Bell Bay on the North Coast of Tasmania operated by Comalco Aluminum Ltd. Announced expansion plans will bring the country's alumina capacity to 2,060,000 tons by 1971.

The Gladstone plant of Queensland Alumina Ltd., came on stream in March, processing bauxite from the Weipa field to produce alumina at a rated annual capacity of 600,000 long tons. Queensland Alumina Ltd., owned 52 percent by Kaiser Aluminum & Chemical Corp., 20 percent by Compaigne Pechiney, and 8 percent by Conzinc Riotinto of Australia, Ltd., announced plans to expand annual capacity to 900,000 tons.

The Kwinana plant processing bauxite from the Darling Range and operated by Western Aluminum Pty., Ltd., a wholly owned subsidiary of Alcoa of Australia Pty., Ltd., increased annual capacity to 410,000 metric tons per year and announced a further expansion to 620,000 tons to be completed in 1968.

WORLD RESERVES

A review of world bauxite reserves based on information available through 1965, was compiled by Sam H. Patterson of the U.S. Geological Survey and published in 1967 as Geological Survey Bulletin 1228, titled, "Bauxite Reserves and Potential Aluminum Resources of the World." Table 17, taken from this publication, contains bauxite reserves and other potential sources of alumina by countries.

Table 17.—Estimated total reserves and potential resources of bauxite, 1965

(Million tons)[1]
(L, large; S, small; VS, very small)

	Reserves [2]	Potential resources
North America:		
United States:		
Arkansas	44	65
Southeastern States	1	25
Oregon and Washington	---------	85
Hawaii	-------	125
Total (rounded)	45	300
Central America:		
Costa Rica	-------	150
Honduras and El Salvador	-------	10
Panama	-------	25
Total (rounded)	-------	200
Caribbean Islands:		
Dominican Republic and Haiti	85	40
Jamaica	600	400
Total (rounded)	690	450
South America:		
Argentina	-------	S(?)
Brazil	40	200
British Guiana	80	250
French Guiana	70	100
Surinam	200	350
Venezuela	-------	103
Total (rounded)	390	1,000
Europe:		
Austria	1	------------
France	70	190
Greece	84	100
Hungary	150	(L)
Italy	24	S
Northern Ireland	-------	3
Poland	-------	S(?)
Rumania	20	---------
Spain	7	---------
U.S.S.R. (including Soviet Asia)	[3] 300	(?)
Yugoslavia	200	100
Total (rounded)	850	400
Africa:		
Angola	S(?)	S(?)
Cameroon	-------	1,500
Chad	-------	30
Congo (Leopoldville)	-------	100
Ghana	290	110
Guinea	1,200	2,400
Malagasy Republic	-------	120
Mali	-------	550
Mozambique	2	---------
Nyasaland (Malawi)	60	S(?)
Portuguese Guinea	-------	10
Southern Rhodesia	-------	2
Sierra Leone	30	M(?)
Tanzania	-------	S(?)
Total (rounded)	1,580	4,800
Asia:		
China (mainland)	150	1,000
India	64	190
Indonesia	20	10+
Iran	-------	S
Malaysia:		
Peninsular Malaysia	10	40
Sarawak	5	S
North Viet Nam	VS	---------
Pakistan	-------	15
Philippines	-------	28
Turkey	30	100
Total (rounded)	280	1,400
Oceania:		
Australia	2,000	1,000
Fiji Islands	-------	1
New Zealand	-------	20
Palau Islands	5	40
Total (rounded)	2,000	1,050
Total for world (rounded)	5,800	9,600

[1] Most figures are in metric or long tons, dry basis; however, many estimates used in compilation failed to designate type of tons used and whether tonnages had been converted to dry basis.
[2] Chiefly measured and indicated reserves that in some degree have been inventoried in terms of commercial enterprise and could be used under economic and technological conditions existing in 1965, but inferred bauxite is included for some large deposits, such as those in Australia not fully explored.
[3] Estimate probably includes much low-grade bauxite that would be classed as potential resources in other countries, and possibly aluminous rocks other than bauxite.

TECHNOLOGY

Bauxite will continue to be the source of alumina so long as it is available at current prices relative to the cost of other aluminous raw materials. Looking ahead to depletion of high-grade bauxite reserves or curtailment of imports, industry and government continued cost studies and research on producing alumina from lower grade sources. Information on the nature and occurrence of these potential sources in the United States and its possessions was published.[3] Over 600 billion tons of ferruginous bauxite, bauxitic clay, kaolin and other types of clay, anorthosite, the kyanite group of minerals, laterites, and shales averaging 27 to 42 percent Al_2O_3 were documented.

Interest continued in the occurrence of dawsonite ($NaAl(OH)_2Co_3$) in oil shales of the Green River Formation in the Piceance Creek Basin of northwestern Colorado.[4] This interest was based on the alumina and soda content of dawsonite and soda content of nahcolite ($NaHCO_3$) which is also present. The dawsonite is disseminated sparsely in the shale. A maximum concentration of 25 percent dawsonite was estimated in a 700-foot interval at a depth of 1,800 to 2,500 feet. Dawsonite contains 36 percent Al_2O_3. Thus, a zone with 25 percent dawsonite would contain 9 percent Al_2O_3 compared with the average Al_2O_3 content of the earths crust of about 15 percent.

In order to present a reference point for cost estimates for nonbauxite alumina processes a report evaluating the Bayer process for treating Jamaican bauxite was published.[5] The operating cost of a 1,000-ton-per-day alumina plant was estimated to be $47.96 per ton of product.

A comparison of the Bayer process with an acid process whereby alumina was recovered from aluminum sulfate crystals was reported.[6]

Reports dealing with the recovery of alumina from ferruginous bauxites of Hawaii, Arkansas, and the Pacific Northwest were published.[7] A caustic, lime reduction-sintering followed by water extraction of alumina and magnetic separation resulted in alumina recoveries of 74 to 95 percent from the Hawaiian and Arkansas bauxites and a magnetic product containing 72 to 86 percent iron. The Pederson process, developed in Norway, was applied to the Northwest bauxites and expanded to include a treatment for removing silica from the leach liquor. In this process, high-iron bauxites are smelted in an electric arc furnace with lime and coke to produce a calcium aluminate slag from which the aluminate can be leached with a sodium carbonate solution. Byproduct iron recovery averaged over 90 percent but contained about 1 percent phosphorous and would require additional refining. The technical feasibility of treating the vast reserves of Pacific Northwest ferruginous bauxites was shown, but successful exploitation will depend on larger scale tests and favorable cost studies.

Continuing the search for economic nonbauxite sources of alumina, an evaluation of a lime-soda sinter process for producing alumina from clay was published.[8] The estimated operating costs per ton of alumina, including straight line depreciation over 20 years but with no provision for profit, ranged from $72 to $80, assuming a delivered cost for clay and limestone of $1 to $2 per ton.

Vast deposits of anorthosite, an igneous rock having a sodium calcium aluminum silicate composition and containing an average of 27 percent Al_2O_3 are known to occur in New York, Wyoming, California, Idaho, Montana, Oklahoma, Minnesota, and Pennsylvania. The results of studies to extract alumina from samples representing this large alumina resource were re-

[3] Bureau of Mines. Potential Sources of Aluminum. Inf. Circ. 8335, 1967, 148 pp.

[4] Smith, John Ward, and Charles Milton. Dawsonite in the Green River Formation of Colorado. Econ. Geol., v. 61, No. 6, 1966, pp. 1029–1042.

[5] Peters, Frank A., Paul W. Johnson, and Ralph C. Kirby. A Cost Estimate of the Bayer Process for Producing Alumina. BuMines Rept. of Inv. 6730, 1966, 21 pp.

[6] Saeman, W. C. Alumina From Crystallized Aluminum Sulfate. J. Metals, v. 18, No. 7, July 1966, pp. 811–818.

[7] Blake, Henry E. Jr., Oliver C. Fursman, Arden D. Fugate, and Lloyd H. Banning. Adaption of the Pederson Process to the Ferruginous Bauxites of the Pacific Northwest. BuMines Rept. of Inv. 6939, 1967, 21 pp.

Calhoun, W. A., and T. E. Hill, Jr. Metallurgical Testing of Hawaiian Ferruginous Bauxites—Concluding Report. BuMines Rept. of Inv. 6944, 1967, 37 pp.

Hill, T. E., Jr., and W. A. Calhoun. Processing of High-Iron Arkansas Bauxite Ores. BuMines Rept. of Inv. 6914, 1967, 18 pp.

[8] Peters, Frank A., Paul W. Johnson, John J. Henn, and Ralph C. Kirby. Methods for Producing Alumina From Clay. An Evaluation of a Lime-Soda Sinter Process. BuMines Rept. of Inv. 6927, 1967, 38 pp.

leased.[9] Nearly complete extraction of the alumina was obtained by leaching melted and quenched anorthosite (ground to minus 65 mesh) for 15 to 20 minutes at the boiling point with 16 percent sulfuric acid. Greater than 90 percent alumina extractions were also obtained from dry-mixed minus 200-mesh anorthosite sinter mixes that were briquetted at 15,000 pounds per square inch, fired between 1,200° and 1,320° C for 20 to 60 minutes, and leached with a 1.5-normal sodium hydroxide solution.

Studies were also conducted to recover alumina from waste products such as coal-associated draw-slate, a nuisance product,[10] and mineral waste solutions. Preliminary studies conducted by the Bureau of Mines indicated that more than 2,000 tons of alumina were being discarded each day in waste solutions from domestic copper leaching plants and that it might be recovered for a cost of $51 to $58 per ton.

Long fine "whiskers" of aluminum silicate were produced by a patented process developed by Bureau of Mines reseachers.[11] As reinforcing fibers in a matrix of plastic or metal, they provide structural strength for components of aircraft, rocket, and space vehicles.

An industrial alumina ceramic, harder than tungsten carbide and equal to platinum in inertness, was developed. The desirable properties of this material, almost pure sapphire (99.98 percent Al_2O_3) and containing no glass, are attributable to controlled microstructure and crystal size—3 microns. Tungsten carbide and platinum are in relatively short supply; however, the new ceramic can compete with tungsten carbide in such applications as metal machining bits, bearings, and extrusion dies and with platinum as a linear in wet chemistry crucibles.[12]

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[9] Ampian, Sarkis G. Lime-Soda Sinter Process, Correlation of Reaction Products With Extractability of Alumina From Anorthosite. BuMines Rept. of Inv. 6933, 1967, 44 pp.

Leitch, H., H. G. Iverson, and J. B. Clemmer. Extraction of Alumina by Leaching Melted and Quenched Anorthosite in Sulfuric Acid. BuMines Rept. of Inv. 6744, 1966, 32 pp.

[10] Shafer, H. E., Jr., and J. A. Solomon. The Effect of Selected Calcining Temperatures on Alumina Extracting From Coal-Associated Draw-Slate. Trans. Min. Eng., v. 238, No. 1, March 1967, p. 101–103.

[11] Johnson, Robert C., and Wilbur H. Warrick (assigned to the United States of America as represented by the Secretary of the Interior). Synthesis of Aluminum Silicate Whiskers. U.S. Pat 3,321,271, May 23, 1967.

[12] Steel. Course Alumina Ceramic Tough, Strong, Inert. v. 160, No. 22, May 29, 1967, p. 62.

Beryllium

By Donald E. Eilertsen [1]

World production and U.S. imports and consumption of beryl increased in 1967. Beryl from India was processed to beryllium metal on barter stockpile contracts. Domestic beryl output continued to be negligible, but the stage was set to use Utah bertrandite ore in competition with imported beryl. New, extensive uses for beryllium in C–5 aircraft brakes and in missiles developed.

Legislation and Government Programs.—Government inventories of beryllium materials were increased by 3,050 tons of beryl and 49 tons of beryllium metal in 1967 as a result of the barter agreement that was negotiated with India in 1963. Through the agreement, India receives surplus agricultural commodities in exchange for beryl. The Beryllium Corp. and The Brush Beryllium Co. had contracts to process the mineral into a total of 75 tons of beryllium billet.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient beryl statistics

	1963	1964	1965	1966	1967
United States: Beryl, approximately 11 percent BeO unless otherwise stated:					
Domestic beryl shipped from mines........short tons..	1	W	W	W	W
Imports........do....	6,243	5,425	7,791	2,147	9,511
Consumption........do....	7,934	4,435	5,845	6,026	7,087
Price, approximate, per unit BeO imported, cobbed beryl at port of exportation........	$24	$23	$24	$25	$30
World: Production........short tons..	7,299	4,943	5,587	3,578	6,950

W Withheld to avoid disclosing individual company confidential data.

Table 2.—Government yearend stocks of beryllium materials
(Short tons)

Item	National stockpile	Supplemental stockpile	Commodity Credit Corporation	All Stocks
Beryl (11 percent BeO):				
Objective........	13,532	1,683	----	15,215
Excess........	8,202	4,827	[1] 3,019	16,048
Total........	21,734	6,510	[1] 3,019	31,263
Beryllium-copper master alloy:				
Objective........	----	----	----	4,750
Excess........	(²)	(²)	----	(²)
Total........	1,075	6,312	----	7,387
Beryllium metal:				
Objective........	----	150	----	150
Excess........	----	37	15	52
Total........	----	187	15	202
On order........	----	----	25	25

[1] Reserved for converting to beryllium.
[2] No excess shown in this commodity due to a deficit in copper.

Source: Office of Emergency Planning. Supplemental Stockpile Report to the Congress. OEP-4, July–December 1967.

DOMESTIC PRODUCTION

Hand-sorted beryl was produced in South Dakota and Colorado. Company data are confidential but reportedly the total output was small.

The Beryllium Corp. of Reading and Hazleton, Pa., and The Brush Beryllium Co. of Elmore, Ohio, processed hand-sorted beryl into beryllium metal, alloys, and compounds. Outputs were principally beryllium and beryllium-copper master alloy. The Brush Beryllium Co. announced plans to commercially mine and process Utah bertrandite. A plant is to be erected between Delta and Lynndyl, Utah, to process bertrandite mined in the Topaz-Spor Mountain area, about 40 miles away. The facilities will cost $8 to $10 million and begin operations in 1969. The company received a $6.5 million contract from the Government for beryllium C–5 aircraft brakes for delivery during 1968–70. Negotiations underway for producing Poseidon missile parts led to a $13 million contract for deliveries in 1968 and 1969.

Beryllium Metals & Chemicals Corp., Bessemer City, N. C., a subsidiary of Lithium Corporation of America, Inc., continued to produce and fabricate electrorefined beryllium.

The Anaconda Company continued its studies on utilizing Utah bertrandite ore, and General Astrometals Corp., Yonkers, N. Y., a subsidiary of The Anaconda Company, continued to produce beryllium shapes from various types of beryllium.

CONSUMPTION AND USES

The beryllium and ceramic industries consumed 7,087 short tons of hand-sorted beryl of which The Beryllium Corp. and The Brush Beryllium Co. were by far the largest consumers. Cobbed beryl was used by Beryl Ores Co., Arvada, Colo., to produce specialized beryl materials for the ceramic and other industries. Lapp Insulator Co., LeRoy, N. Y., used ground beryl in making high voltage electrical porcelain. Cobbed beryl as a minor constituent in special ceramic compositions was used principally for spark plugs by The Ceramic Division, Champion Spark Plug Co., Detroit, Mich.

Aerospace designers and developers continued to be attracted to beryllium's low density, high modulus of elasticity, unique stiffness to weight ratio, high heat capacity, and unusual nuclear properties. The use of beryllium in structural components, aircraft brakes and rudders, jet engine parts, and rocket fuel additives continued to be in various stages of development or evaluation. Interest greatly increased for using beryllium in missile parts. The metal had well-established uses in inertial guidance systems, but only sporadic use in special applications for nuclear reactors.

Beryllium-copper alloys had thousands of uses in business machines, computers, electronic devices, household appliances, automobiles, aircraft, boats, and spacecraft. New uses ranged from ball point pens to space vehicle antennas, and included uses in hydrophones, hot cutters for removing automobile windshield sealant, and diamond-powder-impregnated wire for saws. Beryllium additives were used to control the magnesium content of magnesium-aluminum alloys, and beryllium oxide continued to attract applications in electronics.

STOCKS

Consumers stocks of beryl at yearend totaled 8,177 tons. Dealers stocks of beryl were unknown.

PRICES AND SPECIFICATIONS

Prices of domestic and imported beryl were generally negotiated between a buyer and seller and not quoted in the trade press. The average value of imported beryl at foreign ports was $333 per short ton.

The quoted price of beryllium metal, 97-percent pure, beads, f.o.b. Reading, Pa., and Cleveland, Ohio, was $62 per pound in 1,000- to 2,000-pound quantities. A blend of beryllium powder, 200-grade, was quoted at $54 per pound in quantities of 20,000 pounds. Vacuum-cast beryllium ingot was quoted at $67 to $71 per pound. The quoted price of beryllium-copper master alloy, f.o.b. Reading, Pa., Detroit, Mich., and Elmore, Ohio, was $46 per pound of contained beryllium plus 55 cents per pound of contained copper until May 2, and afterward at the price of copper on the date of shipment. Beryllium-copper (No. 172) strip, rod, bar, and wire was quoted at $2.37 per pound through May 2, and afterward at $2.41 per pound. Beryllium-aluminum was quoted at $60 per pound of contained beryllium with aluminum paid for at the market price.[2]

FOREIGN TRADE

Exports of various forms of beryllium and beryllium-base alloy powder were almost 25 percent larger in 1967 than in 1966, mostly due to greatly increased exports to Canada and West Germany.

Imports for consumption of beryl increased more than fourfold in 1967 compared to 1966 with the imports from India and Italy the largest ever reported from these countries. The beryl from India was obtained under the barter program for conversion to beryllium metal. The beryl from Italy was probably the remainder from former beryllium metal operations.

Imports of beryllium metal from France have increased annually since this reporting began in 1963.

[2] American Metal Market. V. 74, No. 1–249, January-December 1967.

Table 3.—U.S. exports of beryllium alloys, wrought or unwrought, and waste and scrap [1]

Country	1966		1967	
	Pounds	Value (thousands)	Pounds	Value (thousands)
Australia	----	----	5	(2)
Austria	----	----	1	(2)
Brazil	37	$3	----	----
Canada	3,152	20	23,029	$97
Congo (Kinshasa)	82	2	----	----
Denmark	1	1	----	----
France	9,038	464	1,326	33
Germany, West	10,459	141	24,538	107
Greece	----	----	939	3
Israel	986	2	----	----
Italy	3	1	55	4
Japan	5,905	228	6,356	181
Korea, South	17	1	----	----
Mexico	2,220	2	2,222	2
Netherlands	4	1	25	4
Norway	11,619	10	----	----
Philippines	3	1	----	----
Switzerland	1	(2)	10	3
United Kingdom	17,727	206	17,516	96
Venezuela	----	----	95	(2)
Total	61,254	1,083	76,117	530

[1] Consisting of beryllium lumps, single crystals, and powder; beryllium-base alloy powder; and beryllium rods, sheets, and wire.
[2] Less than ½ unit.

Table 4.—U.S. imports for consumption of beryl, by customs district and countries

(Short tons)

Customs district and country	1966	1967
Philadelphia district:		
Argentina	218	313
Australia	15	414
Brazil	877	1,173
Burma	22	----
Burundi and Rwanda	----	100
Finland	17	----
India	----	1,500
Italy	----	1,316
Kenya	----	33
Malagasy Republic	10	12
Mozambique	62	141
Portugal	11	15
Rhodesia, Southern	72	47
South Africa, Republic of	67	197
Uganda	101	235
Western Africa, n.e.c	17	----
Total Philadelphia	1,489	5,496
New York City district:		
Australia	27	----
Brazil	----	53
Burundi and Rwanda	88	44
Mozambique	8	----
South Africa, Republic of	7	----
Uganda	28	----
Total New York City	158	97
Baltimore district:		
India	500	3,907
Norway	----	10
Total Baltimore	500	3,917
El Paso district: Zambia	----	1
Grand total	2,147	9,511
Value (thousands)	$581	$3,167

Table 5.—U.S. imports of beryllium products in 1967, by countries

Country	Beryllium, unwrought, waste and scrap		Wrought beryllium		Beryllium oxide or carbonate		Other beryllium compounds	
	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
France	12,099	$646	349	$13	--	--	66	(1)
Japan	--	--	6	1	90	$2	--	--
United Kingdom	5,373	4	--	--	--	--	--	--
Total	17,472	650	355	14	90	2	66	(1)

[1] Less than ½ unit.

WORLD REVIEW

India.—During fiscal year 1966 (April 1965-March 1966), 3,177 feet of exploration and development drilling was done at Nawagaon in the Dungarpur district, Rajasthan, and at Doddakadanur in the Hassan district, Mysore. The drilling revealed beryl at depths of over 200 feet.

Surface geological studies in 1965 confirmed the existence of beryl-bearing pegmatites in the mica belts of the Monghyr district in Bihar, the Sirohi district in Rajasthan, the Raigarh and Balaghat districts in Madhya Pradesh, the Mahasu and Kinnaur districts in Himachal Pradesh, and the Kolar, Mysore, Mandya, and Shimoga districts in Mysore. Beryl is considered to be a strategic mineral and publication of statistical data are controlled by the Department of Atomic Energy.

Table 6.—World production of beryl, by countries [1]

(Short tons)

Country	1963	1964	1965	1966	1967
Argentina	r 416	r 208	r 248	r 276	NA
Australia	123	125	44	64	NA
Brazil [2]	2,170	1,566	1,227	778	NA
Congo (Kinshasa)	235	136	21	NA	NA
India e	----	----	1,500	600	5,400
Malagasy Republic	453	234	22	13	NA
Mozambique	613	451	202	88	NA
Portugal	2	20	44	15	e 40
Rhodesia, Southern	249	182	[3] 101	e 80	NA
Rwanda	282	328	r 756	147	120
South Africa, Republic of	425	151	53	20	e 90
South-West Africa	61	8	57	24	NA
Uganda	419	434	212	273	NA
U.S.S.R. e	1,100	1,100	1,100	1,200	1,300
United States (mine shipments):					
Cobbed beryl	1	W	W	W	W
Other lower grade beryllium ore	750	----	----	----	----
World total [4]	r 7,299	r 4,943	r 5,587	r 3,578	6,950

r Revised. NA Not available. e Estimate. W Withheld to avoid disclosing individual company confidential data.
[1] Compiled mostly from data available April 1968.
[2] Exports.
[3] U.S. imports.
[4] Totals are of listed figures only; no undisclosed data included.

Japan.—The Japan Society for Newer Metals estimated the country's beryl consumption for fiscal year 1964 (April 1964-March 1965) at 441 short tons and for fiscal year 1965 at 551 tons. Output of beryllium-copper master alloy in fiscal year 1964 was 164 tons. Beryllium-copper products for communication equipment during fiscal year 1964 totaled 65 tons; including wire and bars, 4.4 tons each; strip, 38.6 tons; sheet, 16.5 tons; and other, 1.1 tons. In fiscal year 1965 the total was 58.4 tons distributed as follows: wire and bars, 5.5 tons each; strip, 35.3 tons; sheet, 9.9 tons; and other, 2.2 tons.[3]

TECHNOLOGY

A report on the powder metallurgy of beryllium described the techniques of making powders; the compaction of powders by die pressing, isopressing, slip casting, vibration, and explosives; the sintering of powders by conventional and pressureless procedures; and the consolidation of powders by vacuum hot pressing, hot isostatic pressing, forging, extrusion, and plasma spraying. The mechancial properties of various beryllium metals and their applications were also discussed.[4]

Special procedures to make beryllium wire were being developed. Cost reductions have already been achieved, and further cuts are anticipated if large demand develops. Procedures for producing beryllium wires down to as little as 0.002-inch in diameter were described.[5]

The fabrication of Beryllium-Lockalloy, which is 62 percent beryllium and 38 percent aluminum, was described. Some of the alloy's physical properties were compared with those of aluminum, magnesium, beryllium, and alloys of magnesium-aluminum and titanium-aluminum-vanadium. The alloy can be formed, machined, and joined by conventional methods, and satellite structures is one of its potential uses.[6]

[3] Bureau of Mines. Mineral Trade Notes. V. 64, No. 3, March 1967, p. 4.
[4] Porembka, S. W., H. D. Hanes, and P. J. Gripshover. Powder Metallurgy of Beryllium. Battelle Memorial Institute, Defense Metals Information Center, DMIC Rept. 239, Oct. 15, 1967, 23 pp.
[5] Pinto, Norman P., and John P. Denny. Beryllium Wire: A New Engineering Material. Metal Progress, v. 91, No. 6, June 1967, pp. 107–118.
[6] Van Hamersveld, John A., Thomas S. Svendsen, and Walter C. Hayes. Making Satellite Structures From Beryllium-Lockalloy. Metal Progress, v. 91, No. 2, February 1967, pp. 91–95.

Bismuth

By Donald E. Moulds [1]

The bismuth industry entered 1967 on the crest of an unprecedented demand for metal which necessitated producer allocation to consumers in order to equitably distribute available supply. During the year supply was affected by a labor stoppage at the two major producing refineries. A continuing strong European demand also affected world trade and resulted in an 18-percent decrease in domestic metal imports. Compensating factors in the market—declining requirements, especially industrial chemicals, and initiation of government sales—resulted in a reasonably balanced supply and demand during the year and the merchant premium price on small lots trended downward to approach the producers' quotation of $4 per pound by the end of the year.

The 1968 outlook depends to a large degree on a strike settlement at the Omaha refinery of American Smelting and Refining Company and resumption of bismuth production from foreign and domestic source materials and, also, at the western mines and smelters which produce the domestic bismuth resource. Requirements are clouded by the change in catalyst use and the ability of the pharmaceutical and cosmetic consumers to compensate for the indicated narrowing catalyst application. Availability of government stocks for domestic consumption provides a supply reservoir and a price ceiling for the domestic industry. Sustained domestic and foreign production in 1968 could, however, develop a price weakness late in the year.

Legislation and Government Programs.—The General Services Administration on November 30, offered for sale approximately 1.2 million pounds of bismuth on an off-the-shelf basis as authorized under Public Law 90–153. The bismuth, for domestic consumption only, up to a maximum of 300,000 pounds for the period through March 21, 1968, and 150,000 pounds for each 3-month period thereafter, was priced at $4 per pound f.o.b. destination within the United States excluding Alaska, in 1-ton lots. Sales during the period December 6 to 31, 1967, totaled 64,500 pounds, none of which was shipped in 1967.

In 1967 the stockpile objective was revised from 3.6 million pounds downward to 2.4 million pounds. The Government inventory remained unchanged at approximately 3.8 million pounds and the surplus inventory at 1.4 million pounds, of which the Atomic Energy Commission has prior authorized withdrawal rights to 0.2 million pounds.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient bismuth statistics

(Pounds)

	1963	1964	1965	1966	1967
United States:					
Consumption	2,175,038	2,160,100	2,931,673	3,199,321	2,513,652
Exports [1]	36,035	61,299	341,868	89,382	152,684
Imports, general	1,123,466	1,238,252	1,378,147	1,681,472	1,379,729
Price: New York, average ton lots	$2.25	$2.30	$3.43	$4.00	$4.00
Stocks Dec. 31: Consumer and dealer	428,100	656,900	506,300	651,800	659,600
World: Production	5,566,311	6,350,020	6,707,088	6,660,154	6,931,294

[1] Includes bismuth, bismuth alloys, and waste and scrap.

DOMESTIC PRODUCTION

Production from primary material in 1967 declined almost 17 percent and shipments again slightly exceeded production thus continuing the downward trend in production and stocks since 1965. Refining of primary bismuth was centered in two domestic companies with only one other company producing bismuth, mostly from scrap; thus domestic production cannot be published separately. The strike closure of the American Smelting and Refining Company refinery at Omaha, Neb., on July 1 and of base-metal mines and smelters after July 15 significantly reduced the output from domestic and foreign materials. The other primary producer, United States Smelting, Refining and Mining Co., continued operations at its East Chicago, Ind., plant throughout the year with production at the same level as the preceding year although supply of domestic feed materials was affected and secondary material was processed. Recovery of bismuth from scrap at the Franklin Park, Ill., plant of United Refining & Smelting Co. declined from the peak reached in 1966, the first full year of operation at the new plant.

CONSUMPTION AND USES

The decline in bismuth consumption, indicated by preliminary reportings during the year, was more drastically revealed in final reports, especially for companies reporting only on an annual basis. The final total of 2.5 million pounds represents a decrease of 21 percent in relation to the record use in 1966. While a decline was posted for all three industrial areas—fusible alloys, other alloys, and pharmaceuticals—the most drastic change occurred in pharmaceuticals. This category, composed of various medical, industrial, and cosmetic compounds, had a tremendous growth from 757,000 pounds in 1964 to 1.7 million pounds in 1966. The major growth component was in catalysts for manufacturing acrylonitrile fiber. The sharp decline in catalyst demand in 1967 was due in part to completion of stocking for expanding capacity and low catalyst replacement needs, and in part to development and commercial availability of a less expensive uranium catalyst. The other use elements in the pharmaceutical category—medicines and cosmetics—increased in 1967, especially cosmetics. The pearlescent quality imparted by bismuth to lipstick and body powders is currently in fashion and this use now ranks second to medicine. The future requirements for the pharmaceutical category are presently unclear and will depend on the replacement volume for spent catalysts and the degree of switch to the uranium catalyst at presently operating plants. Medicines have indicated a steady growth rate and while cosmetics is a growing area, it is subject to the vagaries of fashion.

Fusible alloys declined in response to the general decline in industrial activity, especially construction, in relation to 1966. The total used in relation to prior years and a widening application of low-melting point alloys in fire protection, electrical switching, thermoelectric cooling, industrial jigs, and many other nondissipative industrial applications, indicates a continuing growth potential.

Other alloys, essentially all of which (93 percent) are used as metallurgical additives in aluminum, malleable iron, and special steels, was well below recent years. The decreased industrial requirements for malleable iron were reflected especially in the automobile engine area during the second half of 1967. Tellurium also replaced bismuth in some of the malleable iron produced. The current price of bismuth was the leading factor in working with a bismuth-tellurium alloying combination in spite of the working advantage of bismuth alone.

Table 2.—Bismuth metal consumed in the United States, by uses

(Pounds)

Use	1966	1967
Fusible alloys [1]	913,395	826,528
Other alloys	546,637	456,246
Pharmaceuticals [2]	1,719,029	1,211,663
Experimental uses	9,552	9,433
Other uses	10,708	9,782
Total	3,199,321	2,513,652

[1] Includes 191,536 pounds of bismuth contained in bismuth-lead bullion used directly in the production of an end product in 1966 and 170,837 pounds in 1967.

[2] Includes industrial and laboratory chemicals.

STOCKS

Stocks of bismuth metal held by consumers and dealers increased in the first and second quarters to reach 736,000 pounds, the highest level in recent years, and then decreased to 660,000 pounds at yearend. Metal stocks at domestic producers declined to a new low as plant closures prevented normal production flow.

PRICES

The delivered price of refined bismuth metal, as quoted by Metals Week (New York), was stable at $4 per pound in 1-ton lots effective June 21, 1965. The dealer or merchant price, reported to range upward to $4.50 per pound early in the year, was gradually decreased and premiums above producer price disappeared in December when government material was offered. The London Metal Bulletin quotation of $4 per pound (U.S. equivalent) in ton lots also held steady throughout the year.

FOREIGN TRADE

Exports of bismuth, predominantly in the form of alloys and compounds, increased in 1967 to 152,684 pounds gross weight, valued at $396,000. Approximately 45 percent was consigned to the Netherlands, with others in the European industrial area receiving an additional 45 percent. Canada, India, and Japan were the major importers outside of Europe.

Table 3.—U.S. exports of bismuth [1]

Year	Gross weight (pounds)	Value
1965	341,868	$939,570
1966	89,382	225,617
1967	152,684	395,695

[1] Includes bismuth, bismuth alloys, and waste and scrap.

General imports of metallic bismuth declined 18 percent to 1.38 million pounds from the record 1.68 million pounds received in 1966. The 1967 imports were valued at $5.17 million. This decline reflects the redirection of Peruvian exports to the strong European market, and withdrawal of European suppliers from the U.S. market. Increased deliveries from Canada, Japan, South Korea, and Mexico brought their share of U.S. imports to 38 percent in comparison to 27 percent during 1966.

In addition to imports of bismuth metal, bismuth is imported as bismuth alloys, bismuth-lead alloys, and bismuth compounds. Bismuth alloys containing about 578,000 pounds were received from Mexico, Peru, and Canada of which 288,000 pounds were imported for consumption. Bismuth compounds totaling 6,735 pounds gross weight were received from Canada, Japan, France, Italy, the United Kingdom, and West Germany during the year.

International negotiations relating to the General Agreement on Tariff and Trade (GATT) were consumated in 1967 and tariff revisions applicable to the United States were filed on December 18, 1967 (Federal Register Document 67–14749), to become effective on January 1, 1968. The effective duty on bismuth metal was reduced from 1⅞ percent ad valorem to 1 percent in 1968–69, 0.5 percent in 1970, and free thereafter. The duty on bismuth alloys was reduced from 18 percent to 16 percent in 1968 and approximately 2 percent annually thereafter to 9 percent in 1972. The applicable duty on compounds was reduced from 28 percent ad valorem to 25 percent in 1968 and further decreased annually to 14 percent in 1972.

Table 4.—U.S. general imports of metallic bismuth, by countries

(Pounds)

Country	1966	1967
Belgium-Luxembourg	4,489	----------
Canada	36,386	64,829
Japan	59,605	67,039
Korea, South	15,513	29,690
Mexico	348,087	366,211
Netherlands	----------	1,877
Peru	1,182,047	850,083
United Kingdom	4,480	----------
Yugoslavia	30,865	----------
Total	1,681,472	1,379,729

WORLD REVIEW

The demand for bismuth and depletion of producer stocks continued to induce expansion of production to the maximum consistent with efficient smelter recovery practices. Recovery of bismuth as a byproduct from commingled imported ores does not permit full recognition of source country production and output is credited to the country smelting the ore. The estimated 6.9 million pounds for the countries indicated is a 4 percent increase, contributed mainly by Bolivia and Canada. Sales of bismuth in the European area, including Communist countries, were estimated at 3.6 million pounds, a 13 percent increase in relation to 1966. France accounted for about 45 percent of the total European demand.

Bolivia.—Bismuth output is predominantly from the Tasna copper-bismuth ore produced by Corporatión Minera de Bolivia. The bismuth flotation concentrate

Table 5.—World production of bismuth, by countries [1]

(Pounds)

Country	1963	1964	1965	1966	1967 p [2]
Argentina (in concentrates)	1,345	9	----------	----------	----------
Australia (in concentrates)	----------	----------	----------	716	----------
Bolivia	560,872	599,365	[3] 654,766	[3] 822,316	e [3] 1,102,300
Canada (metal) [4]	359,125	399,958	428,759	525,659	542,336
China (in ore) e	660,000	660,000	660,000	660,000	660,000
France (in ore)	149,900	152,100	r 134,500	129,452	e 130,000
Italy (metal)	4,400	2,200	8,800	26,500	e 26,500
Japan (metal)	823,314	1,115,611	1,347,183	1,213,513	e 1,213,000
Korea, South (in ore)	349,000	e 330,000	e 265,000	e 220,000	NA
Mexico [4]	941,400	1,040,500	1,067,000	1,000,900	e 1,168,000
Mozambique	24,317	14,462	r 10,273	3,616	NA
Peru [4]	1,244,367	1,628,514	r 1,780,503	1,674,261	e 1,698,000
South Africa, Republic of (in concentrates)	2,619	161	240	328	e 130
South-West Africa (in ore)	5,115	3,131	388	4	NA
Spain (metal)	25,836	4,184	r 309	NA	NA
Sweden e	155,000	150,000	77,200	77,200	66,100
Uganda	r 44	r 165	r 529	143	NA
U.S.S.R. (metal) e [5]	65,000	65,000	77,000	77,000	88,000
United States	W	W	W	W	W
Yugoslavia (metal)	194,657	184,660	194,638	228,546	236,928
Totals [1] [6]	5,566,311	6,350,020	6,707,088	6,660,154	6,931,294

e Estimate. p Preliminary. r Revised. NA Not available.
W Withheld to avoid disclosing individual company confidential data.
[1] Bismuth is believed to be produced in Brazil and East Germany but production data are not available. Metallic bismuth is produced in West Germany presumably from imported raw materials, as follows: 1963, 277,300 pounds; 1964, 385,800; 1965, 275,600 (estimate); 1966, 165,300 (estimate); and 1967, not available.
[2] Compiled from data available March 1968.
[3] Exports.
[4] Bismuth content of refined metal and bullion plus recoverable content of concentrates exported.
[5] Previous undisclosed estimates for the U.S.S.R. revised sharply downward.
[6] Total is of listed figures only; no undisclosed data included.

is exported for processing at the Peruvian refinery of Cerro Corp. Expansion of mine and concentrator was completed during the year. A small output of bismuth is also obtained in the refining of tin concentrates.

Canada.—The production of bismuth advanced sharply in 1966 with the first full year's output from two new molybdenum-bismuth operations in Preissac Township, Quebec. The Anglo American Molybdenite Mining Corp. and Preissac Molybdenum Mines Ltd. each operate a mine-refinery facility with an ore capacity of 1,200 tons per day and produce by flotation-leach-roast a molybdenum product and bismuth oxychloride and metal. Continued exploration in the molybdenum-bismuth area of northern Quebec indicates the possibility of development of additional bismuth production. Molybdenite Corporation of Canada, Ltd. also operates a similar but smaller plant in the Province of Quebec. Additional bismuth is derived by Cominco Ltd. in the treatment of lead-zinc ores at the Trail, British Columbia, refinery and by Gaspé Copper Mines, Ltd. in eastern Quebec.

Japan.—Five companies operate smelters and refineries recovering bismuth from foreign and domestic base-metal ores with an estimated combined capacity of 825,000 pounds annually. The domestic component of Japanese output has been from the Kamioka and Taishu mines.

A large bismuth deposit, estimated to be the world's largest, was discovered in 1964 near Yamaguchi in western Japan. The ore reportedly averages 1 percent bismuth and confirmed reserves total 39,000 tons of bismuth, 67,000 tons of copper, and 60,000 tons of tungsten. The mine, being developed by Yashima Mining Company, began production in 1967 and expects to eventually reach a monthly output of 100 tons of bismuth metal.

Korea, South.—The Korea Tungsten Mining Co. recovers bismuth as a byproduct of tungsten ore beneficiation and the improved tungsten market in 1966–67 provided the basis for expanded bismuth output.

Mexico.—The base-metal ores of Mexico contain a relatively high bismuth content which is recovered in smelting. The lead refinery operated by Metalurgica Mexicana Peñoles, S.A., refines the bismuth-enriched smelter products to bismuth metal. The lead smelter of Compañia Minera Asarco, S.A., produces a bismuth-lead alloy and high-bismuth drosses which are exported to the United States for refining and marketing.

Peru.—The complex base-metal ores of Peru are the world's largest source of bismuth. Expansion of ore production at the mines of Cerro Corp., as well as other mines selling ore to Cerro Corp. for refining, has expanded output at the Cerro bismuth refinery to approximately 1.7 million pounds annually. Concentrates are also imported from Bolivia. In addition to refined metal, the refinery produces bismuth alloys to various specifications for direct use in end products. A strike at the Peruvian operations of Cerro Corp. of about 2 week's duration in late July-early August reduced output for the year.

Other European.—Seven metal refining plants in the United Kingdom and Western European areas recover the bismuth content of base-metal concentrates and bullion received for refining from various source countries. The Zevcan Lead Smelter and Refinery in Yugoslavia processes ore from extensive mining operations in Yugoslavia, as well as imported concentrates, and produces metallic bismuth. The Ronnskar works of Boliden Aktiebolag produces a bismuth-lead alloy from the complex pyritic ores of Sweden.

TECHNOLOGY

The short supply of bismuth has activated metallurgical research toward maximum conservation of bismuth in base metal and other ores and recovery of this byproduct metal from smelter waste products and secondary materials.

The ability of bismuth to alloy with other metals, such as cadmium, indium, lead, tellurium, tin, and zinc, to achieve a wide range of melting temperatures, expansion-contraction characteristics, and thermoelectric effects offers an interesting field for application research.[2] While this field ranges from metallurgical additives through industrial alloys, and catalytic, medicinal, and cosmetic applications, there were no major technical developments reported during the year.

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[2] Becker, Richard D. Bismuth's Unusual Properties Meet Many Special Needs. Metal Progress, v. 91, No. 6, June 1967, pp. 61–63.

Boron

By Timothy C. May [1]

New record levels in the production of boron minerals and compounds were reached in 1967 to meet the increasing requirements of the glass and enamel industries, and the increasing demand for exports.

A significant new use for boron was its application in boron carbide for manufacture of lightweight armor for new aircraft systems.

Legislation and Government Programs.—General Services Administration sold the entire Government inventory of colemanite amounting to 67,571 long dry tons. Delivery is to be made over a period of 4 years.

Table 1.—Salient boron minerals and compounds statistics in the United States

(Thousand short tons and thousand dollars)

	1963	1964	1965	1966	1967
Sold or used by producers:					
Quantity:					
Gross weight	700	776	807	866	955
Boron oxide	369	405	425	462	496
Value	$54,981	$60,871	$64,180	$68,209	$74,130
Imports for consunption:					
Quantity	(2)	(1) (2)	[1] 6	[1] 12	[1] 27
Value	$58	$21	$279	$1,034	$1,201

[1] Imports for 1964, 1965, 1966, and 1967 include a higher proportion of crude ore to refined products.
[2] Less than ½ unit.

DOMESTIC PRODUCTION

Domestic production of boron minerals and compounds increased 10 percent in volume and 9 percent in value compared with that of 1966. All of the output came from bedded borate deposits in Kern and Inyo Counties, Calif., and the brines of Searles Lake, Calif. U.S. Borax & Chemical Corp. operated refineries in Kern and Los Angeles Counties on crude borates from its open pit mine at Boron, Kern County. The firm also completed and started up on May 1, 1967, a new plant at Boron for the manufacture of anhydrous boric acid. In Inyo County U.S. Borax mined colemanite near Furnace Creek and sodium-calcium borates near Shoshone, and Kern County Land Co. mined colemanite near Ryan. American Potash & Chemical Corp. and Stauffer Chemical Co. extracted boron compounds from brines at Searles Lake.

It was reported that American Potash & Chemical Corp. had purchased the Federal lease and other properties related to the Little Placer borate deposit in the Mojave Desert, near Boron, Calif. Little Placer is a mixed deposit of tincal and kernite. Start-up of mining operations and treatment facilities is expected by end of 1968.[2]

[1] Commodity specialist, Division of Mineral Studies.
[2] Engineering and Mining Journal. American Potash Purchases Little Placer Borate Deposit. V. 168, No. 5, May 1967, p. 144.

CONSUMPTION AND USES

Manufacturers of glass, soap and cleansers, and porcelain enamel continued to be the major consumers of boron compounds. About half of the total consumption was used in the manufacture of heat-resistant glass, glass wool, fiberglass, soap, and cleansers. The remainder was used in the manufacture of porcelain enamels for domestic appliances, borate products for agricultural use, leather tanning, metallurgy, corrosion control, nuclear shielding, flameproofing, manufactùre of adhesives and starches, and other industrial and consumer uses.

New composite reinforcement materials—a large-diameter boron filament and a short random-length boron filament—for use in aerospace structures were being manufactured.

Boron nitrite fiber mat, a resilient nonwoven mat that provides thermal insulation in critical environments where conventional materials become embrittled was reported to be available in developmental quantities. The mat can be used for high-temperature seals, separators, diffusion barriers, and electrical insulation.

Boron carbide, a lightweight armor, is to be used to portect personnel and vital components on new aircraft systems produced for the Department of Defense.

The Federal Aviation Agency approved a biocide fuel additive containing a boron compound that sterilizes or disinfects turbine fuel used in aircraft by destroying the microbes that thrive in the fuel. These microbes cause corrosion, filter plugging, and a slime that suspends water and matter in fuel.[3]

PRICES

Borax and boric acid prices remained constant during the year. The 1967 yearend prices for boron compounds are shown in table 2.

Table 2.—Borate prices at yearend

	Dollars (per ton)[1]
Borax, technical:	
Anhydrous, 99 percent:	
Bags	$97.50
Bulk	88.00
Granular, decahydrate, 99.5 percent:	
Bags	54.25
Bulk	46.75
Granular, pentahydrate, 99.5 percent:	
Bags	69.75
Bulk	62.25
Boric acid, technical:[2]	
Anhydrous, 99.9 percent: Bags	325.00
Crystals, 99.9 percent:	
Bags	158.50
Drums	183.50
Granular, 99.9 percent:	
Bags	102.00
Drums	127.00
Bulk	96.00
Sodium borate powder, U.S.P.: Bags	54.00

[1] In carlots at plant works.
[2] Boric acid U.S.P. $25 per ton higher than technical grade.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE

Boric acid and borates exported totaled 186,482 tons valued at almost $19 million. About 87 percent of the quantity was refined sodium borate compounds; the remainder, boric acid. The Netherlands received 39 percent of the exports of sodium borates and Japan 21 percent, the remainder was exported to 36 different countries.

Total imports of boron compounds and metal reached 54 million pounds valued at $1.2 million. Almost all of the 53,548,798 pounds of imported material consisted of crude calcium borate (colemanite) from Turkey but this quantity only accounted for 57 percent of the total value of imports. Boron carbide imports in 1967 reached 214,620 pounds valued at $469,167 compared with 183,300 pounds valued at $513,380 in 1966. Approximately 87 percent of the material came from Canada and the remainder came from West Germany and France. Boric acid imports amounted to 78,263 pounds valued at $5,063, all from France. Boron metal imports were 251 pounds valued at $24,843.

[3] United States Borax & Chemical Corp. Annual Report 1967. 1967, p. 9.

Table 3.—U.S. exports of boric acid and sodium borates, in 1967

Destination	Boric acid (H_3BO_3 content) Short tons	Boric acid Value (thousands)	Sodium borates (refined) Short tons	Sodium borates Value (thousands)
Australia	2,027	$254	4,288	$348
Belgium-Luxembourg	14	10	640	52
Brazil	958	120	585	61
Canada	3,128	367	9,754	859
Colombia	98	15	671	68
Costa Rica	8	1	425	44
Denmark	39	6	174	12
Finland	------	-----	243	17
France	------	-----	2,571	348
Germany, West	3,572	348	2,381	217
Hong Kong	156	19	3,606	333
Indonesia	------	-----	392	27
Iran	------	-----	336	27
Ireland	8	1	211	12
Israel	2	(1)	482	42
Italy	1	(1)	3,393	342
Japan	8,448	939	34,447	3,027
Korea, South	63	7	1,110	76
Malaysia	69	11	176	13
Mexico	1,329	206	8,562	829
Netherlands	1,036	178	63,215	6,755
New Zealand	523	61	3,268	401
Norway	4	1	239	17
Pakistan	64	8	649	44
Peru	298	35	384	38
Philippines	220	25	852	105
Singapore	35	5	265	18
South Africa, Republic of	153	20	1,228	117
Spain	------	-----	733	76
Sweden	586	52	2,110	171
Switzerland	6	1	656	47
Taiwan	74	8	2,082	151
Thailand	53	8	602	55
United Kingdom	170	15	6,736	617
Uruguay	39	5	-------	------
Venezuela	272	40	155	12
Viet-Nam, South	5	1	803	78
Yugoslavia	33	3	3,075	319
Other	296	55	1,196	110
Total	23,787	2,825	162,695	15,885

[1] Less than ½ unit.

WORLD REVIEW

Argentina.—Rivadavite, a new borate mineral was found in the Tincalayu borax deposit located in Salar del Hombre Meurto Province of Salta. The new mineral is a hydrous sodium magnesium borate.

Chile.—Servicio de Minas del Estado reported that Chilean production of boron minerals in 1966 was 4,125 tons of ulexite with a 33 percent B_2O_3 content compared with 5,073 tons with a 33 percent B_2O_3 content in 1965. Borax Consolidated Limited is the only Chilean producer. Sales amounted to 3,385 tons, all to the Chilean market except for 250 tons which were shipped to Uruguay.[4]

India.—Imports of boron in 1967 were 3,060 tons compared with 2,394 tons in 1966. Exports in 1967 were 67 tons compared with 112 tons in 1966.[5]

Turkey.—Output of boron in 1966 amounted to 248,133 tons compared with 188,490 tons in 1965. The largest producer was Etibank's Hisarcik open cut mine. Borates now rank third in value among Turkish exports and production and exports have tripled since 1961. Exports in 1966 amounted to 193,261 tons—Italy received 63,360 tons; France, 43,735 tons; United States, 21,003 tons; United Kingdom, 12,443 tons; and Poland, 11,739 tons.[6]

[4] U.S. Embassy, Santiago, Chile. State Department Airgram A–183, Oct. 11, 1967, 49 pp.
[5] U.S. Embassy, New Delhi, India. State Department Airgram A–932, Apr. 4, 1968.
[6] U.S. Embassy, Ankara, Turkey. State Department Airgram A–28, July 18, 1967, 20 pp.

It was reported that Turkish boron producers were increasing mine and plant capacities to keep pace with steadily increasing exports. The recently constructed borax plant at Bandirma on the Sea of Marmara will have a capacity of 20,000 tons of pentahydrate borax and 6,000 tons of boric acid.[7]

TECHNOLOGY

The Bureau of Mines, used a statistical approach to evaluate the effects of temperature, current density, and composition of the electrolyte on the purity of boron prepared by electrolysis of a fused mixture of boric oxide in potassium fluoborate. The best products, better than 95 percent boron, were obtained when the current density was less than 2 amperes per square feet and the boric oxide content was less than 2 molal. The effects of three factors—temperature, cathode current density, and composition of the electrolyte—on the purity of electrolytic boron were investigated. It was found that reasonably pure boron can be prepared by electrolysis of a fused mixture of boric oxide in potassium fluoborate. A regression equation was obtained which relates the purity of the product to the temperature, cathode current density, and composition of the electrolyte. Extrapolation by using this equation indicates that 95-percent-pure boron can be produced by electrolysis at a variety of conditions, but the results were not always reproducible. The relatively large standard error of estimate, 6 percent boron, suggests that other factors must also be considered.[8]

A unique seismic monitoring system was used by United States Borax in early detection of potential slope problems and in determining the effectiveness of corrective action. Microseismic equipment converted rock noise into electrical impulses which were amplified and directed to a graphic recorder.[9]

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[7] Industrial Minerals (London). Boron Producers Respond. No. 1, October 1967, p. 20.

[8] Russell, James H., and Hal J. Kelly. A Statistical Evaluation of Some Factors in the Preparation of Boron by Fused-Salt Electrolysis. BuMines Rept. of Inv. 7028, 1967, 16 pp.

[9] Paulsen, J. C., R. B. Kistler, L. L. Thomas. Slope Stability Monitoring at Boron. Min. Cong. J. v. 53, No. 9, September 1967, pp. 28–32.

Bromine

By Timothy C. May [1]

The growth in the demand for bromine and bromine compounds for gasoline additives, water sanitation chemicals, and fumigants, set new record levels in the production and sales of bromine and bromine compounds in the United States in 1967. Total production of bromine compounds in 1967 exceeded that of 1966 by 7 percent and the production of ethylene dibromide in 1967 increased 5 percent over 1966 output. Imports in 1967 were approximately 52 percent less than in 1966.

DOMESTIC PRODUCTION

The domestic output of bromine and bromine compounds in 1967 was 6 percent higher than in 1966 with Michigan accounting for the largest output followed by Texas, Arkansas, and California in order of output. Producers of bromine and bromine compounds in the United States are the following:

State	*Company*	*County*	*Plant*	*Raw material*
Arkansas	Arkansas Chemicals, Inc	Union	Arkansas Chemicals	Oil field brines.
	Great Lakes Chemical Corp	do	El Dorado	Do.
	Michigan Chemical Corp	do	Michigan Chemical Corp.	Do.
	The Dow Chemical Co	Columbia	Magnolia	Do.
California	American Potash & Chemical Corp.	San Bernardino	Trona	Searles Lake brines.
	FMC Corporation	Alameda	Newark	Sea water bitterns.
Michigan	Great Lakes Chemical Corp	Manistee	Filer City	Natural saline brines
	Michigan Chemical Corp	do	East Lake	Do.
	Michigan Chemical Corp	Gratiot	St. Louis	Do.
	Morton Chemical Co	Manistee	Manistee	Do.
	The Dow Chemical Co	Mason	Ludington	Do.
	The Dow Chemical Co	Midland	Midland	Do.
Texas	Ethyl-Dow Chemical Co	Brazoria	Ethyl-Dow	Sea water.

It was announced that the Great Lakes Chemical Corp., and Arkansas Chemicals, Inc., started projects to double the capacity of their respective bromine extraction units near El Dorado, Ark.[2]

[1] Commodity specialist, Division of Mineral Studies.
[2] Chemical & Engineering News. V. 45, No. 19, May 1, 1967, p. 24.
Chemical Week. V. 100, No. 13, Apr. 1, 1967, p. 25.

Table 1.—Sales of bromine and bromine compounds by primary producers in the United States

(Thousand pounds and thousand dollars)

Year	Quantity: Gross weight	Quantity: Bromine content	Value
1963	238,583	203,333	$48,558
1964	283,530	238,019	66,064
1965	328,115	274,569	77,259
1966	326,498	275,009	78,883
1967	349,757	292,072	85,391

Table 2.—Bromine and bromine compounds sold by primary producers in the United States

(Thousand pounds and thousand dollars)

Product	Quantity		Value
	Gross weight	Bromine content	
1966:			
Elemental bromine	39,952	39,952	$8,388
Ethyl bromide	696	618	284
Methyl bromide	15,346	13,484	6,912
Other, including ethylene dibromide, sodium bromide, ammonium bromide, and potassium bromide	270,504	220,955	63,299
Total	326,498	275,009	78,883
1967:			
Elemental bromine	48,720	48,720	$10,008
Ethyl bromide	526	385	182
Methyl bromide	18,308	15,414	8,300
Other, including ethylene dibromide, sodium bromide, ammonium bromide, and potassium bromide	284,872	230,223	67,328
Total [1]	349,757	292,072	85,391

[1] Total has been adjusted to avoid duplication of transferred or purchased material.

CONSUMPTION AND USES

The major outlet for bromine was in the manufacture of ethylene dibromide used to formulate antiknock compounds for gasoline. Second in consumption of bromine was elemental bromine followed by methyl bromide, potassium bromide, sodium bromide, ammonium bromide, and ethyl bromide. Bromine and bromine compounds were used in the production of fire retardants, sanitizers, pharmaceuticals, dyes, agricultural chemicals, intermediates for other chemical processes, and photographic chemicals.

PRICES

Prices for bromine and some of the bromine compounds showed a slight change in 1966. Purified bromine in tanks, carlots, east of Rocky Mountains, and ammonium bromide increased in price in 1967. The following prices for bromine and bromine compounds were quoted by the Oil, Paint and Drug Reporter.

	Cents per pound
Bromine, purified:	
Cases, carlots, ton lots, delivered east of Rocky Mountains	33
Drums, carlots, ton lots, delivered east of Rocky Mountains	29
Tanks, carlots, same basis	22.5
Ammonium bromide, National Formulary (N.F.) granular, drums, carlots, ton lots, freight equalized	46
Bromochloromethane:	
Drums, carlots, freight equalized	48
Tanks, same basis	47
Ethylene dibromide:	
Drums, carlots, freight equalized	30.5
Tanks, freight equalized	28.5
Potassium bromate, 200-pound drums, carlots, freight allowed	49
Potassium bromide, N.F., granular, drums	40
Sodium bromide, N.F., granular, barrels, drums, freight equalized	40

FOREIGN TRADE

Total imports of bromine and bromine products in 1967 was 254,560 pounds compared with 613,335 pounds in 1966. Most of the reduction in imports was in ethylene dibromide. Because of increased output of this product in the U.S. the demand for imported material was reduced.

Transactions involving bromine compounds reported under the existing tariff schedules (TSUS) were the importation of 185,187 pounds of ethylene dibromide valued at $34,500 from Israel; 7,760 pounds of sodium bromide valued at $525 from Israel; 16,845 pounds of theobromine valued at $28,612 from Netherlands; and 44,768 pounds of potassium bromide valued at $7,819 of which Belgium-Luxemburg accounted for 2,202 pounds, France acounted for 41,516 pounds, and Israel accounted for 1,050 pounds. No transactions were reported for bromine. All other classes of bromine compounds are part of a blanket category and are no longer classified separately.

Exports of bromine, bromides, and bromates were no longer separately classified effective January 1, 1965.

WORLD REVIEW

Israel.—Dead Sea Bromide Ltd. (DSBL) and its 50-percent owned subsidiary, Bromine Compounds Ltd. (BCL) plan to step up distribution of bromine to U.S. chemical markets. Major exports are ethylene dibromide, ammonium bromide, and methyl bromide. BCL is expanding its 5-million pound-per-year organic and inorganic bromide plant by adding 700,000 pounds per-year of inorganic bromide capacity. DSBL and BCL have a 20-million-pound-per-year bromide capacity.[3]

Production of bromine and bromine compounds in 1967 was 16.3 million pounds and sales amounted to 14.6 million pounds.[4]

TECHNOLOGY

A monograph was published which emphasized the fundamentals of bromine chemistry and the various commercial uses of bromine. Methods of preparation, and physical and chemical properties, including classified reactions are discussed in detail.[5]

It was announced that a bromine-charcoal reagent was available for use in inorganic laboratories where the handling of liquid bromine is a potential safety hazard. The reagent-grade bromine is carefully absorbed on charcoal. This safety speciality chemical can be used for brominating organic compounds on the semimicrolevel and for preparing test reagent solutions for organic and inorganic identification.[6]

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[3] Chemical Week. Bromide Chemical Markets. V. 101, No. 5, July 29, 1967, pp. 57–58.
[4] Foreign Service Despatch A-769, Apr. 15, 1968, Tel Aviv.
[5] Jolles, Z. E. Bromine and Its Compounds. Academic Press. New York, 1966, 940 pp.
[6] Industrial and Engineering Chemistry. Bromine-Charcoal Reagent. V. 59, No. 4, April 1967, p. 62.

Cadmium

By Harold J. Schroeder[1]

Although the apparent domestic consumption of cadmium declined in 1967 reduced supply from production and imports required substantial sales from the Government stockpile and a drawdown of industrial stocks to balance demand. The quoted producer price was increased in January when producer stocks reached the lowest level since 1964.

Legislation and Government Programs.—The General Services Administration (GSA) cadmium disposal program remained in effect during 1967. Cadmium available for sale each quarter was 600,000 pounds and was restricted to domestic consumption. Total sales for the year amounted to 807,504 pounds with 600,000 pounds in the first quarter, 103,204 pounds in the second quarter, 22,000 pounds in the third quarter, and 82,300 pounds in the fourth quarter. At yearend, approximately 3.5 million pounds of the 5 million pounds authorized for sale by 1964 legislation remained unsold.

Government stockpiles were reduced to 13.75 million pounds, of which 6.57 million was in the strategic stockpile and 7.18 million in the supplemental stockpile. The stockpile objective remained 5.1 million pounds.

Table 1.—Salient cadmium statistics

(Thousand pounds)

	1963	1964	1965	1966	1967
United States:					
Production [1]	9,990	10,458	9,671	10,460	8,699
Shipments by producers [2]	10,124	9,689	8,128	11,792	9,606
Value thousands	$21,880	$27,421	$19,153	$26,771	$24,665
Exports	1,313	1,439	73	379	691
Imports for consumption, metal	991	1,104	2,121	3,358	1,587
Consumption	11,482	9,364	10,431	14,780	11,561
Price: Average [3] per pound	$2.26	$3.00	$2.58	$2.42	$2.64
World: Production	26,003	27,942	25,741	28,707	NA

NA Not available.
[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 bars in lots of 1 to 5 tons.

DOMESTIC PRODUCTION

Production of cadmium metal from primary and secondary sources was 8.7 million pounds, 17 percent below the preceding year and the lowest output since 1952. The reduced output was largely attributed to strikes at several smelters during the latter half of the year.

About 12 percent of the metal output was derived from imported cadmium flue dust. Except for a relatively small quantity recovered from scrap, the balance was obtained from processing domestic and imported zinc and other base-metal concentrates, with approximately equal quantities supplied by each source. The imported zinc concentrates were largely from Canada, Mexico, and Peru. Secondary cadmium was recovered mainly from scrap alloys.

[1] Commodity specialist, Division of Mineral Studies.

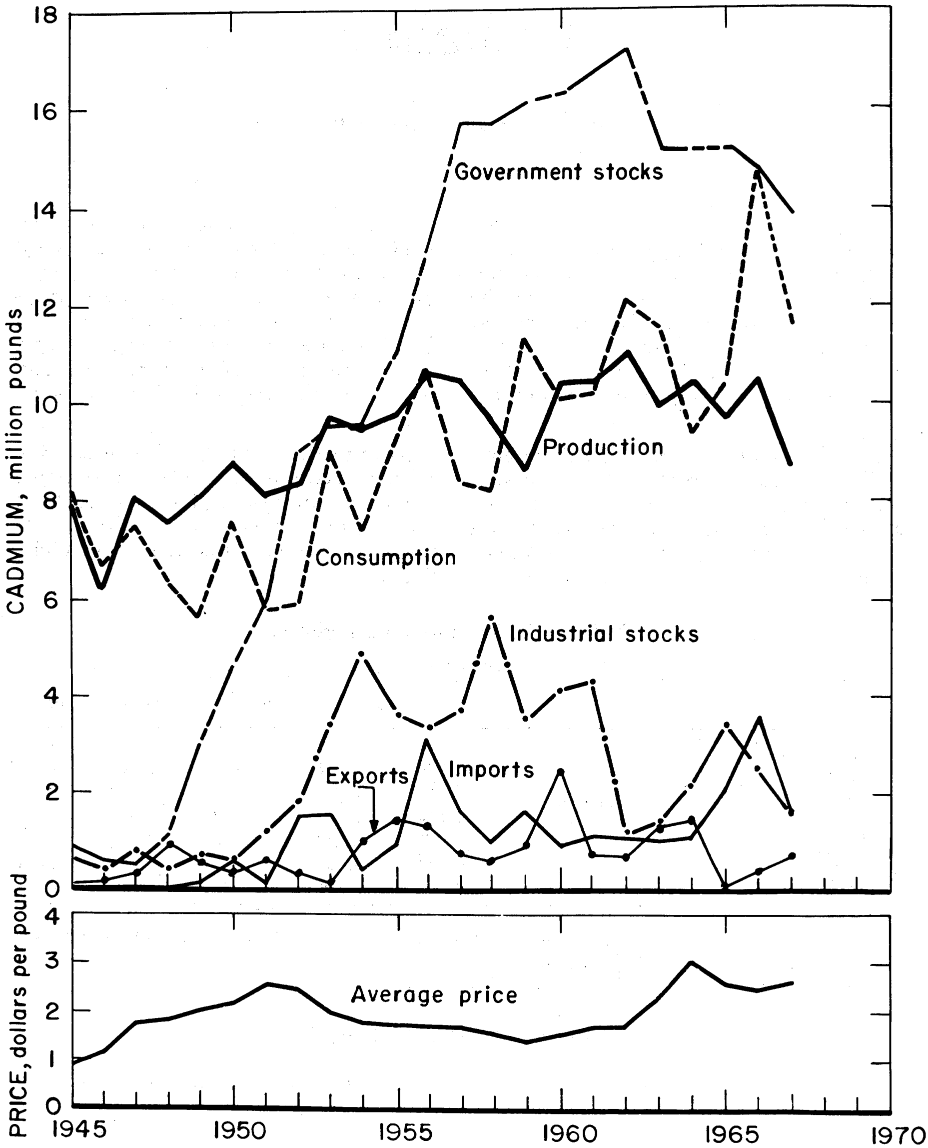

Figure 1.—Trends in production, consumption, yearend stocks, imports, exports, and average price of cadmium metal in the United States.

Production of cadmium sulfide, cadmium lithopone, and cadmium sulfoselenide totaled 1.54 million pounds of contained cadmium, a decrease of 32 percent from the record high of the previous year and the lowest quantity since 1964. Two firms continued to produce cadmium oxide.

The following plants produced cadmium metal in the United States in 1967:

American Smelting and Refining Company, Denver, Colo., and Corpus Christi, Tex.
American Zinc Co., East St. Louis, Ill.
The Anaconda Company, Great Falls, Mont.
Blackwell Zinc Co., Blackwell, Okla.
The Bunker Hill Co., Kellogg, Idaho.
The Eagle-Picher Industries, Inc., Galena, Kans.
National Zinc Co., Inc., Bartlesville, Okla.
The New Jersey Zinc Co., Palmerton, Pa.
St. Joseph Lead Co., Josephtown, Pa.
United Refining & Smelting Co., Chicago, Ill.

Table 2.—Cadmium oxide [1] and cadmium sulfide produced in the United States

(Thousand pounds)

Year	Sulfide [2]	
	Gross weight	Cadmium content
1963	4,560	1,542
1964	4,514	1,531
1965	4,666	1,575
1966	5,644	2,267
1967	4,327	1,536

[1] Cadmium oxide withheld to avoid disclosing individual company confidential data.
[2] Includes cadmium lithopone and cadmium sulfoselenide.

CONSUMPTION AND USES

Consumption of cadmium metal—calculated as production and plus or minus net foreign trade and net changes of known industrial and government stocks—was 11.6 million pounds, a 22-percent drop from the record high of 1966 but 11 percent above the 1965 quantity.

Plating continued to be the largest use for cadmium and was estimated to have consumed about 60 percent of the total. Applications for cadmium plating include parts for automobiles, household appliances, aircraft, industrial machines, radio and television sets, electrical and electronic equipment, hardware fittings, instruments, and numerous fastening items such as nuts, bolts, and screws.

Other principal uses of cadmium were as pigments for industrial colors, stabilizers for vinyl plastics, electrodes for nickel-cadmium batteries, phosphors for television tubes, and a metal component of solders, low-melting-point fusible alloys, and other alloys.

STOCKS

Stocks of cadmium metal at producers, compound manufacturers, and distributors decreased from 2.5 million pounds at the start of the year to 1.6 million pounds by the end of the year, the lowest yearend level since 1963.

Table 3.—Industry stocks, December 31

(Thousand pounds)

	1966		1967	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	1,735	W	921	W
Compound manufacturers	536	963	419	687
Distributors	222	46	218	49
Total	2,493	1,009	1,558	736

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

PRICES

Producer-to-consumer quoted prices for cadmium metal in 1-ton lots was increased 10 cents to $2.65 per pound by one producer on January 11 and by all producers, effective January 13. With respect to sales from the Government stockpile GSA established, effective January 13, a sales price for cadmium of $2.53 per pound in ton lots and $2.58 in less than ton lots, f.o.b. storage location. The GSA price was established 12 cents below producer quotations to allow for conversion to desirable consumer shapes.

Cadmium metal on the London Market from the United Kingdom and Commonwealth sources was quoted at 16s ($2.23) per pound at the start of the year and advanced to 18s 9d ($2.62) on January 27. Following devaluation of the pound, the quotation was changed on November 24 to 21s 9d with the U.S. equivalent of $2.62 remaining unchanged.

In Italy the quoted price of 3,900 lire per kilogram ($2.85 per pound) at the beginning of the year, moved upward in increments to 4,400 lire ($3.22) by the end of April. Beginning in late June prices declined, leveling at 3,700 lire ($2.70) by yearend.

The French quotation for metal was 28 francs per kilogram ($2.59 per pound) at the start of the year, moved upward to 30.50 francs ($2.82) by March 21, then trended downward to 27.25 francs ($2.52) by late October.

Table 4.—Prices quoted for cadmium in the United States in 1967

(Per pound)

Date	Producer to consumer		Distributor to consumer	GSA	
	1-ton lots	Less than 1-ton lots		1-ton lots	Less than 1-ton lots
January 1	$2.55	$2.60	$2.65–$1.80	(1)	(1)
January 11	2.55–2.65	2.60–2.70	2.65– 2.80	(1)	(1)
January 13 to December 31	2.65	2.70	(2)	$2.53	$2.58

[1] Published quotations began Jan. 13, 1967.
[2] Published quotations discontinued.

FOREIGN TRADE

Exports.—Exports of cadmium as metal, dross, flue dust, residues, and scrap were 691,000 pounds, almost twice the quantity of the preceding year and the largest since 1964. About 71 percent of the exports were in the first quarter, continuing the high export rate during the latter part of 1966 and largely attributed to a higher price level in Europe.

Table 5.—U.S. exports of cadmium metal and cadmium in alloys, dross, flue dust, residues, and scrap

(Thousand pounds and thousand dollars)

Year	Quantity	Value
1965	73	$195
1966	379	795
1967	691	1,669

Imports.—General imports of cadmium metal were 1.6 million pounds, less than half of the record high of 1966 and the smallest quantity since 1964. Imports of cadmium in flue dust, all from Mexico, declined to 1.17 million pounds of contained cadmium, the lowest quantity shown in records available since 1936.

Tariff.—The import duty on cadmium metal remained at 3.75 cents per pound in 1967—the rate effective January 1, 1948, as established at the Geneva Trade Conference in 1947. Tariff revisions filed in the Federal Register December 18 reduced the rate of duty on cadmium metal to 3.0 cents per pound, effective January 1, 1968. Cadmium contained in flue dust remained duty free.

Table 6.—U.S. imports of cadmium metal and cadmium in flue dust, by countries

(Thousand pounds and thousand dollars)

Country	General imports [1]				Imports for consumption [2]			
	1966		1967		1966		1967	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
CADMIUM METAL								
Austria	48	$96	-----	------	48	$96	-----	------
Australia	424	860	290	$657	424	860	290	$657
Belgium-Luxembourg	6	12	28	68	6	12	28	68
Canada	907	1,773	538	1,396	907	1,773	538	1,396
Congo (Kinshasa)	154	310	22	53	154	310	22	53
France	22	42	-----	------	22	42	-----	------
Germany, West	22	42	-----	------	22	42	-----	------
Japan	1,085	2,205	304	702	1,048	2,129	302	696
Mexico	15	31	201	488	16	37	181	434
Mozambique	10	20	-----	------	10	20	-----	------
Netherlands	6	12	-----	------	6	12	-----	------
Peru	352	793	209	472	352	793	209	472
Poland and Danzig	56	112	-----	------	41	80	-----	------
South Africa, Republic of	7	17	6	16	7	17	6	16
United Kingdom	295	590	-----	------	295	590	-----	------
Yugoslavia	-----	-----	11	25	-----	-----	11	25
Total	3,409	6,915	1,609	3,877	3,358	6,813	1,587	3,817
FLUE DUST (CADMIUM CONTENT)								
Mexico	1,181	$989	1,166	$1,093	1,181	$989	1,166	$1,093
Grand total	4,590	7,904	2,775	4,970	4,539	7,802	2,753	4,910

[1] Comprises cadmium imported for immediate consumption plus material entering bonded warehouses.
[2] Comprises cadmium imported for immediate consumption plus material withdrawn from bonded warehouses.

WORLD REVIEW

World production of cadmium metal in 1967, including estimates of countries for which reports were not available, decreased about 4 percent to 27.6 million pounds. The decrease was largely attributed to the United States, Canada, Japan, and Australia.

Canada.—Refined cadmium was produced by Canadian Electrolytic Zinc Ltd., Valleyfield, Quebec, for the first full year. Prior to completion of refinery facilities in 1966, cadmium was recovered as sponge or precipitate in purifying zinc-bearing solutions.

United Kingdom.—"The World Metal Statistics," published by the World Bureau of Metal Statistics, reports production of 460,000 pounds and imports of 2.4 million pounds of cadmium for the United Kingdom during 1967. Cadmium consumption was 3 million pounds and was used for the following purposes (in thousand pounds): Plating anodes, 1,080; plating salts, 265; cadmium-copper alloys, 62; other alloys, 62; batteries, 272; solder, 143; colors, 949; and miscellaneous, 178.

Table 7.—World smelter production of cadmium by countries [1] [2]

(Thousand pounds)

Country	1963	1964	1965	1966	1967 [p] [3]
North America:					
Canada	r 2,354	r 2,220	r 1,086	r 2,314	e 1,800
Mexico	r 359	r 348	r 152	r 243	NA
United States [4]	9,990	10,458	9,671	10,460	8,699
South America: Peru	382	435	473	r 442	NA
Europe:					
Austria	41	43	46	r 46	NA
Belgium (exports)	1,943	1,857	849	322	NA
France	655	1,085	r 944	r 988	NA
Germany:					
East e	11	22	22	22	NA
West	492	705	723	785	880
Italy	622	r 611	r 619	540	595
Netherlands e	r 220	r 231	r 198	r 220	220
Norway	243	r 249	r 287	e r 280	e 290
Poland e	930	r 940	r 970	950	NA
Spain	119	133	r 137	e r 130	NA
U.S.S.R. e	3,700	3,900	4,200	r 4,500	4,900
United Kingdom [4]	247	435	r 485	r 405	460
Yugoslavia e	88	90	90	90	110
Africa:					
Congo (Kinshasa)	254	363	278	r 329	NA
South-West Africa	--------	--------	73	r 582	e 375
Zambia	33	32	40	27	e 16
Asia: Japan	2,231	2,678	3,242	r 3,872	NA
Oceania: Australia	1,089	1,107	r 1,156	r 1,160	NA
Total	26,003	27,942	25,741	28,707	NA

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Data derived in part from bulletins of the World Metal Statistics (London) and annual issues of Metal Statistics (Metallgesellschaft).
[2] No estimate included for Bulgaria, but it is reported to be producing cadmium.
[3] Compiled mostly from data available April 1968.
[4] Including secondary.

TECHNOLOGY

Research continued in an effort to reduce the hydrogen embrittlement problem encountered in cadmium plating of high-strength steels. Investigations included use of a low-hydrogen bath, baking after plating, surface treatment before plating, and vacuum plating.

Expanded use of the nickel-cadmium battery has promoted substantial research in that area of utilization. The history of the nickel-cadmium battery is the subject of an article which includes descriptions of beginning research in 1899, first commercial development in 1912, and recent developments.[2]

[2] Atkinson, G. Scott. A Short History of the Junger-Nife Nickel-Cadmium Battery. Electrochem. Tech., v. 4, No. 7–8, July-August 1966, pp. 431–438.

Calcium and Calcium Compounds

By Paul M. Ambrose [1] and Donald E. Eilertsen [2]

Outputs of calcium metal, calcium chloride, and calcium-magnesium brines continued to hover at high levels. Imports of calcium metal increased fivefold over 1966 while imports of calcium chloride were the largest on record.

DOMESTIC PRODUCTION

Calcium metal output continued at a high level.

Production of natural and synthetic solid forms of calcium chloride totaled 710,200 short tons, calculated as 75 percent chloride equivalent.

Production of natural and synthetic calcium chloride brine and calcium-magnesium chloride brine (about 40 percent chloride), excluding those used to produce granular forms, totaled 509,500 short tons.

Producers of calcium metal, calcium chloride, and calcium-chloride-bearing brines were as follows:

Material and company:	*Location*
Calcium metal:	
Minerals, Pigments and Metals Division of Chas. Pfizer & Co	Canaan, Conn.
Natural calcium chloride:	
The Dow Chemical Co	Ludington and Midland, Mich.
Michigan Chemical Corp	St. Louis, Mich.
Wyandotte Chemical Corp	Wyandotte, Mich.
Synthetic calcium chloride:	
Industrial Chemical Division, Allied Chemical Corp	Syracuse, N.Y.
Chemical Division, Pittsburgh Plate Glass Co	Barberton, Ohio
Natural calcium-chloride and calcium magnesium chloride brine:	
Chloride Products, Inc	Niland, Calif.
Imperial Thermal Products, Inc	Do.
Leslie Salt Co. (California Salt Co.)	Amboy, Calif.
National Chloride Company of America	Do.
The Dow Chemical Co	Ludington and Midland, Mich.
Michigan Chemical Corp	St. Louis, Mich.
Morton Chemical Co	Manistee, Mich.
Wilkinson Chemical Corp	Mayville, Mich.
Wyandotte Chemicals Corp	Wyandotte, Mich.
Inorganic Chemical Division of FMC Corp	Charleston, W. Va.
Synthetic calcium chloride and calcium-magnesium chloride brine:	
Industrial Chemical Division, Allied Chemical Corp	Syracuse, N.Y.
Chemical Division, Pittsburgh Plate Glass	Barberton, Ohio
Hooker Chemical Corp	Tacoma, Wash.
Reichhold Chemicals, Inc	Do.

Production of all forms of natural calcium and calcium-magnesium chlorides (solid, flake, and liquids), calculated at 75 percent chloride equivalent, averaged 552,000 tons annually for the period 1963–67. The annual average value was $11.3 million ($20.58 per ton) for the same 5-year period.

The Bureau of the Census, Department of Commerce reported total shipments including interplant transfers for 1966 as follows: Calcium chloride, solid (73 to 75 $CaCl_2$) and flake (77 to 80 percent $CaCl_2$)

[1] Mineral specialist. Division of Mineral Studies.
[2] Commodity specialist, Division of Mineral Studies.

—681,443 short tons, valued at $20.4 million ($29.92 per ton); brine 40 to 45 percent $CaCl_2$)—380,499 tons, valued at $3.8 milion ($9.93 per ton); precipitated (100 percent $CaCO_3$)—169,816 tons, valued at $9.1 million ($53.72 per ton); and calcium carbide—586,966 tons, valued at $51.3 million ($87.40 per ton).[3]

CONSUMPTION AND USES

Calcium was used to remove oxygen and halogens from metal compounds in producing metals that were otherwise difficult to recover as relatively pure products, and it was used to remove sulfur, phosphorus, oxygen, and other nonmetals from molten metals. In the organic chemical industry, calcium was used as a reducing agent and as a dehydrating agent, and in the removal of sulfur from some hydrocarbons. It was used to separate nitrogen from argon. In the form of the hydride it was a valuable portable source of hydrogen released when the hydride reacted with water. Organocalcium compounds are used in lubricants, corrosion inhibitors, detergents, and for other purposes.

The uses of calcium chloride were deicing, dust control, concrete treatment, industrial uses (including synthetic rubber, paper, and oilfield drilling), brine refrigeration, and tireweighting material.

PRICES AND SPECIFICATIONS

Prices obtained from the producing company for commercial-grade calcium metal, over 99 percent calcium, in 1966 ranged from $0.95 per pound for full crowns, 2,000 pounds and over, to $3 per pound for less than 100-pound quantities of turnings. Other products and quantities were between these limits. Redistilled-grade calcium 99.9 percent calcium with up to 0.5 percent magnesium ranged from $1.50 per pound for broken crowns in lots of 6,000 pounds or more to $5 for ⅛-inch nodules in lots of less than 100 pounds. The price of other size lots of broken crowns, ⅛-inch metal and 6-mesh nodules, were between these limits depending on quantity purchased.

Most calcium chloride ($CaCl_2$) prices were increased over $1 per ton of contained chloride on October 1, 1967.

Table 1.—Price quotations for calcium chloride in 1967 [1]

(Per short ton)

Compound	Jan. 3	Dec. 26
Concentrated flake or pellet, 94 to 97 percent $CaCl_2$ (paper bags, carlots, at works, freight equalized)	$43.00	$44.50
Concentrated flake, 77 to 80 percent $CaCl_2$ (paper bags, carlots, at works, freight equalized)	34.00	36.25
Powdered, 77 percent minimum $CaCl_2$ (paper bags, carlots, at works, freight equalized)	41.00	42.25
Liquor, 40 percent $CaCl_2$ (tank cars, freight equalized)	14.50	15.00
Granulated $CaCl_2$ U.S.P. (225-pound drums, freight equalized) remained constant at $0.29 per pound in truck lots and $0.31 to 0.32 per pound in less than truck lots.		

[1] Oil, Paint and Drug Reporter. V. 191, No. 1, Jan. 2, 1967, p. 12; v. 192, No. 26, Dec. 25, 1967, pp. 12–13.

FOREIGN TRADE

Canada was the only country that exported calcium metal to the United States. Almost five times as much metal was imported in 1967 compared with 1966 imports. Countries supplying calcium chloride for consumption were Belgium-Luxembourg, 51 percent; Canada, 35 percent; United Kingdom, 6 percent; West Germany, 4 percent; and Japan, 4 percent. The 3,968 pounds from Sweden was not significant.

Other principal imports of calcium compounds in 1967 included 11.6 million pounds of dicalcium phosphate mostly from Belgium-Luxembourg; 16.7 million pounds of calcium carbide all from Canada; 33 million pounds of calcium cyanide mostly from Canada; 53.8 million pounds

[3] U.S. Department of Commerce. Bureau of the Census. Industry Division. Inorganic Chemicals and Gases, 1966. Current Ind. Rept. Series M28A(66)-13, Mar. 20, 1968, p. 11.

of crude calcium borate mostly from Turkey; and 23 million pounds of whiting mostly from United Kingdom, Belgium-Luxembourg, and France. An additional total of 9.8 million pounds of other calcium chemicals was imported.

Table 2.—U.S. imports for consumption of calcium and calcium chloride

Year	Calcium		Calcium chloride	
	Pounds	Value	Short tons	Value
1965	28,219	$27,616	3,658	$99,751
1966	85,941	72,176	r 2,499	r 81,012
1967	423,631	370,407	4,385	157,570

r Revised.

WORLD REVIEW

Canada.—Dominion Magnesium, Ltd., in Haley, Ontario, was the only Canadian producer of calcium. Revised data for production and value in 1965 are 159,434 pounds valued at Can$152,848.[4] Production for 1966 was 249,179 pounds valued at Can$245,125, and for 1967, estimate, 622,237 pounds valued at Can$591,125.[5]

U.S.S.R.—Large deposits of Iceland spar were reportedly being mined in the Evenk region of central Siberia. This spar sometimes has yellowish or violet hues and Soviet scientists were investigating ways of improving the color.[6]

United Kingdom.—Calcium carbide was being replaced by naphtha as a less expensive source of acetylene in the United Kingdom. Imports of calcium carbide to Britain in 1965 were 281 million pounds; 34 percent greater than in 1964. Four naphtha crackers with a total annual acetylene capacity of almost 300 million pounds were under construction in 1966.[7]

TECHNOLOGY

Introducing fine feed through hollow electrodes in the manufacture of calcium carbide resulted in cooler electrode operation, a decrease in electrode consumption, a lower energy requirement and less dust loss.[8]

The addition of calcium carbide to basic oxygen steel heats permitted increased use of scrap. Normally, the quantity of cold charge is limited to 28 to 30 percent of the heat, but the use of 20,000 pounds of calcium carbide made it possible to charge 102 tons of scrap in a 200-ton heat. This was an increase of 70 precent over normal scrap usage. At least one 185-ton batch contained a record 61.7 percent scrap but required 30,000 pounds of calcium carbide. The use of carbide resulted in some reduction in rate of production since blowing time was about 12 percent longer for a typical heat, but because of the low cost of scrap there might be a cost reduction under certain conditions.[9]

A process was developed for producing substantially anhydrous pellets of calcium chloride from semianhydrous chloride particles in a weight ratio of 8 to 30 times that of a 50-percent-chloride solution that was sprayed on them. Hot particles were sprayed with a hot solution maintained within 25° C of its atmospheric boiling point. The mass was subjected to a tumbling rolling action while being sprayed in the presence of drying flue gases capable of drying them and producing larger semianhydrous pellets that were screened

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[4] Jackson, W. H. Calcium. Preprint ch. of Canadian Minerals Yearbook, 1966, 3 pp.
[5] Dominion Bureau of Statistics (Canada). Canada's Mineral Production, Preliminary Estimate 1967. Catalogue No. 26–202, Jan. 2, 1968, 4 pp.
[6] Industrial Minerals (London). Iceland Spar in Siberia. No. 1, October 1967, p. 28.
[7] Chemical & Engineering News. Chemicals Brighten U.K.'s Trade Imbalance. V. 44, No. 7, Feb. 14, 1966, pp. 52–53.
[8] Hamby, D. E. Hollow Electrode System for Calcium Carbide Furnaces. J. Metals, v. 19, No. 1, January 1967, pp. 45–48.
[9] Chemical Engineering. Carbide Lets Steelmakers Use More Scrap Metal. V. 73, No. 19, Sept. 12, 1966, p. 112. Iron Age, New Steelmaking Method Uses 70% More Scrap. V. 197, No. 24, June 16, 1966, p. 31.

and dried with any semidry material being returned to the head of the circuit.[10]

The action of calcium chloride and rock salt on ice, including lowest temperature at which ice can be melted, rate of solubility, moisture attraction, heat of solution, and character of solution, was presented in a brief table. Two popular mixes for deicing, using flake and granular calcium chloride with rock salt, were presented. By volume one part of flake chloride and two parts of salt, or one part of granular or pellet chloride and three parts salt were recommended for temperatures not too far below freezing to start brine formation and increase the melting rate. At lower temperatures or when heavy snow or ice accumulations were to be removed the proportion of calcium chloride to salt was increased. Equal parts of flake chloride and salt, or two parts granular or pellet chloride and three parts salt, were recommended.[11]

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[10] Wilcox, Le Roy A., and Albert C. Speer (assigned to The Dow Chemical Co., Midland, Mich.). Method of Producing Calcium Chloride Pellets. U.S. Pat. 3,250,593, May 10, 1966.

[11] Calcium Chloride Institute News. Mixtures Keep the Wheels Turning. V. 16, No. 3, 1966, pp. 3–5.

Carbon Black

By W. B. Harper[1]

Total shipments of carbon black decreased 4.8 percent in 1967 as a result of a softening in domestic demand due to strikes in the tire and automobile industries, and a drop in exports.

Use of carbon black in the rubber industry overshadowed, by far, all other uses of blacks, accounting for 93.5 percent of the domestic sales in 1967. With the demand for tires and tubes tapering off as a result of reduced sales of passenger cars and trucks, carbon black shipments to the rubber manufacturers in 1967 declined 2.8 percent, and total domestic sales were 2.7 percent below the 1966 level.

Carbon black plants operated at 80.1 percent of capacity in 1967 compared with 87.8 percent in 1966. During 1967, however, daily capacity for carbon black manufacture expanded 5.9 percent.

There was also a significant buildup in inventories at the producer level. Compared with the year earlier, stocks of carbon black as of December 31, 1967, were up 31 million pounds or 13 percent and at the highest level in 5 years.

The average value of carbon black at the plant in 1967 was 7.17 cents per pound, unchanged from the previous year.

Table 1.—Salient statistics of carbon black produced from natural gas and liquid hydrocarbons in the United States

(Thousand pounds)

	1963	1964	1965	1966	1967
Production:					
Channel process	179,012	169,919	147,909	153,117	149,420
Furnace process	1,879,904	2,053,297	2,205,867	2,418,435	2,334,420
Total	2,058,916	2,223,216	2,353,776	2,571,552	2,483,840
Shipments:					
Domestic sales	1,727,420	1,911,494	2,072,500	2,277,595	2,216,145
Exports	370,928	333,907	274,608	297,280	236,034
Total	2,098,348	2,245,401	2,347,108	2,574,875	2,452,179
Losses	592	910	135	1,236	559
Stocks of producers, December 31	254,216	231,171	237,704	233,145	264,247
Value:					
Production ... thousand dollars	147,824	155,761	166,111	184,308	178,158
Average per pound ... cents	7.18	7.01	7.06	7.17	7.17

The volume of natural gas used as feedstock continued to decline in 1967. Although Louisiana used more natural gas as feedstock, declines in Texas and other carbon black producing States more than offset that increase. The cost of natural gas used in the manufacture of carbon black declined for the second year. There was also a moderate reduction in the use of liquid hydrocarbons as a feedstock for carbon black manufacture, the first since 1961 (from 433.7 million gallons in 1966 to 421.3 million, or 2.9 percent). In another significant development, the average yield of carbon black from a gallon of liquid hydrocarbons expanded to a record high of 4.79 pounds of black.

[1] Mineral specialist, Division of Mineral Studies.

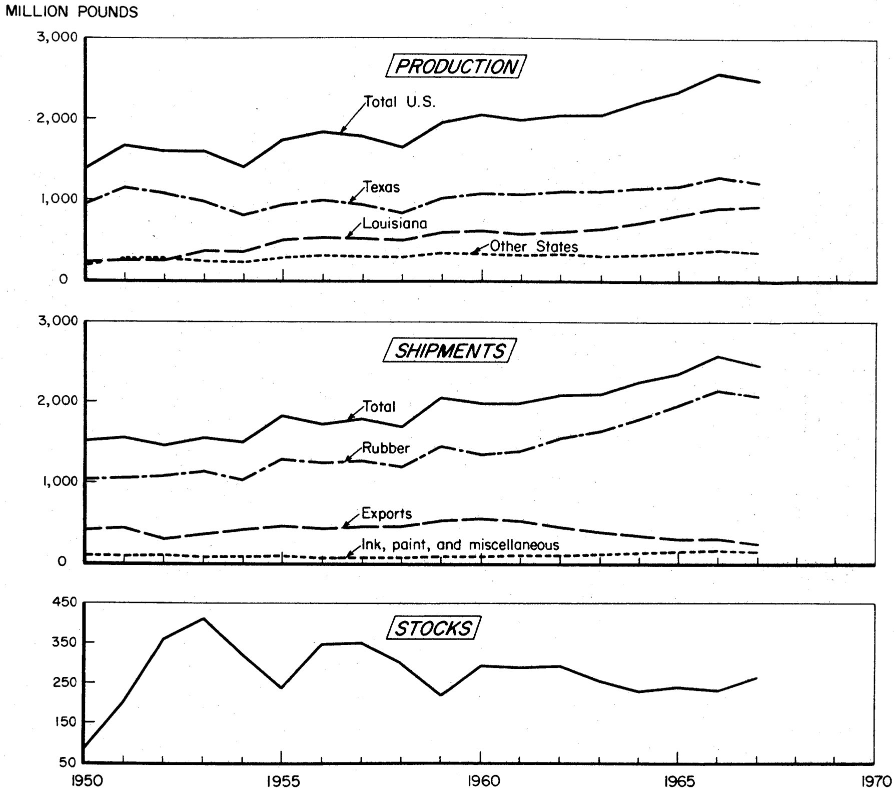

Figure 1.—Production by State, shipments by use, and exports, and stocks of carbon black.

PRODUCTION AND CAPACITY

Production by States.—Carbon black production in 1967 totaled nearly 2,483.8 million pounds, a decrease of 87.7 million pounds or 3.4 percent below the 1966 volume. Texas continued to account for most of the output but Louisiana made inroads on the leader. In 1963, for example, Texas accounted for 53.7 percent of the total carbon black output, whereas in 1967, the state provided only 48.9 percent. During the same period, Louisiana expanded its output from 31.5 percent of the total to 37.2 percent.

Both furnace and channel blacks, were produced in 1967 with output of furnace blacks reported in eight grades: Semireinforcing furnace (SRF); high modulus furnace (HMF); general-purpose furnace (GPF); fast extrusion furnace (FEF); high abrasiom furnace (HAF); super-abrasion furnace (SAF); intermediate-abrasion furnace (ISAF); and the thermal. The thermal grade is not strictly comparable to the other seven grades, but is included as one of the furnace grades in the report. Production and shipments by months and types are given in table 3.

Production by Grades and Types.—The furnace process, accounted for some 94 percent of the total production. The HAF and the ISAF grades accounted for about half of tht total furnace blacks production; a pattern that has prevailed for more than a decade, although the most rapid rate of growth is found in the ISAF category. Production of carbon black from the channel process was 149.4 million pounds, 2.4 percent below the output in 1966.

Table 2.—Carbon black produced from natural gas and liquid hydrocarbons in the United States, by States

(Thousand pounds)

State	1963	1964	1965	1966	1967	Change from 1966 (percent)
Louisiana	649,170	725,669	820,552	899,178	923,286	+2.68
Texas	1,105,189	1,165,593	1,172,693	1,296,292	1,214,349	−6.32
Other States	304,557	331,954	360,531	376,082	346,205	−7.94
Total	2,058,916	2,223,216	2,353,776	2,571,552	2,483,840	−3.41

Table 3.—Production and shipments of carbon black in the United States in 1967, by months and grades of furnaces

(Thousand pounds)

	SRF [1]	HMF [2]	GPF [3]	FEF [4]	HAF [5]	SAF [6]	ISAF [7]	Thermal	Total	Channel	Grand total
PRODUCTION [8]											
January	26,442	3,319	17,392	26,097	62,157	1,662	40,195	24,445	201,709	12,870	214,579
February	28,130	1,358	15,196	23,992	59,628	1,867	38,933	21,280	190,384	12,083	202,467
March	35,390	2,693	13,611	28,037	62,999	963	46,432	24,633	214,758	13,239	227,997
April	33,200	2,779	13,268	23,951	61,140	1,621	35,072	24,874	195,905	12,609	208,514
May	27,493	1,866	12,759	17,711	53,510	2,525	25,024	26,102	166,990	13,419	180,409
June	27,597	1,161	13,456	12,901	54,034	986	20,153	23,811	154,099	11,831	165,930
July	24,997	1,875	7,784	15,841	47,795	1,113	25,542	23,592	148,539	12,432	160,971
August	29,999	1,583	11,831	19,899	60,757	1,111	36,717	25,647	187,544	13,008	200,552
September	32,815	3,058	10,685	22,926	62,156	1,225	41,104	25,655	199,624	12,020	211,644
October	37,746	1,407	11,113	27,650	71,683	924	42,716	29,330	222,569	12,310	234,879
November	35,980	1,904	13,278	26,809	72,728	1,647	41,157	28,779	222,282	11,503	233,785
December	38,668	2,197	15,535	27,998	77,518	1,741	38,394	27,966	230,017	12,096	242,113
Total	378,457	25,200	155,908	273,812	746,105	17,385	431,439	306,114	2,334,420	149,420	2,483,840
SHIPMENTS (includes exports) [9]											
January	30,205	2,987	15,922	24,321	60,854	1,282	40,958	25,291	201,820	14,024	215,844
February	27,427	1,803	15,347	24,158	56,714	1,269	38,234	22,398	187,350	10,925	198,275
March	29,968	2,475	14,426	26,903	59,863	1,205	45,565	26,374	206,779	13,183	219,962
April	23,045	3,160	13,230	19,616	54,831	1,467	30,679	23,739	169,767	10,958	180,725
May	26,749	1,374	11,759	13,541	53,826	1,208	20,958	23,110	152,525	11,578	164,103
June	24,856	1,330	12,473	13,031	47,923	1,120	24,022	18,605	143,360	10,775	154,135
July	21,476	1,148	7,749	13,807	43,778	1,807	22,398	18,679	130,842	9,584	140,426
August	35,498	2,370	11,887	26,518	67,216	970	42,705	24,626	211,790	13,062	224,852
September	38,088	2,106	12,833	25,796	69,125	1,547	43,397	24,760	217,652	11,197	228,849
October	38,479	2,325	12,289	29,984	77,231	1,073	43,840	27,492	232,713	11,575	244,288
November	36,228	2,354	13,894	27,119	72,615	1,916	43,509	25,888	223,523	12,159	235,682
December	38,170	2,422	16,139	30,400	76,785	1,162	41,024	27,824	233,926	11,671	245,597
Total	370,189	25,854	157,948	275,194	740,761	16,026	437,289	288,786	2,312,047	140,691	2,452,738

[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 anual reports of individual producers.
[9] Includes losses.

Number and Capacity of Plants.—The total daily production potential of carbon black plants in the United States expanded impressively in 1967, some 475,000 pounds or 5.9 percent. Capacity in Texas increased nearly 200,000 pounds per day or 4.8 percent. Facilities in Louisiana capable of producing 2,964,700 pounds per day were in operation at the end of 1967. This represented an increase in the Louisiana daily capacity of 244,000 pounds or 8.9 percent. There was no change in the number of plants operating in Texas, but a new channel black producing facility began to operate on a modest scale in Louisiana.

Table 4.—Number and capacity of carbon black plants operated in the United States

State or district	County or Parish	Number of plants 1966 Channel	Number of plants 1966 Furnace	Number of plants 1967 Channel	Number of plants 1967 Furnace	Total daily capacity (pounds) 1966	Total daily capacity (pounds) 1967
Texas	Aransas	—	1	—	1	4,072,300	4,270,900
	Carson	1	—	1	—		
	Ector	1	—	1	—		
	Gaines	1	—	1	—		
	Gray	—	1	—	1		
	Harris	—	1	—	1		
	Howard	—	2	—	2		
	Hutchinson	1	4	1	4		
	Montgomery	—	1	—	1		
	Moore	—	1	—	1		
	Orange	—	1	—	1		
	Terry	—	1	—	1		
	Wheeler	—	1	—	1		
Total Texas		4	14	4	14	4,072,300	4,270,900
Louisiana	Avoyelles	—	1	—	1	2,721,000	2,964,700
	Calcasieu	—	1	—	1		
	Evangeline	—	1	—	1		
	Ouachita	—	2	1	2		
	St. Mary	—	3	—	3		
Total Louisiana		—	8	1	8	2,721,000	2,964,700
Arkansas	Union	—	1	—	1	1,230,000	1,262,600
California	Contra Costa	—	1	—	1		
	Kern	—	2	—	2		
Kansas	Grant	—	1	—	1		
New Mexico	Lea	1	1	1	1		
Oklahoma	Kay	—	1	—	1		
Total		1	7	1	7	1,230,000	1,262,600
Total United States		5	29	6	29	8,023,300	8,498,200

Materials Used and Yields.—Liquid hydrocarbon feedstocks totaling some 421.3 million gallons, were used to produce about 2,018 million pounds of carbon black during 1967 or 81.2 percent of the total output. Yields also improved in 1967 with the average 4.79 pounds per gallon as compared with 4.72 pounds in the preceding year. Conversely, natural gas supplied 18.7 percent of the feedstocks compared with 20.4 percent in 1966 and the average yield per thousand cubic feet of natural gas shrunk from 5.75 pounds per thousand cubic feet to 5.54 pounds in 1967.

Table 5.—Carbon black and the feedstocks used in its production, by States

	Louisiana	Texas	Other States [1]	Total
1966:				
Carbon black production:				
Total_____thousand pounds__	899,178	1,296,292	376,082	2,571,552
Value_____thousand dollars__	60,467	100,022	23,819	184,308
Average value_____cents per pound__	6.72	7.72	6.33	7.17
Natural gas used:				
Total_____million cubic feet__	22,100	48,541	20,513	91,154
Value_____thousand dollars__	3,486	6,598	3,085	13,169
Average value_cents per thousand cubic feet__	15.77	13.59	15.04	14.45
Carbon black produced___thousand pounds__	286,627	145,987	91,350	523,964
Liquid hydrocarbons used:				
Total_____thousand gallons__	135,133	243,788	54,779	433,700
Value_____thousand dollars__	10,132	16,867	3,759	30,758
Average value_____cents per gallon__	7.50	6.92	6.86	7.09
Carbon black produced___thousand pounds__	612,551	1,150,305	284,732	2,047,588
1967:				
Carbon black production:				
Total_____thousand pounds__	923,286	1,214,349	346,205	2,483,840
Value_____thousand dollars__	61,092	94,565	22,501	178,158
Average value_____cents per pound__	6.62	7.79	6.50	7.17
Natural gas used:				
Total_____million cubic feet__	23,148	42,869	18,051	84,068
Value_____thousand dollars__	3,690	5,644	2,785	12,119
Average value_cents per thousand cubic feet__	15.94	13.17	15.43	14.42
Carbon black produced___thousand pounds__	292,518	92,659	80,328	465,505
Liquid hydrocarbons used:				
Total_____thousand gallons__	129,403	240,335	51,548	421,286
Value_____thousand dollars__	9,542	16,872	3,361	29,775
Average value_____cents per gallon__	7.37	7.02	6.52	7.07
Carbon black produced___thousand pounds__	630,768	1,121,690	265,877	2,018,335

[1] Arkansas, California, Kansas, New Mexico, and Oklahoma.

Table 6.—Natural gas and liquid hydrocarbons used in manufacturing carbon black in the United States and average yield

	1963	1964	1965	1966	1967
Natural gas used_____million cubic feet__	117,378	106,759	93,296	91,154	84,068
Average yield of carbon black per thousand cubic feet_____pounds__	4.63	5.38	6.36	5.75	5.54
Average value of natural gas used per thousand cubic feet_____cents__	12.70	13.34	14.59	14.45	14.42
Liquid hydrocarbons used_____thousand gallons__	333,103	354,874	389,173	433,700	421,286
Average yield of carbon black per gallon___pounds__	4.55	4.65	4.52	4.72	4.79
Average value of liquid hydrocarbons used per gallon_____cents__	6.66	6.79	6.86	7.09	7.07
Number of producers reporting_____	9	9	9	9	9
Number of plants_____	39	37	34	34	35

CONSUMPTION AND USES

Reflecting the impact from a softening economy and strikes in the tire and automobile industries, domestic sales of carbon black were 2,216 million pounds or 61 million pounds below the volume sold in 1966. Exports of carbon black also declined 61 million pounds to 236 million or 20.6 percent for the year. In this instance, however, the drop was attributable in large part to a startup of carbon black plants abroad which negated a need to import from the United States and other carbon black producing countries.

The rubber industry again accounted for the bulk of carbon black used (about 94 percent), but the quantity consumed decreased by 58.6 million pounds or 2.8 percent. The printing industry was the second largest consumer even though it accounted for only 2.9 percent of domestic consumption and its use in this field at 63.9 million pounds, was virtually unchanged from the volumes consumed in 1966.

Manufacturers of printing inks are in the market for two major types of carbon black. "Short-ink," used in manufacturing inks for printing newspapers, was made from oil-furnace blacks. "Long-ink," blacks used in lithographic or halftone printing inks, require a high quality type of product produced by the channel process.

The plastics industry used 20.9 million pounds of carbon black in 1967, a million pounds less than in 1966. Carbon black was also used in the manufacture of specialty papers, as a tinting agent, as an anticaking agent in cement and fertilizers, as a pigment in cement work, and in the confectionary and cosmetic industries. It was also an important ingredient in liquid oxygen explosives.

Table 7.—Sales of carbon black for domestic consumption in the United States, by uses

(Thousand pounds)

Use	1963	1964	1965	1966	1967	Change from 1966 (percent)
Chemical	7,288	10,259	8,447	(1)	(1)	(1)
Ink	46,471	45,688	54,333	63,682	63,963	+0.4
Paint	13,008	17,982	10,896	11,959	12,553	+5.0
Paper	8,721	8,004	7,649	6,108	5,658	−7.4
Plastics	8,539	12,281	20,183	21,945	20,907	−4.7
Rubber	1,629,905	1,789,432	1,945,459	2,131,169	2,072,543	−2.8
Miscellaneous	13,488	27,848	25,533	42,732	40,521	−5.2
Total	1,727,420	1,911,494	2,072,500	2,277,595	2,216,145	−2.7

1 Chemical and food combined with "Miscellaneous" in 1966 and 1957 to avoid disclosing individual company confidential data.

STOCKS

The continued high rate of production coupled with a softening in demand during 1967 caused an increase in the year-end stocks of 31 million pounds, 13.3 percent above the 1966 level.

Stocks of carbon black produced by the thermal process declined sharply in 1966 but built up during 1967, and by the close of the year totaled 26.9 million pounds compared with 9.6 million at the end of 1966. Channel black stocks increased 8.7 million pounds in 1967 and stocks of the semireinforcing grade of carbon black were 8.3 million pounds higher.

Table 8.—Producers' stock of channel- and furnace-type blacks in the United States, December 31

(Thousand pounds)

Year	Furnace									Channel	Grand total
	SRF 1	HMF 1	GPF 1	FEF 1	HAF 1	SAF 1	ISAF 1	Thermal	Total		
1963	31,101	7,927	21,129	23,137	61,473	4,115	50,391	6,338	205,611	48,605	254,216
1964	39,200	9,234	26,166	20,641	46,230	5,134	36,062	5,529	188,196	42,975	231,171
1965	34,828	7,291	20,385	23,275	48,644	4,277	35,506	22,835	197,041	40,663	237,704
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

1 For explanation, see footnotes to table 3.

FOREIGN TRADE

The U.S. export market for carbon black has been sharply curtailed as a result of increased production abroad. Exports in 1967 were 236 million pounds, less than half the volume shipped abroad in 1960.

Although the European countries have made substantial gains in the production of carbon black, they still represent the best export market for the United States. Shipments to France, West Germany, the United Kingdom, and Italy accounted for 41 percent of the 1967 export market for carbon black.

Table 9.—U.S. exports of carbon black, by countries

(Thousand pounds and thousand dollars)

	1965		1966		1967	
	Quantity	Value	Quantity	Value	Quantity	Value
North America:						
Canada	17,909	$1,624	45,243	$3,511	27,591	$2,309
Guatemala	1,411	127	2,479	220	1,423	125
Mexico	2,767	216	2,698	256	1,792	203
Other	202	19	209	24	1,534	135
Total	22,289	1,986	50,629	4,011	32,340	2,772
South America:						
Argentina	9,987	1,028	3,295	352	1,373	213
Brazil	3,712	322	6,321	555	3,190	301
Chile	5,828	568	4,921	464	4,473	426
Colombia	11,733	1,015	8,345	757	1,074	117
Peru	5,214	454	6,087	531	6,317	550
Venezuela	1,537	151	1,527	150	690	77
Other	1,409	130	1,684	154	802	76
Total	39,420	3,668	32,180	2,963	17,919	1,760
Europe:						
Austria	1,263	102	750	61	494	47
Belgium-Luxembourg	4,717	424	5,471	495	5,366	467
Denmark	1,066	162	969	171	1,110	173
Finland	605	63	656	67	595	58
France	27,825	2,779	39,287	3,979	35,584	3,624
Germany, West	37,595	3,045	35,225	2,809	24,174	2,063
Greece	383	34	717	59	275	26
Italy	21,919	2,262	15,862	1,797	17,186	2,048
Netherlands	3,707	418	2,890	384	3,185	349
Norway	1,067	101	747	69	959	85
Poland and Danzig	1,559	134	2,537	251	2,394	233
Portugal	1,866	182	2,324	229	1,941	193
Spain	2,667	337	4,332	470	3,492	438
Sweden	5,383	428	5,089	388	3,335	261
Switzerland	1,726	166	2,784	247	2,140	205
United Kingdom	18,691	2,704	17,436	2,506	19,745	2,885
Yugoslavia	632	69	632	82	511	63
Other	2,384	210	242	29	262	67
Total	135,055	13,620	137,950	14,093	122,748	13,285
Africa:						
South Africa, Republic of	11,861	1,005	7,877	675	9,338	851
Other	1,078	103	2,140	196	813	77
Total	12,939	1,108	10,017	871	10,151	928
Asia:						
India	22,085	1,830	16,117	1,285	6,510	661
Indonesia	1,274	109	665	57	805	60
Iran	907	90	3,034	296	364	39
Israel	949	102	1,378	143	1,102	112
Japan	5,037	1,054	6,300	1,248	10,296	1,824
Korea, South	5,683	478	7,014	573	7,972	706
Malaysia	1,399	117	929	77	512	50
Pakistan	595	53	801	66	536	45
Philippines	8,100	721	10,150	904	7,340	644
Taiwan	229	47	412	58	804	110
Thailand	2,249	191	3,996	338	4,050	339
Turkey	6,400	546	4,169	349	2,216	199
Other	2,125	199	2,472	227	1,179	122
Total	57,032	5,537	57,437	5,621	43,686	4,911
Oceania:						
Australia	4,967	486	4,995	474	6,472	554
New Zealand	2,906	253	4,073	374	2,716	246
Total	7,873	739	9,068	848	9,188	800
Grand total	274,608	26,658	297,281	28,407	236,032	24,456

Table 10.—U.S. exports of carbon black in 1967, by months

(Thousand pounds)

Month	Channel	Furnace	Total
January	5,908	15,339	21,247
February	4,761	15,609	20,370
March	4,845	17,194	22,039
April	4,815	14,355	19,170
May	5,872	16,028	21,900
June	4,967	13,579	18,546
July	4,448	12,849	17,297
August	6,305	16,063	22,368
September	4,015	12,092	16,107
October	4,373	13,712	18,085
November	5,126	15,434	20,560
December	4,640	13,703	18,343
Total	60,075	175,957	236,032

On the import side of foreign trade, nearly 5 million pounds of carbon black derived from acetylene was imported from Canada in 1967. Another 800,000 pounds came from East Germany. Both East and West Germany supplied the United States with 139,000 pounds of carbon black for use in pigments and 70,000 pounds of similar blacks were obtained from the United Kingdom. Switzerland and Belgium accounted for some 40,000 pounds of specialty black and small amounts of bone black were imported from West Germany.

WORLD REVIEW

On the international scene, it is becoming increasingly apparent that foreign countries are steadily becoming more self-sufficient in carbon black requirements for industrial needs. There have been sizable increases in the production of carbon black in Europe and South America as well as in other parts of the world. In Europe an overall uptrend in production was noted for France, West Germany, Italy, the Netherlands, Rumania, the United Kingdom, and Yugoslavia. In South America, significant gains are shown for Argentina, Brazil, and Venezuela.

Table 11.—World production of carbon black, by countries [1] [2]

(Thousand pounds)

Country	1963	1964	1965	1966	1967 [p]
Argentina	12,820	25,132	31,967	NA	NA
Brazil	54,784	52,699	49,780	64,917	67,682
France	167,991	189,507	220,019	265,216	NA
Germany, West	221,119	269,371	276,380	[r] 306,943	297,249
India	26,455	NA	31,901	NA	NA
Italy	96,341	141,756	162,920	184,450	199,750
Japan	176,882	244,567	[r] 273,080	297,165	388,745
Korea, South	276	694	725	NA	NA
Netherlands	NA	114,198	136,244	153,881	164,244
Rumania	73,142	78,030	80,918	[r] 84,410	115,683
South Africa, Republic of	21,402	26,334	29,020	NA	NA
Spain	2,866	3,307	3,748	NA	NA
Taiwan	425	434	1,404	[r] 1,014	NA
United Kingdom	308,000	338,200	353,400	[r] 365,500	359,000
United States	2,058,916	2,223,216	2,353,776	2,571,552	2,483,840
Venezuela	10,000	13,499	15,000	[e] 16,200	NA
Yugoslavia	9,438	10,818	11,241	[r] 14,462	[e] 15,400
Total [3]	3,240,857	3,731,762	4,031,523	4,325,710	4,091,593

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] Australia, Belgium, Canada, mainland China, Colombia, Mexico, and Sweden produce carbon black, but production data are not available.
[2] Compiled mostly from data available May 1968.
[3] Total is of listed figures only; no undisclosed data included.

TECHNOLOGY

Carbon black is a petrochemical made from gaseous or liquid hydrocarbons. The three basic production processes are the channel, thermal, and oil furance process. The furnace process, which accounts for 94 percent of total carbon black output, utilizes a carefully controlled flame in refractory-lined furnaces.

A most desirable feedstock for furnace black plants is an oil having 0° to 4° API gravity, low in sulfur, and high in aromatics and olefins, which comes from near the "bottom of the refinery barrel" and is similar in many respects to residual fuel oil. These plants convert approximately 50 percent of their inputs into carbon black. The economic advantage of the oil furnace process, its versatility, plus the rising cost of natural gas have been factors in the shift to a greater use of liquid feedstocks and a decline in the use of natural gas as a source of carbon. There has been a continuation of the trend toward larger percentage increases in production of furnace blacks and declines in output of channel blacks which, with advancing technology, have resulted in all furnace blacks being predominantly oil based.

Some progress has been made towards utilizing coal as the raw material for making carbon black. Carbon black obtained from coal in experiments by the Bureau of Mines has been tested in industrial laboratories and found "nearly identical" to commercial thermal black. Preliminary cost estimates show that the process may have commerical feasibility.

To increase the versatility of its process, the Bureau of Mines is now seeking ways in which the process can be modified to produce grades of carbon black other than thermal. Thermal black, a grade distinguished by relatively large size particles, is used mostly in rubber products requiring great resiliency or good heat conductivity. Grades with a smaller particle size, on the other hand, are desirable in rubber products requiring strength and abrasion resistence, such as tire treads, shoe soles and heels, and conveyor belts.

Commercial manufacturers of carbon black were supplied with samples of the Bureau's product for a determination of its physical and chemical properties and its utility. Tests were also made on batches of rubber made with the Bureau of Mines' carbon black derived from coal.

Excouraged by the brisk demand for blacks for diverse applications, both in this country and abroad, producers are expanding their plant facilities and additional production facilities are in the blueprint stage. The impressive growth of the foreign market for carbon black has prompted U.S. producers to build more plants and enlarge others in foreign countries. Domestic facilities in addition to new plants under construction are being expanded. One of the companies manufacturing thermal blacks has boosted its capacity by construction of new equipment to raise yields from the natural gas used as a raw material.

A carbon black plant has been built near Parkersburg, W. Va., and closer to its largest market, the rubber manufacturers. The new plant is not a great distance from Akron, Ohio, an important rubber goods manufacturing center.

The Parkersburg plant, which began operation early in 1968, could have an impact on future carbon black plant construction sites and marketing. Most U.S. carbon black is made in plants along the Texas and Louisiana gulf coast, in west Texas, in New Mexico, and in California, near raw material sources. While some carbon black is consumed near the proucing plants, much of it is moved long distances to consumers. Carbon black producers have initiated studies on the economics of locating plants nearer to consumers and farther from raw materials.

Demand for carbon black obviously is tied to the rubber industry, particularly to the synthetics, which use proportionately more of it than natural rubber. However, its growth rate has been higher than that of the rubber industry, reflecting not only the rise in synthetic rubbers but also the gradual increase in the carbon black content of these materials. An example is nitrile rubber, a copolymer of butadiene and acrylonitrile. Its most important properties and the major reason for its extensive use are oil and fuel resistance at both normal and elevated temperatures. The use of carbon black as a reinforcing pigment is necessary with nitrile rubber to achieve product specification requirements.

Cement

By Paul L. Allsman [1]

Cement shipments declined slightly in 1967, as domestic consumption slowed down from the amazing growth recorded in recent years. New plants and modernization of existing plant capacity continued as the long-term outlook for the national economy appeared promising. Domestic production of cement was 4 percent lower in 1967.

Portland cement plant capacity at the end of 1967 was reported to be 509.0 million 376-pound barrels, compared with 495.2 million barrels at the end of 1966. The operating level decreased to 72.6 percent in 1967, compared with 77.7 percent in 1966 and 77.0 percent in 1965. Prices in 1967 rose to an average value of $3.17 per barrel, compared with $3.15 in 1966. Increased competition among building materials caused cement prices to drop, and producers were forced to post raises to improve price levels during 1967.

Table 1.—Salient cement statistics

	1963	1964	1965	1966	1967
United States:					
Production [1] thousand 376-pound barrels	361,235	377,475	381,578	r 393,700	377,885
Capacity used at portland cement mills [1] percent	73.4	76.5	76.8	77.3	72.7
Shipments from mills [1] thousand 376-pound barrels	358,024	375,340	384,402	r 389,856	381,824
Value [1 2] thousands	$1,156,890	$1,209,470	$1,221,454	r $1,226,806	$1,210,736
Average value [1] per barrel	$3.23	$3.22	$3.18	$3.15	$3.17
Stocks Dec. 31: at mills [1] thousand 376-pound barrels	39,496	39,761	32,942	r 40,698	41,529
Exports do	460	713	748	1,069	980
Imports for consumption do	4,030	3,633	5,505	7,066	5,913
Consumption, apparent [3] do	361,594	378,260	389,159	r 395,853	386,757
World: Production do	2,216,735	2,437,754	2,541,802	2,722,561	2,813,855

r Revised.
[1] Excludes Puerto Rico.
[2] Value received f.o.b. mill, excluding cost of containers.
[3] Quantity shipped plus imports minus exports.

Management increased the diversification of products and markets, as interest in white cement, computerized manufacturing, and allied industries such as crushed stone and lightweight aggregates heightened. Modernization policies should increase the consumption of cement, as current capitol costs for new plants are $5 to $8 per barrel of annual capacity, compared with $10 a decade ago. New distribution systems, transports, and bulk handling systems were expected to increase the use and competitive position of the cement industry.[2]

DOMESTIC PRODUCTION

PORTLAND CEMENT

Four new plants commenced commercial production during 1967. These were Dundee Cement Co. at Clarksville, Mo.; Ideal Cement Co., on the Duwamish Waterway, Seattle, Wash.; Medusa Portland Cement Co., at Charlevoix, Mich.;

[1] Commodity specialist, Division of Mineral Studies.
[2] Schenck, George H. K., and Peter G. Donald. Cement—An Industry in Flux. Min. Eng., v. 19, No. 4, April 1967, pp. 85–89.

and Pacific Western Industries, Inc., at Lebec, Kern County, Calif.

New plants under construction included the $20 million Martin Marietta Corp. (Rocky Mountain Cement Co.) plant at Lyons, Colo.; the 1.7-million-barrel Kaiser Cement & Gypsum Corp. plant at Scholle, N. Mex.; the 6-million-barrel, $40 million Ideal Cement Co. plant at Redwood City, Calif.; the 2.5-million-barrel Kaiser Cement & Gypsum Corp. plant on the Duwamish Waterway, Seattle, Wash.; the 4-million-barrel, $20 million Lone Star Cement Corp. plant at Greencastle, Ind.; the 1-million-barrel, Betterroads, Inc., plant at Artesia, Miss., to be completed in 1968; and the $11 million Rochester Portland Cement Corp. plant at Stony Point, N.Y.

Plans were announced for three new production plants. American Cement Corp. made plans for a new 3-million-barrel plant at Ione, Amador County, Calif. to be built in 3 to 5 years. Creole Corp., a subsidiary of Texas Industries, Inc., planned a 3-million-barrel plant near Plaster City, Imperial County, Calif. Maule Industries, Inc., announced construction of a 2-million-barrel plant near Miami, Fla., to be completed in 1968.

Twelve major plant expansions or modernizations were either underway in 1967 or due to begin shortly: Alpha Portland Cement Co., Orange, Tex.; Ideal Cement Co., Houston, Tex.; Lone Star Cement Corp., Davenport, Calif., and Seattle, Wash.; Martin Marietta Corp., Bay City, Mich.; Medusa Portland Cement Co., Manitowoc, Wis.; National Gypsum Co. (Huron Portland Cement Co.), Alpena, Mich.; Northwestern States Portland Cement Co., Mason City, Iowa; Oregon Portland Cement Co., Lake Oswego, Oreg.; Portland Cement Co. of Utah, Salt Lake City, Utah; River Cement Co., Festus, Mo.; Universal Atlas Cement Division, United States Steel Corp., Waco, Tex.

Ideal Cement Co. announced the closure of its plants at Grotto, Wash., Spokane, Wash., and Gold Hill, Oreg. These three plants had a capacity of 2.1-million-barrels, and are replaced by its new Duwamish Waterway plant with a capacity of 2.5-million-barrels. Lone Star Cement Corp. announced it would close its plant at Concrete, Wash., to be replaced by expansion of its Seattle plant to 4-million-barrels; plans for a new plant at Anacortes, Wash., were canceled. Lone Star Cement Corp. also announced it intended to close mariginal plants at Hudson, N. Y., Lake Charles, La., and Dallas, Tex. Martin Marietta Corp. canceled plans for a new cement plant at Milan, Mich., owing to drainage problems which developed in excavating the quarry. Louisville Cement Co. sold 1,350 acres of limestone reserves it had acquired for a new cement plant near Roanoke, Va., because of opposition of local residents to quarrying.

Cement producers attempted to meet the competition from other building materials by continuing to improve products and manufacturing processes. Ash Grove Lime & Portland Cement Co. completed a laboratory for analysis of cement, lime, mortars, aggregates, and related materials at Kansas City, Kans. Martin Marietta Corp. planned an institute for research on cement, lime, and refractory materials near Baltimore, Md.; the 20,000-square-foot facility is estimated to cost $750,000. The Portland Cement Association enlarged its Research and Development Laboratories in Skokie, Ill., with the addition of a $1.5 million building to house the general offices of the Association.

The trend toward larger, fully integrated, and automated plants with their consequent low production costs continued. Dundee Cement Co. opened a 7-million-barrel plant, and Huron Portland Cement Co. completed its expansion to 18 million barrels. Kaiser Cement & Gypsum Corp's. 8.5-million-barrel plant at Permanente, Calif., was described along with several other modern plants.[3]

The number of portland cement plants in the United States (including Puerto Rico) in 1967, by size group follows:

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[3] Bergstrom, John H. Maximum Efficiency with Minimum Manpower (Ideal Cement Co., Seattle, Wash.). Rock Prod., v. 70, No. 10. October 1967, pp. 74–82.

Kinard, John. This Business Demands a Thick Hide and Strong Beliefs (Pacific Western Industries, Inc.). Rock Prod. v. 70 No. 5, May 1967, pp. 104–105, 108, 140.

Levine, Sidney. Santee Surges Into Southeast Cement Market. Rock Prod., v. No. 2, February 1967, pp. 65–68, 70-72.

Minerals Processing. One Mill Feeds Six Kilns (Kaiser Cement and Gypsum Co., Permanente, Calif.). V. 8, No. 8, August 1967, pp. 36–37.

Taeler, David H. Marquette-Catskill. Miner. Proc., v. 8, No. 5, May 1967, pp. 14–18.

Estimated annual capacity of portland cement plants in the United States (including Puerto Rico) December 31, 1967

Million barrels	Number of plants	Percent of total capacity
Less than 1	[1] 11	1.5
1 to 2	[2] 59	17.3
2 to 3	52	24.5
3 to 4	40	26.6
4 to 5	12	10.0
5 and over	14	20.1
Total	188	100.0

[1] Two plants received clinker from other sources.
[2] One plant received clinker from other sources.

NATURAL AND SLAG CEMENTS

Natural cement was produced at two plants, and slag cement was produced at two others. These four plants reported an annual capacity of approximately 1 million barrels.

Because masonry cements prepared at these plants contained some portland cement, they are included in the tabulations of masonry cements prepared at portland cement plants. Production figures from 1957 to 1967 are not strictly comparable with those of earlier years because of changes in methods of reporting by some producers.

TRANSPORTATION

New cement distribution terminals were completed by Huron Portland Cement Co., at Minneapolis, Minn., and Buffalo, N. Y.; Texas Industries, Inc., at Jackson and Tupelo, Miss.; General Portland Cement Co., at Statesville, N. C.; River Cement Co., at Natchez, Miss.; Kaiser Cement & Gypsum Corp., at Tyler, Tex.; American Cement Corp., at Sacramento, Calif.; Rocky Mountain Cement Co., at Florence, Colo.; and Idaho Portland Cement Co., at Heyburn, Idaho.

Dundee Cement Co. announced a network of eight new distribution centers to service its new plant at Clarksville, Mo. These were to be at New Orleans, La.; St. Louis, Mo.; Quad City, Ill.; Rock Island, Ill.; West Chicago, Ill.; Nashville, Tenn.; Houston, Tex.; and Minneapolis-St. Paul, Minn. The company also awarded a $4 million contract for a fleet of 34, jumbo covered, 7,500-barrel, hopper barges for use on the Mississippi River.

Medusa Portland Cement Co. converted a ship to a self-unloading cement carrier for use at its new Charlevoix, Mich., plant as well as other Great Lakes plants. The 11,000-ton vessel was named the Medusa Challenger, and was refitted at Manitowoc, Wis., with an 8,000-barrel-per-hour unloading conveyor.

The modern cement truck transport fleet operated by Herman Bros., Inc., from Omaha, Neb., was described. Nearly 100 tankers deliver cement on order to highway paving and large construction works throughout the Midwest. This type of truck fleet represents the efficient transportation system which the modern cement industry relies on.[4]

CONSUMPTION AND USES

The use of concrete for heavy structures in place of steel continued to grow, as many new contracts were awarded for dams, bridges, and large buildings. The new U.S. Post Office in Phoenix, Ariz., utilized a unique flat-slab concrete roof construction, set on capitals, which proceded from the center outwards. Reuse of steel forms and precasting of columns made the use of concrete economical.[5]

Oilwell cement grew increasingly popular, and constituted a major market in southern California. New ASTM and API specifications were written creating a Class G cement, following years of research by Southwestern Portland Cement Co. and Riverside Division of American Cement Corp. This is a practical new class of cement that should find increasing use in anchoring surface pipe, sealing off water and oil strata, and oilwell cementation.[6]

The growing use of pozzolanic cements,

[4] Roads and Streets. Meet the Hermans: They Keep the Cement Coming. V. 109, No. 12, December 1967, pp. 28–29, 58.
[5] Engineering News-Record. Flat Slab Starts in the Middle. V. 178, No. 25, June 22, 1967, p. 20.
[6] Harder, Paul. Oilwell Cement—Something Special in Reliability. Miner. Proc., v. 8, No. 3, March 1967, pp. 24–26.

which are highly reactive with a great variety of materials, was in evidence during the year. Pozzolanic cements are widely used in cinder block and ready-mixed concrete products manufacture, and in concrete pipe. Asbestos-cement specifications were tested by the Mineral Fiber Products Bureau. Measurement was made of resistance to exposure and surface deterioration.[7]

The use of cement in stabilizing sand fills in mine stoping has become increasingly popular in recent years. A paper describing this practice in nickel mines in Canada was published by the International Nickel Co.[8]

PRICES

The price of cement in 1967 rose to $3.17 per barrel from $3.15, as prices rose slightly in the Central and Midwestern States, and in the Far Western States. Over capacity continued to be a serious problems, although older and antiquated plants were shut down at about the same rate as new, highly efficient plants went into operation in several areas.

Portland cement values at plant changed from $3.08 per barrel in the last quarter of 1966 to $3.16 per barrel in the first quarter of 1967 and dropped back to $3.11 by the fourth quarter. The average value of types I and II cement was $3.03 in the fourth quarter of 1966, $3.11 in the first quarter of 1967, and $3.07 in the fourth quarter of 1967. Type III cement was valued at $3.47 in the fourth quarter of 1966, $3.48 in the first quarter of 1967, and $3.45 in the fourth quarter of 1967. The average price of prepared masonry cement in 280-pound barrels was $2.80 in the fourth quarter of 1966, $2.87 in the first quarter of 1967, and $2.88 in the fourth quarter of 1967. The average value of natural, slag, and hydraulic-lime cement shipments was $3.87 in 1967, compared with $3.74 per barrel in 1966.

Engineering News-Record gives f.o.b. base prices per barrel for portland cement in carload lots in 20 cities across the Nation. In bulk, during 1967, cement sold for an average of $3.99 and ranged from a high of $4.95 in Pittsburgh to a low of $3.45 in New York. In paper bags, during 1967, the average price quoted was $4.77, ranging from a high of $5.65 in Pittsburgh to a low of $3.70 in New York. Mortar cement sold for an average $4.37 per barrel and ranged from a high of $5.20 in New Orleans to a low of $3.81 in Atlanta.

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7 Materials Research and Standards. Asbestos-Cement Sheet OK After 5 Years in Salt Water. V. 7, No. 6, June 1967, p. 277.

8 Mining and Minerals Engineering. Cemented Sand Fill at Inco. V. 3, No. 4, April 1967, pp. 129–130.

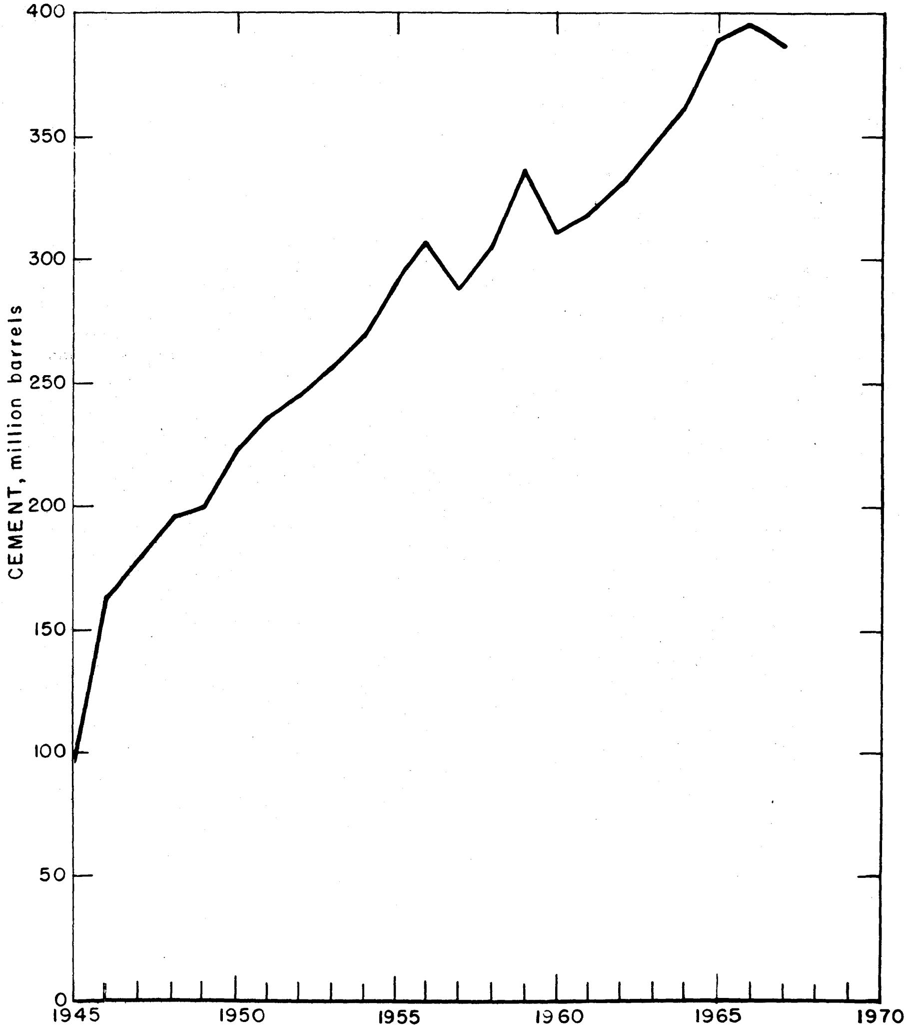

Figure 1.—Apparent consumption of finished portland cement in the United States.

FOREIGN TRADE

United States exports of cement decreased 8 percent in 1967. Imports in 1967, although 16 percent below the record level of 1966, were the second highest on record, as shipments from the Bahama Islands increased markedly.

WORLD REVIEW

NORTH AMERICA

Canada.—St. Mary's Cement Co. Ltd. was constructing a new $15 million cement plant at Bowmanville, Ontario, scheduled for completion in July 1968. Lafarge Cement Co. of North America Ltd. planned to double the capacity of its plant at Lulu Island, British Columbia from 1.7 to 3.5 million barrels per year.

Canada Cement Co. Ltd. obtained control of Francon Ltd., a ready-mixed concrete products producer, for $12.8 million. Denison Mines Ltd. acquired 14 percent of Canada Cement Co. Ltd., listed as consisting of nine plants with a capacity of 30 million barrels, and obtained control of Lake Ontario Cement Ltd., with a capacity of 5 million barrels.

Inland Cement Industries Ltd. new, 2-million-barrel plant at Winnipeg, Manitoba, was described. The fully automated, $16 million plant is the third for the company.[9]

El Salvador.—The Grupo Eternit of Brazil completed a $1.4 million cement plant in El Salvador during 1967.

Mexico.—New capacity planned or under construction is estimated to total 7.9 million tons by 1968, an increase of 54 percent over installed 1966 capacity. Expansion of existing plants or construction of new plants was underway in Jasso and Atotonilco, Hidalgo; Tamuin and Valles, Potosi; Tlaquepaque, Jalisco; Apaxco, Mexico; Minatitlan, Veracruz; Torreon, Coahuila; Lagunas, Oaxaca; Macusapan, Tabasco; Cuernavaca, Morelos; and Actlan, Puebla.

Panama.—Cemento Atlântico, S. A., began producing cement at its new 300-ton-per-day plant at Samba Bonita, Colon.

Puerto Rico.—Puerto Rican Cement Co. Inc., put the 5,500-ton MV Cemento Ponce into service to deliver cement to its terminals at St. Croix and St. Thomas in the Virgin Islands. The company was also building a 250,000-barrel white cement plant at its Ponce operation.

SOUTH AMERICA

Bolivia.—Co-operativa Boliviana de Cemento planned to construct a 100,000-ton cement factory at Cochabamba; total cost is estimated at $4.5 million. Another factory was planned at Santa Cruz, and enlargement of the existing works at Sucre was planned.

Brazil.—Cement was produced at 29 plants operated by 28 companies in 14 States. Companhia Nacional de Cemento Portland, a subsidiary of Lone Star Cement Corp., was planning a new plant at Cantagalo, and expansion of the Aratu plant of its subsidiary, Cemento Aratu S. A. A white cement plant was planned at Irajo, Sao Paulo, by Cemento Portland Branco do Brazil, with the help of a $4.65 million loan from the Inter-American Development Bank.

Ecuador.—The National Development Bank agreed to relinquish control of the 900-barrel-per-day Cemento Chimborazo plant at Riobamba to a U.S. investor; value is about $2.6 million.

Paraguay.—A new 100,000 ton, $8.7 million cement plant is to be built at Vallemi, the site of the only existing plant in Paraguay. The contract was awarded Fried Krupp of West Germany.

Peru.—Five cement plants were reported operating; Cemento El Sol, S. A., Cemento Chilca, S. A., Cemento Pacasmayo, S. A., Cemento Andino, S. A., and Cemento Sur, S. A. A sixth plant, Cemento Arequipa, S. A., at Yura, went into operation at the rate of 3,000 to 5,000 barrels per day in 1967. The bagging plant of Cemento Andino, S. A., at Condorcocha, was described.[10]

EUROPE

Netherlands.—Portland and slag cement were produced by N. V. Eerste Nederlandsche Cement Industrie, at Limburg and Maastricht, N. V. Cementfabriek Rozenburg, and N. V. Cementfabriek Ijmuiden. Over 50 percent of the production is blast furnace slag-cement.[11]

Norway.—Expansion of Norweigian cement plants provided sufficient excess

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[9] Pit and Quarry. New Winnipeg Plant Third for Inland Cement Industries Ltd. V. 59, No. 8, February 1967, pp. 88–92.

[10] Pit and Quarry. Cemento Andino, S.A., Near Lima, Peru, Solves Bag Breakage Problems. V. 59, No. 12, June 1967, p. 41.

[11] Van der Blist, A. A. Netherlands Cement Industry. Miner. Proc., v. 8, No. 7, July 1967, pp. 21–23.

production to enable the export of about 500,000 tons per year. Both A/S Dalen-Portland Cementfabriek and A/S Christiania Portland Cementfabrik raised respective capacities to 1.1 millions tons.

Sweden.—The modern, automated cement plant and quarry of A B Gullhogens Bruk at Skovde, Sweden, was described. Mechanization includes computer control of kiln and grinding plants.[12]

AFRICA

Cameroon.—The long-awaited construction of a new cement plant at Figuil was planned by the Cement Co. of Cameroon, with a capacity of 46,000 metric tons. Also planned was a clinker grinding plant at Douala. Total investment is estimated at $7 million.

Dahomey.—The Societe des Ciments du Dahomey announced plans for a 100,000-ton cement plant in Cotonou, to produce cement from imported clinker. Plans for a cement plant near Pobe were abandoned.

Ethiopia.—The Imperial Ethiopian Government was planning a new 200,000-ton cement plant, to go into production by 1972. Existing plants are at Massawa (70,000 tons); Addis Ababa (70,000 tons); and Dire Dawa (40,000 tons).

Gabon.—Ciments de Marseille, a French firm, signed an agreement with the Government of Gabon for creation of a 35,000-metric-ton, $1.2 million cement-clinker crushing plant in Owendo Port.

Nigeria.—The West African Portland Cement Co., Ltd., 500,000-ton, $13 million, semi-dry-process plant, at Ewekoro, Nigeria, was described.[13]

Rhodesia, Southern.—The Salisbury Portland Cement Co., Ltd., plant at Mauressa was diagramed. The semi-dry-process plant produces 2,000 barrels per day of clinker. Portland, blast-furnace-slag, and masonry cement are produced.[14] United Portland Cement Co. (Pvt.) Ltd. was also described. The company has plants at Bulawayo and Colleen Bawn. Annual capacity is rated at 2 million barrels of cement and 25,000 tons of lime.[15]

South Africa, Republic of.—Fifteen plants operated by eight companies were in full production in 1967. Annual production is over 21 million barrels. The industry uses 5 million tons of limestone, 1 million tons of coal, 200,000 tons of gypsum, and 400 million kilowatt hours of electrical power per year.[16]

Uganda.—A second cement plant, near Kilembe mines in western Uganda, was reported in the planning stages. The only existing cement plant is at Tororo, in eastern Uganda.

Zambia.—Plans for a new 200,000-ton cement plant at Ndola on the Copperbelt were announced by Chilanga Cement Ltd. The company also increased capacity of its plant at Lusaka from 200,000 to 300,000 tons in 1967.

ASIA

Indonesia.—The Indarung cement plant near Podang is one of two major industrial projects in West Sumatra. Annual capacity is 240,000 metric tons; current production is about 60 percent of capacity.

Iraq.—Iraqi Cement Co. completed plans for a new 500,000-ton grinding plant at Um Qasr. Semiprocessed cement will be shipped from the Samawa factory, providing a total annual capacity of 2 million metric tons.

Japan.—The Japanese Cement Assn. estimated 1967 sales at 220 million barrels, a 6.6 percent increase over 1966.

Over 10 million barrels were exported to Korea, Okinawa, and Thailand.

Nepal.—Himal Cement Ltd. was erecting the country's first cement plant in Kathmandu Valley. The $4 million plant is rated at 175 tons per day.

Pakistan.—Societe Fives-Lille-Cail was constructing a $6 million, 1,000-ton-per day plant at Chittagong. Chatak Cement Factory at Thakerghat was being expanded to 300,000 tons capacity. Jamalpur

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12 Rock Products. Swedish Cement Plant Triples Productivity. V. 70, No. 5, May 1967, pp. 98–100.

13 Minerals Processing. Nigeria's West African Cement. V. 8, No. 5, May 1967, pp. 24–25.

14 Minerals Processing. Rhodesia's Salisbury Portland Cement. V. 8, No. 5, May 1967, pp. 30, 36–37.

15 Minerals Processing. Rhodesia's United Portland Cement. V. 8, No. 7, July 1967, pp. 22–23.

16 Holz, Peter. Commentary on South Africa's Cement Industry. Miner. Proc., v. 8, No. 5, May 1967, pp. 32–34, 36.

Cement Factory being built at Bogra will have a capacity of 600,000 tons.

Philippines.—Mindanao Portland Cement Corp. planned a $6 million, 2-million-barrel cement plant and Philippine Cement Co. a 2.6-million barrel, $4.5 million cement plant. Contracts for both plants were awarded to Japanese companies.

Saudi Arabia.—Arabian Cement Co. was expanding its plant at Jidda from 600 to 1,000 tons per day. Saudi Cement Co. was expanding its plant at Ḥofuf from 300 to 600 tons per day, and announced plans for further expansion at Riyadh from 300 to 900 tons per day.

Taiwan.—Cement production was estimated at 4 million tons, 95 percent of capacity. Exports to Vietnam were 1.2 million tons, an increase of 77 percent. Two new kilns were completed, and a third was scheduled during 1967.

Thailand.—Kaiser Cement & Gypsum Corp., acquired a 30 percent interest in Jalaprathan Cement Co., with a 2-million-barrel plant at Takli. Value of the shares was $1.8 million.

Turkey.—Five State plants were expanded, increasing total capacity by 600,000 tons. New State-owned plants were being constructed at Trabzon, 300,000 tons; and at Van, 220,000 tons. Private industry was planning new plants at Bursa, Izmir, and Ankara.

OCEANIA

Fiji.—Fiji Industries Ltd., planned to expand capacity from 47,000 to 85,000 tons annually, with a new kiln and cement mill. Prestressed Concrete (Fiji) Ltd. planned to build a concrete products factory on the cement plant site.

TECHNOLOGY

A new edition of a book on portland cement was issued during the year. The work is a standard reference on portland cement manufacture, and provides an interesting history of the industry. Covered are proportioning, fuels, grinding, plant design, and concrete mixing.[17]

Operating cement kilns was the topic of the Second Annual Cement Seminar sponsored by Rock Products. Typical problems discussed were quality control, clinker coolers, interlocking computer control systems, kiln refractories, power supply, and economics of using large kilns.[18] A simulated cement kiln was developed to facilitate design of a computer control system by Electronic Associates, Inc. The model can describe any kiln, and the equations mechanize the energy and material balance, and the continuous kiln operation. Results can be used directly in kiln design and control systems design.[19] The variations which occur in modern, long cement kilns were metered. A rotary kiln is able to minimize surges that are inherent in the operation of open hearth type furnaces.[20]

Chemistry of cements was the subject of a series of articles, as modern research by the industry kept pace with current problems. The characteristics of calcium sulfoaluminate hydrates were studied by X-ray diffraction. This should enable control of expansion during setting of cements.[21] Chemical experiments on false-setting of cement were described. The effects of aeration and additives to control hemihydrate reactions were discussed. Strength of cement and concrete is affected by false-set.[22] Setting phases in portland cement were quantified by the research laboratory of the Universal Atlas Cement Co. Differential thermal analysis of cement and clinker pastes was shown to be a satisfactory method of studying hydration reactions. This type of thoroughgoing

17 Witt, J. C. Portland Cement Technology. Chemical Publishing Co., New York, 2nd Ed., 1967, 346 pp.
18 Rock Products. Operating Large Cement Kilns. V. 70, No. 5, May 1967, pp. 80–85.
19 Bailey, Ray B., and Joe F. Paul. Rotary Cement Kiln Experimentation Utilizing a Hybrid Computer Simulation. Miner. Proc., v. 8 No. 3, March 1967, pp. 16–21.
20 Goller, C. H., and W. R. Bendy. How To Figure Your Kiln's Range of Variation. Rock Prod., v. 70, No. 3, March 1967, pp. 75–76.
21 Mehta, P. K. Expansion Characteristics of Calcium Sulfoaluminate Hydrates. J. Am. Ceram. Soc., v. 50, No. 4 April 1967, pp. 204–208.
22 Goetz, Hans W. False Set of Cement as Influenced by Hydroxylated Carboxylic-Acid-Type Admixture. Mat. Res. and Standards, v. 7, No. 6, June 1967, pp. 246–250.

research should eventually provide complete knowledge of cement chemistry.[23]

A device for laboratory study of water-cement ratios, physical, and mechanical properties of portland cement pastes was developed. Tests include static fatigue, strength, and effects of humidity. The technique may perfect field testing of cement and concrete.[24]

The chemistry of clinker burning was investigated by the engineering department of the Fuller Co. The formation of alite, tricalcium silicate, and other phases was described. The important results should enable complete and effective kiln control.[25]

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[23] Kalousek, G. L., Z. T. Jugovic, and J. L. Gillam. A New Factor in Abnormal Setting of Portland Cement. Am. Ceram. Soc. Bull., v. 46, No. 3, March 1967, pp. 270–274.

[24] Sereda, P. J., and E. G. Swenson. Apparatus for Preparing Portland Cement Paste of High Water-Cement Ratio. Mat. Res. and Standards, v. 7, No. 4, April 1967, pp. 152–154.

[25] Duda, Walter H. Portland Cement Clinker Burning. Miner. Proc., v. 8, No. 8, August 1967, pp. 16–18.

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)	
					1966			1967				
						Value			Value			
	1966	1967	1966	1967	Thousand 376-pound barrels	Total (thousands)	Average per barrel	Thousand 376-pound barrels	Total (thousands)	Average per barrel	1966 [2]	1967
New York, Maine	12	13	30,555	26,684	30,525	$80,829	$2.65	28,816	$75,780	$2.63	3,793	3,535
Eastern Pennsylvania	17	17	30,793	28,957	29,227	80,828	2.76	29,596	81,704	2.76	3,662	2,906
Western Pennsylvania	5	5	11,387	10,453	10,777	33,529	3.11	10,601	32,888	3.10	1,897	1,716
Maryland, West Virginia	4	4	10,392	9,675	10,089	30,815	3.05	10,160	30,509	3.00	1,163	662
Ohio	9	9	15,755	14,773	15,181	48,740	3.21	14,726	46,860	3.18	2,271	2,224
Michigan	8	9	28,848	29,862	28,171	87,413	3.10	29,645	94,515	3.19	3,264	3,825
Indiana, Kentucky, Wisconsin	8	8	21,816	20,966	20,286	65,547	3.24	21,061	69,478	3.30	2,563	2,184
Illinois	4	4	9,108	9,608	9,203	28,617	3.11	9,069	30,186	3.33	1,163	1,811
Tennessee	6	6	8,286	7,947	8,177	25,718	3.15	8,062	25,548	3.17	1,129	955
Virginia, North Carolina, South Carolina	6	6	12,425	12,560	12,106	35,553	2.94	12,835	38,698	3.02	1,311	1,041
Georgia, Florida	7	6	11,940	11,608	11,667	37,579	3.22	11,593	38,348	3.31	800	787
Alabama	8	8	14,632	13,445	[3] 16,394	49,537	3.02	15,364	46,510	3.03	1,072	1,529
Louisiana, Mississippi	6	6	9,249	8,943	9,722	30,793	3.17	9,158	29,033	3.17	754	816
Minnesota, South Dakota, Nebraska	4	4	7,715	6,512	7,899	26,374	3.34	6,535	21,990	3.36	1,028	1,007
Iowa	5	5	13,669	13,650	14,058	46,736	3.32	13,712	45,394	3.31	1,475	1,526
Missouri	7	8	13,956	14,888	13,848	46,228	3.34	15,044	52,119	3.46	1,931	2,539
Kansas	6	6	9,174	9,023	8,979	27,246	3.03	8,833	25,545	2.89	1,490	1,403
Oklahoma, Arkansas	5	5	12,516	12,370	12,320	36,435	3.96	12,014	35,954	2.99	1,126	1,362
Texas	19	19	31,487	32,277	30,827	97,188	3.15	31,944	99,329	3.11	2,848	3,157
Wyoming, Montana, Idaho	4	4	3,694	3,485	3,704	12,354	3.34	3,356	11,548	3.44	670	792
Colorado, Arizona, Utah, New Mexico	7	7	11,655	10,974	11,484	38,844	3.38	10,885	37,664	3.46	1,199	1,287
Washington	6	7	6,205	5,884	6,820	24,340	3.57	5,614	20,581	3.67	480	799
Oregon, Nevada	4	4	4,276	3,393	4,541	16,393	3.61	3,518	12,707	3.61	265	265
Northern California	6	6	18,931	17,877	19,020	63,088	3.32	17,822	61,109	3.43	1,372	1,418
Southern California	7	8	26,391	24,178	26,367	83,214	3.16	24,212	76,851	3.17	1,776	1,745
Hawaii	2	2	1,706	1,444	1,749	9,046	5.17	1,395	7,360	5.28	177	217
Puerto Rico	2	2	8,071	7,963	7,603	24,277	3.19	8,447	27,397	3.24	618	151
Total	184	188	384,632	369,399	[3 4] 380,694	1,187,261	3.12	374,017	1,175,605	3.14	41,297	41,659

[1] Includes Puerto Rico.
[2] Incorporates some revisions.
[3] Includes imported cement.
[4] Does not include finished cement used in manufacturing prepared masonry cement as follows: 1966, 2,065,000 barrels; 1967, 2,134,000 barrels.

Table 3.—Portland cement produced and shipped by plants in the United States,[1] by types

Type and year	Active plants	Production (thousand 376-pound barrels)	Shipments: Thousand 376-pound barrels	Shipments: Value: Total (thousands)	Shipments: Value: Average
General use and moderate heat (types I and II):					
1963	180	[2] 329,929	326,918	$1,032,809	$3.16
1964	181	[2] 347,954	346,052	1,090,712	3.15
1965	181	[2] 348,665	352,431	1,095,639	3.11
1966	[3] 183	[2] 359,493	358,446	1,102,940	3.08
1967	[4] 186	[2] 346,577	352,254	1,091,956	3.10
High-early-strength (type III):					
1963	145	[5] 14,592	14,559	51,167	3.51
1964	144	[5] 12,873	12,530	44,124	3.52
1965	153	[5] 13,388	12,757	44,621	3.50
1966	149	[5] 14,550	12,955	44,828	3.46
1967	145	[5] 12,899	12,188	42,453	3.48
Low-heat (type IV):					
1963	3	----------	---------	-----------	-------
1964	1	(6)	(6)	(6)	-------
1965	-------	----------	---------	-----------	-------
1966	-------	----------	---------	-----------	-------
1967	-------	----------	---------	-----------	-------
Sulfate-resisting (type V):					
1963	18	349	324	1,267	3.91
1964	16	446	398	1,443	3.63
1965	19	512	425	1,648	3.88
1966	18	540	482	1,796	3.73
1967	18	870	560	2,023	3.61
Oil-well:					
1963	15	1,239	1,158	3,878	3.35
1964	12	1,347	1,306	4,329	3.31
1965	13	1,645	1,613	5,571	3.45
1966	14	2,172	2,006	6,954	3.47
1967	14	2,518	2,413	9,251	3.83
White:					
1963	5	[7] 2,050	1,935	13,547	7.00
1964	5	[7] 2,139	2,111	14,821	7.02
1965	5	[7] 2,241	2,128	14,517	6.82
1966	[r] 5	[7] 2,208	2,060	14,675	7.12
1967	6	[7] 2,244	2,092	13,928	6.66
Portland-slag and portland pozzolan:					
1963	8	[8] 2,470	2,620	8,681	3.31
1964	10	[8] 1,047	1,057	3,656	3.46
1965	6	[8] 967	913	2,878	3.15
1966	[3] 5	[8] 956	562	1,732	3.08
1967	[3] 6	[8] 818	780	2,610	3.35
Miscellaneous: [9]					
1963	23	[7] 1,914	1,739	6,625	3.81
1964	22	[10] 2,827	2,850	9,902	3.47
1965	34	[10] 4,004	3,819	12,989	3.40
1966	39	[10] 4,713	4,183	14,336	3.43
1967	22	[10] 3,473	3,730	13,384	3.59
Grand total:					
1963	[11] 181	352,543	349,253	1,117,974	3.20
1964	[11] 181	368,633	366,304	1,168,987	3.19
1965	[11] 181	371,422	374,086	1,177,863	3.15
1966	[4] [11] 184	384,632	380,694	1,187,261	3.12
1967	[11] [12] 188	369,399	374,017	1,175,605	3.14

[r] Revised.
[1] Includes Puerto Rico.
[2] Includes air-entrained portland cement as follows (in thousand 376-pound barrels): 1963, 40,649; 1964, 43,950; 1965, 46,118; 1966, 46,022; 1967, 43,801.
[3] Includes one plant which received clinker from another source.
[4] Includes two plants which received clinker from other sources.
[5] Includes air-entrained portland cement as follows (in thousand 376-pound barrels): 1963, 4,879; 1964, 2,754; 1965, 2,677; 1966, 2,611; 1967, 2,213.
[6] Less than ½ unit.
[7] Includes a small quantity of air-entrained portland cement.
[8] Includes air-entrained portland cement as follows (in thousand 376-pound barrels): 1963, 1,369; 1964, 343; 1965, none; 1966, 392; 1967, 167.
[9] Includes hydroplastic, plastic, and waterproofed cements.
[10] Includes air-entrained portland cement as follows (in thousand 376-pound barrels): 1964, 367; 1965, 775; 1966, 853; 1967, 434.
[11] Includes number of plants making air-entrained portland cement as follows: 1963, 121; 1964, 130; 1965, 132; 1966, 129; 1967, 132.
[12] Includes three plants which received clinker from other sources.

Table 4.—Shipments of prepared masonry cement from mills in the United States, by States

(Thousand 280-pound barrels)

Destination	1966	1967
Alabama	666	633
Alaska [1]	W	W
Arizona	W	W
Arkansas	344	335
Colorado	185	183
Connecticut [1]	148	145
Delaware [1]	47	55
District of Columbia [1]	360	275
Florida	1,222	1,287
Georgia	1,255	1,189
Idaho	10	11
Illinois	716	730
Indiana	831	808
Iowa	230	217
Kansas	182	162
Kentucky	557	575
Louisiana	447	428
Maine	71	75
Maryland	713	642
Massachusetts [1]	272	265
Michigan	1,494	1,474
Minnesota	430	419
Mississippi	394	374
Missouri	230	214
Montana	21	18
Nebraska	78	74
Nevada	W	W
New Hampshire [1]	82	70
New Jersey [1]	670	612
New Mexico	100	76
New York	973	940
North Carolina	1,519	1,490
North Dakota [1]	49	57
Ohio	1,481	1,404
Oklahoma	292	267
Oregon	1	1
Eastern Pennsylvania	483	452
Western Pennsylvania	631	616
Rhode Island [1]	28	29
South Carolina	903	884
South Dakota	55	51
Tennessee	1,098	1,139
Texas	864	856
Utah	9	5
Vermont [1]	42	43
Virginia	1,215	1,161
Washington	45	52
West Virginia	235	240
Wisconsin	527	482
Wyoming	11	11
Total United States	22,216	21,526
Other countries [2]	151	174
Total shipped from cement plants	22,367	21,700

W Withheld to avoid disclosing individual company confidential data; included with "Other countries."
[1] Noncement producer.
[2] Direct shipments by producers to other countries and to Alaska, Arizona, Nevada and Puerto Rico.

Table 5.—Prepared masonry cement produced and shipped in the United States, by districts

District	Active plants		Production (thousand 280-pound barrels)		Shipments from mills					
					1966			1967		
	1966	1967	1966	1967	Thousand 280-pound barrels	Value (thousands)	Average per barrel	Thousand 280-pound barrels	Value (thousands)	Average per barrel
New York, Maine	9	9	1,106	937	1,063	$2,583	$2.43	994	$2,284	$2.30
Eastern Pennsylvania	11	11	2,019	1,978	1,902	4,926	2.59	1,930	5,048	2.62
Western Pennsylvania	5	5	1,099	1,013	1,058	2,934	2.77	999	2,901	2.90
Maryland, West Virginia	5	5	1,037	880	1,046	2,496	2.39	876	2,104	2.40
Ohio	7	7	996	925	976	2,785	2.85	946	2,731	2.89
Michigan	6	5	2,358	1,989	2,032	5,221	2.57	1,995	5,296	2.65
Indiana, Kentucky, Wisconsin	6	6	3,108	3,033	3,071	9,341	3.04	3,012	9,184	3.05
Illinois	4	4	577	595	614	1,868	3.04	591	1,851	3.13
Tennessee	5	5	1,133	1,047	1,095	2,822	2.58	1,092	2,992	2.74
Virginia, North Carolina, South Carolina	6	7	1,933	1,951	1,913	5,949	3.11	1,905	5,904	3.10
Georgia, Florida	5	4	1,019	1,026	1,017	2,834	2.79	1,046	2,918	2.79
Alabama	9	9	2,518	2,503	2,570	7,613	2.96	2,377	6,938	2.92
Louisiana, Mississippi	5	5	501	517	449	1,140	2.54	441	1,142	2.59
Minnesota, South Dakota, Nebraska	4	4	267	256	250	761	3.04	246	829	3.37
Iowa	4	4	643	634	633	1,890	2.99	612	1,853	3.03
Missouri	5	6	353	437	382	1,075	2.81	371	1,172	3.16
Kansas	7	7	352	331	395	1,151	2.91	350	1,000	2.86
Oklahoma, Arkansas	5	5	522	549	546	1,634	2.99	532	1,593	2.99
Texas	13	13	859	867	884	2,872	3.25	888	2,847	3.21
Wyoming, Montana, Idaho	3	3	25	27	24	78	3.25	24	79	3.29
Colorado, Arizona, Utah, New Mexico	6	6	388	401	386	1,242	3.22	407	1,295	3.18
Washington	4	5	51	65	60	187	3.12	65	200	3.08
Oregon, Nevada	---	-----	--------	--------	1	5	5.00	1	7	7.00
Total	134	135	22,864	21,961	22,367	63,407	2.83	21,700	62,168	2.86

Table 6.—Natural, slag, and hydraulic-lime cements produced, shipped, and in stock at mills in the United States

Year	Production		Shipments		Stocks Dec. 31 (thousand 376-pound barrels)
	Active plants	Thousand 376-pound barrels	Thousand 376-pound barrels	Value (thousands)	
1963	4	357	352	$1,407	83
1964	4	275	283	1,057	76
1965	4	279	279	1,027	76
1966	3	113	109	415	19
1967	3	95	94	360	21

[1] Revised data.

Table 7.—Portland-cement-manufacturing capacity of the United States,[1] by districts

District	Capacity Dec. 31 (thousand 376-pound barrels)		Percent utilized	
	1966	1967	1966	1967
New York, Maine	40,485	37,225	75.5	71.7
Eastern Pennsylvania	42,294	37,194	72.8	77.9
Western Pennsylvania	13,540	13,740	84.1	76.1
Maryland, West Virginia	13,850	12,650	75.0	76.5
Ohio	19,449	19,749	81.0	74.8
Michigan	35,162	39,162	82.0	76.2
Indiana, Kentucky, Wisconsin	26,560	24,700	82.1	84.9
Illinois	11,600	11,600	78.5	82.8
Tennessee	10,256	10,156	80.8	78.2
Virginia, North Carolina, South Carolina	16,900	16,900	73.5	74.3
Georgia, Florida	17,381	17,381	68.7	66.8
Alabama	16,660	16,660	87.8	80.7
Louisiana, Mississippi	11,600	11,400	79.7	78.4
Minnesota, South Dakota, Nebraska	9,017	9,117	85.6	71.4
Iowa	15,416	15,462	88.7	88.3
Missouri	18,803	27,210	74.2	54.7
Kansas	12,972	12,822	70.7	70.4
Oklahoma, Arkansas	16,126	15,400	77.6	80.3
Texas	45,074	46,199	69.8	69.9
Wyoming, Montana, Idaho	5,100	5,100	72.4	68.3
Colorado, Arizona, Utah, New Mexico	15,600	16,650	74.7	65.9
Washington	6,975	9,575	89.0	61.5
Oregon, Nevada	4,900	6,400	87.3	53.0
Northern California	21,150	21,700	89.5	82.4
Southern California	37,600	40,600	70.2	59.6
Hawaii	2,700	2,700	63.2	53.5
Puerto Rico	8,001	11,500	100.9	69.2
Total	495,171	508,952	77.7	72.6

[1] Includes Puerto Rico.

Table 8.—Capacity of portland cement plants in the United States,[1] by processes

Process	Capacity, Dec. 31						Percent of capacity utilized			Percent of total finished cement produced		
	Thousand 376-pound barrels			Percent of total								
	1965	1966	1967	1965	1966	1967	1965	1966	1967	1965	1966	1967
Wet	291,276	301,658	313,735	60.4	60.9	61.6	77.0	76.7	71.6	60.4	60.1	60.8
Dry	191,163	193,513	195,217	39.6	39.1	38.4	77.0	79.2	74.1	39.6	39.9	39.2
Total	482,439	495,171	508,952	100.0	100.0	100.0	77.0	77.7	72.6	100.0	100.0	100.0

[1] Includes Puerto Rico.

Table 9.—Portland cement clinker produced and in stock at mills in the United States,[1] by process

Clinker	Number of plants [2]		Thousand 376-pound barrels			
			Production		Stocks on Dec. 31—	
	1966	1967	1966	1967	1966	1967
Wet	114	116	231,375	230,906	9,515	10,899
Dry	70	72	158,227	147,670	10,775	11,916
Total	184	188	389,602	378,576	20,290	22,815

[1] Includes Puerto Rico.
[2] Two plants received clinker from other sources (1966); three plants (1967).

Table 10.—Production and percentage of total output of portland cement in the United States,[1] by raw materials used

(Quantities in thousand 376-pound barrels)

Year	Cement rock and pure limestone		Limestone and clay or shale [2] [3]		Blast-furnace slag and limestone	
	Quantity	Percent	Quantity	Percent	Quantity	Percent
1963	85,741	24.3	251,068	71.2	15,734	4.5
1964	85,884	23.3	260,376	70.6	22,373	6.1
1965	84,360	22.7	266,148	71.7	20,914	5.6
1966	86,095	22.4	277,597	72.2	20,940	5.4
1967	68,810	18.6	281,704	76.3	18,885	5.1

[1] Includes Puerto Rico.
[2] Includes output of plants using marl and clay; 1 plant in 1963; 1 plant using marl only in 1963; 2 plants in 1964, 1965, 1966, and 1967.
[3] Includes output of plants using oystershell and clay; 11 plants in 1963, 1965, 1966, and 1967; 12 plants in 1964.

Table 11.—Raw materials used in producing portland cement in the United States [1]

(Thousand short tons)

Raw materials	1965	1966	1967
Cement rock	19,879	21,072	21,544
Limestone (including oystershell)	81,943	84,068	80,013
Marl	611	762	716
Clay and shale [2]	11,397	11,545	11,574
Blast-furnace slag	935	1,132	1,058
Gypsum	3,274	3,280	3,264
Sand and sandstone (including silica and quartz)	1,834	1,920	1,467
Iron materials [3]	755	714	658
Miscellaneous [4]	125	288	225
Total	120,753	124,781	120,519

[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, diatomite, air-entraining compounds, and grinding aids.

Table 12.—Average mill value in bulk, of cement in the United States [1]

(Per barrel)

Year	Portland cement [2]	Natural slag, and hydraulic-lime cements [2]	Prepared masonry cement [3 4]	All classes of cement [5]
1963	$3.20	$3.99	$2.84	$3.23
1964	3.19	3.73	2.83	3.22
1965	3.15	3.68	2.84	3.18
1966	3.12	3.74	2.83	3.15
1967	3.14	3.87	2.86	3.17

[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.

Table 13.—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			Fuel consumed		
	Plants	Thousand 376-pound barrels	Percent of total	Coal (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1966:						
Wet	114	231,279	60.1	5,350	3,408	141,381,957
Dry	70	153,353	39.9	3,986	503	62,423,036
Total	184	384,632	100.0	[2] 9,336	3,911	203,804,993
1967:						
Wet	117	223,327	60.5	5,258	4,365	138,923,356
Dry	71	146,072	39.5	3,838	591	56,794,140
Total	188	369,399	100.0	[3] 9,096	4,956	195,717,496

[1] Includes Puerto Rico.
[2] Comprises 186,632 tons of anthracite and 9,149,002 tons of bituminous coal.
[3] Comprises 238,809 tons of anthracite and 8,857,445 tons of bituminous coal.

Table 14.—Portland cement produced in the United States,[1] by kinds of fuel

Year and fuel	Finished cement produced			Fuel consumed		
	Plants	Thousand 376-pound barrels	Percent of total	Coal (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1966:						
Coal	59	[2] 128,054	33.3	6,265	-------	-----------
Oil	8	[2] 15,783	4.1	-------	2,722	-----------
Natural gas	43	[2] 78,493	20.4	-------	-------	94,972,992
Coal and oil	19	43,326	11.3	1,721	677	-----------
Coal and natural gas	24	46,486	12.1	1,113	-------	32,244,987
Oil and natural gas	22	54,746	14.2	-------	462	59,505,538
Coal, oil, and natural gas	9	17,744	4.6	237	50	17,081,476
Total	184	384,632	100.0	[3] 9,336	3,911	203,804,993
1967:						
Coal	63	[2] 126,255	34.2	6,168	-------	-----------
Oil	7	[2] 15,531	4.2	-------	3,406	-----------
Natural gas	45	[2] 73,530	19.9	-------	-------	89,704,241
Coal and oil	18	37,428	10.1	1,628	974	-----------
Coal and natural gas	25	47,735	12.9	1,187	-------	33,391,828
Oil and natural gas	22	55,091	15.0	-------	554	57,558,770
Coal, oil, and natural gas	8	13,829	3.7	113	32	15,062,657
Total	188	369,399	100.0	[4] 9,096	4,956	195,717,496

[1] Includes Puerto Rico.
[2] Average consumption of fuel per barrel of cement produced as follows: 1966—coal, 97.8 pounds; oil, 0.1725 barrel; natural gas, 1,210 cubic feet; 1967—coal, 97.7 pounds; oil, 0.2193 barrel; natural gas, 1,220 cubic feet.
[3] Comprises 186,632 tons of anthracite and 9,149,002 tons of bituminous coal.
[4] Comprises 238,809 tons of anthracite and 8,857,441 tons of bituminous coal.

Table 15.—Electric energy used at portland cement plants in the United States,[1] by processes

Year and process	Electric energy used: Generated at portland cement plants		Purchased		Total		Finished cement produced (thousand 376-pound barrels)	Average electric energy used per barrel of cement produced (kilowatt-hours)
	Active plants	Million kilowatt-hours	Active plants	Million kilowatt-hours	Million kilowatt-hours	Percent		
1966:								
Wet	15	687	111	4,974	5,661	58.8	231,279	24.5
Dry	19	951	70	3,014	3,966	41.2	153,353	25.9
Total	34	1,638	181	7,988	9,627	100.0	384,632	25.0
Percent of total electric energy used	---	17.0	-----	83.0	100.0	-------	---------	------
1967:								
Wet	15	344	113	5,038	5,382	58.8	224,752	23.9
Dry	16	872	72	2,902	3,774	41.2	144,647	26.1
Total	31	1,216	185	7,940	9,156	100.0	369,399	24.8
Percent of total electric energy used	---	13.3	-----	86.7	100.0	-------	---------	------

[1] Includes Puerto Rico.

Table 16.—Shipments of portland cement from mills in the United States,[1] in bulk and in containers by types of carriers

Year and type of carrier	In bulk: Thousand 376-pound barrels	In bulk: Percent	In paper bags [2]: Thousand 376-pound barrels	In paper bags [2]: Percent	Total shipments: Thousand 376-pound barrels	Total shipments: Percent
1966:						
Truck	232,159	68.5	33,008	79.0	265,167	69.7
Railroad	100,508	29.7	8,292	19.8	108,800	28.6
Boat	6,033	1.8	515	1.2	6,548	1.7
Used at the plant	173	-------	6	-------	179	-------
Total	338,873	100.0	41,821	100.0	380,694	100.0
Percent of total	89.0	-------	11.0	-------	100.0	-------
1967:						
Truck	233,651	69.3	29,092	78.8	262,743	70.3
Railroad	96,350	28.6	7,264	19.7	103,614	27.7
Boat	7,012	2.1	572	1.5	7,584	2.0
Used at the plant	71	-------	5	-------	76	-------
Total	337,084	100.0	36,933	100.0	374,017	100.0
Percent of total	90.1	-------	9.9	-------	100.0	-------

[1] Includes Puerto Rico.
[2] Cloth bags and other containers included with paper bags to avoid disclosing individual company confidential data.

Table 17.—Destination of shipments of all types of finished portland and high-early-strength cement from mills in the United States, by States

(Thousand 376-pound barrels)

Destination	Finished portland		High-early-strength	
	1966	1967	1966	1967
Alabama	5,640	5,631	78	81
Alaska [1]	W	W	W	W
Arizona	3,630	3,579	W	W
Arkansas	4,903	4,436	42	31
Northern California	17,912	16,490	46	23
Southern California	24,414	21,700	194	146
Colorado	4,837	4,591	24	37
Connecticut [1]	4,322	3,701	372	299
Delaware [1]	1,136	1,126	31	59
District of Columbia [1]	1,559	1,295	31	27
Florida	[2] 13,705	14,524	869	887
Georgia	9,226	9,354	142	202
Hawaii	1,546	1,341	--------	--------
Idaho	1,354	1,130	41	55
Illinois	18,333	19,060	580	578
Indiana	9,812	10,699	383	381
Iowa	8,779	9,035	111	84
Kansas	5,129	4,755	84	72
Kentucky	4,969	5,983	137	126
Louisiana	11,619	11,773	54	42
Maine	997	987	42	46
Maryland	6,885	6,722	377	336
Massachusetts [1]	5,986	6,063	502	459
Michigan	16,900	16,386	879	858
Minnesota	8,174	8,366	257	241
Mississippi	4,708	4,224	17	14
Missouri	9,230	9,355	276	200
Montana	1,412	1,092	7	13
Nebraska	4,959	4,396	154	153
Nevada	1,456	1,164	8	7
New Hampshire [1]	1,011	916	73	59
New Jersey [1]	9,828	9,855	514	497
New Mexico	2,726	2,351	189	121
New York	17,822	17,544	994	961
North Carolina [1]	7,126	7,477	251	276
North Dakota [1]	1,384	934	28	29
Ohio	19,125	18,484	532	400
Oklahoma	5,366	5,258	24	38
Oregon	4,280	3,415	117	104
Eastern Pennsylvania	10,260	10,707	517	478
Western Pennsylvania	6,521	6,819	272	218
Rhode Island [1]	1,169	1,221	103	113
South Carolina	3,801	3,932	54	112
South Dakota	1,667	1,199	47	54
Tennessee	6,931	6,770	145	196
Texas	26,995	26,955	1,642	1,504
Utah	2,268	1,891	66	45
Vermont [1]	597	641	42	48
Virginia	8,558	8,314	539	346
Washington	7,926	7,368	640	631
West Virginia	2,739	2,305	40	33
Wisconsin	9,410	10,000	333	366
Wyoming	979	985	5	10
Total United States	372,021	364,299	12,905	12,096
Other countries	[3] 8,673	[3] 9,718	[4] 50	[4] 92
Total shipped from cement plants	380,694	374,017	12,955	12,188

W Withheld to avoid disclosing individual company confidential data; included with "Other countries."
[1] Noncement producer.
[2] Includes shipments from Puerto Rican mills.
[3] Direct shipments by producers to foreign countries, the State of Alaska, and to Puerto Rico, including distribution from Puerto Rican mills.
[4] Direct shipments by producers to other countries and the States of Alaska and Arizona.

Table 18.—Cement shipments by types of customers in 1967

(Quantities in thousand 376-pound barrels)

District	Number of plants in district	Building material dealers		Concrete product manufacturers		Ready-mixed concrete		Highway contractors		Other contractors		Federal State, and other Government agencies		Miscellaneous including own use		Total
		Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	
New York, Maine	13	7.4	2,140	10.8	3,104	59.8	17,239	4.7	1,352	3.5	994	0.1	27	13.7	3,960	28,816
Eastern Pennsylvania	17	10.6	3,128	22.2	6,580	57.1	16,892	7.3	2,164	.5	135	.2	71	2.1	626	29,596
Western Pennsylvania	5	8.0	850	13.7	1,449	60.2	6,377	13.3	1,413	3.1	327	----	------	1.7	185	10,601
Maryland, West Virginia	4	5.0	505	21.4	2,172	62.9	6,395	9.3	939	.7	71	.1	15	.6	63	10,160
Ohio	9	5.4	790	16.3	2,405	63.4	9,334	13.3	1,962	.5	67	----	------	1.1	168	14,726
Michigan	9	8.1	2,390	14.2	4,226	61.0	18,070	13.3	3,944	3.0	897	----	------	.4	118	29,645
Indiana, Kentucky, Wisconsin	8	5.4	1,141	13.3	2,808	64.4	13,559	12.5	2,635	2.0	415	.6	119	1.8	384	21,061
Illinois	4	4.9	444	9.0	819	74.1	6,717	10.5	951	1.5	135	----	2	----	1	9,069
Tennessee	6	6.5	528	20.0	1,610	62.8	5,065	6.4	517	3.3	264	.1	9	.9	69	8,062
Virginia, North Carolina, South Carolina	6	7.8	1,000	16.2	2,080	57.2	7,346	13.7	1,762	2.5	315	1.5	194	1.1	138	12,835
Georgia, Florida	6	15.2	1,760	17.2	1,989	51.5	5,976	8.7	1,011	5.4	629	.8	94	1.2	134	11,593
Alabama	8	5.7	879	15.5	2,380	56.2	8,631	18.7	2,875	2.5	380	1.1	177	.3	42	15,364
Louisiana, Mississippi	6	4.9	453	11.9	1,087	52.6	4,817	11.3	1,036	15.3	1,399	.1	5	3.9	361	9,158
Minnesota, South Dakota, Nebraska	4	10.0	655	9.2	604	51.5	3,364	25.8	1,688	2.3	151	.2	10	1.0	63	6,535
Iowa	5	6.4	880	15.7	2,147	62.2	8,532	11.6	1,593	3.9	533	.1	20	.1	7	13,712
Missouri	8	3.9	592	8.1	1,211	68.9	10,358	13.3	2,004	4.4	659	.2	35	1.2	185	15,044
Kansas	6	6.8	601	10.5	927	56.1	4,953	13.0	1,153	5.4	477	.2	17	8.0	705	8,833
Oklahoma, Arkansas	5	9.4	1,133	6.3	752	56.3	6,765	18.5	2,224	8.2	988	.1	5	1.2	147	12,014
Texas	19	6.6	2,105	8.6	2,741	52.7	16,836	9.6	3,084	6.9	2,203	1.6	512	14.0	4,463	31,944
Wyoming, Montana, Idaho	4	7.3	247	9.0	301	52.9	1,777	6.2	208	19.0	636	.1	3	5.5	184	3,356
Colorado, Arizona, Utah, New Mexico	7	7.9	855	9.6	1,050	64.0	6,972	9.3	1,007	5.9	639	.6	65	2.7	297	10,885
Washington	7	4.6	257	10.8	604	70.1	3,937	8.9	498	4.3	244	.6	35	.7	39	5,614
Oregon, Nevada	4	4.8	169	8.7	307	72.5	2,550	3.6	128	10.2	357	.1	2	.1	5	3,518
Northern California	6	6.7	1,188	9.0	1,601	66.6	11,877	5.6	990	11.2	1,994	.2	47	.7	125	17,822
Southern California	8	8.5	2,063	12.3	2,982	61.4	14,857	7.2	1,738	7.9	1,912	1.8	446	.9	214	24,212
Hawaii	2	8.3	116	9.2	128	73.4	1,024	1.4	20	4.2	59	3.4	47	.1	1	1,395
Puerto Rico	2	55.1	4,655	4.9	417	28.8	2,430	.5	41	.3	23	----	4	10.4	877	8,447
Total	188	8.4	31,524	13.0	48,481	59.5	222,650	10.4	38,937	4.5	16,903	.6	1,961	3.6	13,561	374,017

Table 19.—U.S. exports of hydraulic cement by countries

(Thousand 376-pound barrels and thousand dollars)

Destination	1965		1966		1967	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	4	$40	7	$30	9	$73
Bahamas	41	200	33	166	45	233
Bolivia	2	15	4	39	4	34
Canada	281	1,916	495	2,130	349	1,426
Chile	3	57	7	53	2	28
Dominican Republic	1	10	1	9	6	25
France	1	9	5	20	5	21
French West Indies	76	155	160	347	210	509
Germany, West	2	44	3	28	1	31
Indonesia	2	17	(1)	4	6	60
Iran	5	47	14	108	5	40
Italy	3	26	2	24	3	23
Jamaica	2	10	3	41	5	28
Japan	12	126	6	127	8	155
Leeward and Windward Islands	35	103	64	180	104	273
Liberia	103	403	34	128	5	22
Mexico	95	436	120	504	37	260
Netherlands	2	22	4	18	1	8
Netherlands Antilles	(1)	2	4	9	29	75
Nicaragua	7	33	3	14	3	17
Nigeria	1	11	6	25	67	463
Norway	2	21	3	13	4	16
Pakistan	4	14	1	6	1	5
Panama	2	21	2	27	3	20
Peru	9	93	10	70	15	103
Philippines	5	54	8	88	8	52
Spain	2	29	8	114	7	49
Sweden	2	24	3	14	1	16
Taiwan	2	22	3	38	2	26
Trinidad and Tobago	(1)	7	1	3	4	83
United Kingdom	1	17	3	19	2	8
Venezuela	2	20	3	21	2	13
Viet-Nam, South	2	14	3	17	2	10
Western Africa, n.e.c	-----	-------	9	39	3	28
Other	37	270	37	363	22	219
Total	748	4,288	1,069	4,836	980	4,452

[1] Less than ½ unit.

Table 20.—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
1965	4,838	$11,307	378	$962	289	$1,254	5,505	$13,523
1966	6,211	15,003	648	1,847	207	996	7,066	17,846
1967	5,569	13,002	157	813	187	883	5,913	14,698

Table 21.—U.S. imports for consumption of hydraulic cement in 1967, by countries and customs districts

(Thousand 376-pound barrels and thousand dollars)

	Quantity	Value
Country:		
Bahamas	2,459	$5,951
Belgium-Luxembourg	93	419
Canada	1,699	4,126
Colombia	457	998
Denmark	74	293
France	44	300
Germany, West	14	131
Japan	53	219
Mexico	6	31
Norway	878	1,586
Sweden	37	62
United Kingdom	57	406
Venezuela	26	58
Yugoslavia	16	118
Total	5,913	14,698
Customs district:		
Boston	(1)	(1)
Bridgeport	377	625
Buffalo	1,395	3,008
Chicago	92	603
Duluth	(1)	(1)
Great Falls	21	78
Honolulu	3	22
Customs district—Continued:		
Houston	1	$6
Juneau	28	163
Laredo	6	31
Los Angeles	11	50
Miami	913	2,202
Milwaukee	(1)	(1)
New Orleans	3	13
New York City	540	1,205
Norfolk	499	1,210
Ogdensburg	31	117
Pembina	130	505
Philadelphia	30	258
Portland, Maine	6	26
Portland, Oregon	2	13
St. Albans	5	19
San Francisco	(1)	3
San Juan	605	1,484
Savannah	6	40
Seattle	83	227
Tampa	1,126	2,790
Total	5,913	14,698

1 Less than ½ unit.

Table 22.—World production of hydraulic cement, by countries [1]

(Thousand 376-pound barrels)

Country	1963	1964	1965	1966	1967 p
North America:					
Canada (sold or used by producers)	37,314	42,075	44,432	r 47,827	41,981
Costa Rica	-------	193	698	674	651
Cuba e	4,761	4,726	4,697	4,691	5,254
Dominican Republic	1,343	1,747	1,243	1,618	1,818
El Salvador [2]	457	528	475	r 833	838
Guatemala	921	1,091	r 1,378	1,184	1,313
Haiti	293	328	246	223	235
Honduras	352	428	551	616	651
Jamaica	r 1,161	r 1,624	r 1,823	r 2,052	1,964
Mexico	22,058	r 25,904	r 25,236	r 28,771	e 36,693
Nicaragua	317	358	387	r 493	563
Panama	833	733	973	879	880
Trinidad	950	1,032	r 1,114	1,243	1,114
United States (including Puerto Rico)	368,406	385,386	388,847	r 401,771	385,848
South America:					
Argentina	14,863	16,951	19,378	20,475	20,827
Bolivia	r 364	375	352	352	364
Brazil	30,395	r 32,975	32,700	35,450	37,554
Chile	6,837	7,429	6,966	7,998	7,054
Colombia	10,759	11,562	12,210	13,063	12,407
Ecuador	1,513	1,689	1,906	2,568	e 2,520
Paraguay	106	135	170	152	82
Peru	4,421	4,767	r 5,963	r 6,268	6,110
Uruguay	1,994	2,415	2,527	2,803	2,468
Venezuela	9,264	10,847	12,383	12,395	13,181
Europe:					
Albania	762	745	879	e 792	e 760
Austria	19,419	22,099	23,711	26,391	26,666
Belgium	27,610	34,277	34,623	33,984	34,124
Bulgaria	12,929	15,434	15,720	16,746	19,689
Czechoslovakia	30,360	32,207	33,497	r 35,942	e 36,400
Denmark	8,918	11,129	r 11,700	r 12,300	12,900
Finland	8,373	9,217	r 10,378	9,129	8,877
France	106,325	126,278	131,133	r 136,638	144,237
Germany:					
East	32,002	33,814	35,690	r 37,818	42,146
West	171,308	197,195	200,132	203,685	184,737
Greece	13,450	15,667	18,833	21,038	20,228
Hungary	10,542	13,233	13,972	15,250	15,573
Iceland	575	633	668	674	680
Ireland	4,697	5,705	6,168	r 6,526	7,611
Italy	129,509	133,918	121,341	131,185	154,041
Luxembourg	1,190	1,202	1,302	1,243	1,073
Netherlands	12,202	16,845	17,432	18,546	19,636
Norway	8,431	9,035	9,399	r 10,712	12,114
Poland	44,995	51,368	56,129	58,873	65,305
Portugal	8,402	9,510	9,850	r 10,085	10,765
Rumania	25,617	27,862	31,697	34,511	37,162
Spain (includes Canary Islands)	45,429	49,838	r 54,054	69,228	76,803
Sweden	19,343	21,260	r 22,134	21,641	22,498
Switzerland	20,996	25,341	23,682	25,365	24,485
U.S.S.R	357,767	380,728	424,433	469,017	497,208
United Kingdom	82,438	99,477	r 100,796	r 98,210	103,059
Yugoslavia	16,693	17,819	18,188	18,950	19,425
Africa:					
Algeria	5,183	4,603	4,333	3,864	3,928
Angola	1,137	1,255	1,437	1,548	1,636
Cape Verde Islands	64	70	e 70	(r)	NA
Congo, (Kinshasa)	1,442	1,319	1,454	e 1,548	e 1,524
Ethiopia	199	258	563	e 586	880
Ivory Coast	-------	-------	-------	627	1,501
Kenya	2,017	2,474	2,838	2,838	2,809
Malagasy Republic	240	258	229	270	352
Malawi	147	182	182	258	e 258
Morocco	4,450	5,435	4,632	5,025	5,095
Mozambique	979	1,067	1,290	r 1,319	1,431
Niger	NA	NA	NA	88	129
Nigeria	3,084	3,887	5,764	5,875	4,597
Rhodesia, Southern e	1,466	1,466	1,466	1,466	e 1,466
Senegal	1,114	1,202	1,061	1,137	1,026
South Africa, Republic of	16,910	20,258	22,761	23,359	22,339
Sudan	680	534	469	586	528
Tanzania	-------	-------	-------	r 281	874
Tunisia	2,117	2,668	2,662	2,803	2,767
Uganda	322	428	768	709	815
United Arab Republic	14,711	14,781	14,201	r 15,415	16,042
Zambia	680	885	1,296	e 1,290	1,431

Table 22.—World production of hydraulic cement, by countries [1]—Continued

(Thousand 376-pound barrels)

Country	1963	1964	1965	1966	1967 p
Asia:					
Afghanistan [3]	604	733	997	1,026	1,026
Burma	727	768	r 792	827	762
Cambodia	---------	59	293	346	e 352
Ceylon	440	440	504	487	1,126
China, mainland e	58,633	61,565	64,496	64,496	46,900
Cyprus	563	410	575	580	1,096
Hong Kong	1,272	1,261	1,413	1,448	1,261
India	54,851	56,815	62,022	64,801	68,600
Indonesia	1,935	2,574	e 2,140	r 1,982	1,760
Iran e 3	4,368	4,368	4,601	8,171	8,174
Iraq	5,517	6,403	7,534	7,869	e 9,381
Israel	5,992	6,438	7,388	6,848	4,720
Japan	175,594	193,377	191,665	224,359	252,081
Jordan	1,671	1,806	1,788	2,199	1,760
Korea:					
North	14,834	15,303	14,072	14,658	e 15,200
South	4,562	7,282	9,463	11,023	14,306
Lebanon	5,254	5,166	5,687	6,426	5,957
Malaysia	2,123	2,732	4,333	e 4,984	e 4,896
Pakistan	8,783	9,065	10,009	11,058	11,961
Philippines	5,576	7,042	8,965	r 9,458	12,383
Ryukyu Islands	---------	-----------	598	751	879
Saudi Arabia	1,149	1,519	1,483	1,466	2,076
Singapore	1,137	e 1,173	1,190	2,275	2,762
Syrian Arab Republic	4,016	3,723	3,952	3,618	4,034
Taiwan	13,169	13,808	14,330	18,247	20,445
Thailand	5,840	6,215	7,323	8,695	10,185
Turkey	15,819	17,238	19,513	22,662	24,913
Viet-Nam:					
North	2,879	3,805	4,397	e 4,397	e 4,398
South	---------	440	1,143	792	e 1,032
Oceania:					
Australia	18,288	21,260	22,292	21,542	22,380
Fiji Islands	NA	182	235	240	276
New Zealand	4,233	4,620	4,937	5,148	4,773
Total [4]	r 2,216,735	r 2,437,754	r 2,541,802	r 2,722,561	2,813,855

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Compiled mostly from data available May 1968.
[2] Sales.
[3] Year ended March 20 of year following that stated.
[4] Total is of listed figures only, no undisclosed data included.

Chromium

By John L. Morning[1]

The year was marked by the United States implementing the United Nations Security Council's resolution imposing mandatory sanctions against Southern Rhodesia prohibiting importation of chromite. Owing to uncertainty of supply of metallurgical-grade chromite, the domestic chromium industry turned to government stockpile offerings late in 1966 and 1967 and contracted for 666,000 tons for future delivery.

Chromium alloy production returned to normal in the first quarter with the settlement of labor problems of the major producer. Despite reduced demand for chromium alloys, domestic production continued at a high level allowing producer's stock to increase.

Table 1.—Salient chromite statistics

(Thousand short tons)

	1963	1964	1965	1966	1967
United States:					
Exports	10	6	7	19	8
Reexports	64	32	95	173	157
Imports for consumption	1,391	1,428	1,518	1,864	1,240
Consumption	1,187	1,451	1,584	1,461	1,355
Stocks Dec. 31: Consumer	1,583	1,287	1,111	1,306	1,197
World: Production	4,314	4,632	5,348	4,974	5,111

Legislation and Government Programs.—Barter contracts for high-and low-carbon ferrochromium, negotiated in fiscal year 1964, were extended to 1968 for completion. Contracts called for delivery of ferrochromium produced from Turkish ore to the Government stockpile with payment for the chromite made in surplus wheat delivered to a third country. Of the 15,000 tons of ferrochromium on order, 3,500 tons were delivered in 1966 and 10,500 tons in 1967.

Early in 1966, General Services Administration (GSA) sold by competitive bid 84,287 tons of surplus metallurgical-grade chromite held in the Defense Production Act (DPA) inventory.

On May 11, 1966, the President signed a bill (Public Law 89–415) authorizing a long-range disposal plan for 1.9 million tons of metallurgical-grade chromite from the national and supplemental stockpiles that were excess to stockpile needs. This surplus was grouped together with the DPA surplus for disposal at the rate of 200,000 tons per year.

Actual delivery of metallurgical-grade chromite to industry under these programs was 66,237 tons in 1966 and 62,890 tons in 1967.

Under Public Law 89–247, a long-range plan authorized GSA to dispose of 659,100 tons of chemical-grade chromite. No interest was shown by industry in this material, either in 1966 or 1967.

Implementing the United Nations Security Council's resolution of December 16, 1966, which imposed mandatory sanctions against Southern Rhodesia, the President signed Executive Order No. 11322 on January 5, 1967, prohibiting importation of chromite along with 11 other commodities.

[1] Commodity specialist, Division of Mineral Studies.

Table 2.—U.S. defense materials inventories and objectives

(Thousand short tons)

Type of material	Objective	Inventory by program, Dec. 31, 1967			
		National stockpile	Defense Production Administration	Commodity Credit Corporation and supplemental stockpile	Total
Chromite, chemical: Stockpile grade	591	559	----	484	1,043
Chromite, refractory:					
Stockpile grade	1,425	1,047	----	380	1,427
Nonstockpile grade	------	(1)	----	----	(1)
Chromite, metallurgical:					
Stockpile grade	2,509	2,216	(1)	373	2,589
Nonstockpile grade	------	767	906	----	1,673
Ferrochromium, high-carbon					
Stockpile grade	65	125	----	274	399
Nonstockpile grade	------	(1)	----	----	(1)
Ferrochromium, low-carbon:					
Stockpile grade	80	108	----	191	299
Nonstockpile grade	------	20	----	----	20
Ferrochromium-silicon:					
Stockpile grade	58	25	----	31	56
Nonstockpile grade	------	(1)	----	2	3
Chromium metal, electrolytic: Stockpile grade	3	1	----	3	4
Chromium metal, aluminothermic: Stockpile grade	3	------	----	4	4

[1] Less than ½ unit.

DOMESTIC PRODUCTION

Although the United States does not produce chromite ore, about 25 percent of the world's supply was consumed in producing chromium alloys, chromium-bearing refractories, and chromium chemicals.

The principal producers of chromium products were as follows:

Company	*Plant*
Metallurgical industry:	
Airco Alloys Division, Air Reduction Co. Inc. (Formerly Pittsburgh Metallurgical Corp.).	Calvert City, Ky. Niagara Falls, N.Y. Charleston, S.C.
Chromium Mining and Smelting Corp	Woodstock, Tenn.
Foote Mineral Co. (Formerly Vandium Corporation of America).	Vancoram, Ohio Graham, W. Va.
Interlake Steel Corp.	Beverly, Ohio.
Ohio Ferro-Alloys Corp	Brilliant, Ohio. Takoma, 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	Buckhannon, W. Va. Louisville, Ky.
E. J. Lavino & Co	Newark, Calif. Plymouth Meeting, Pa.
General Refractories Co	Baltimore, Md. Gary, Ind. Lehi, Utah.

Company	*Plant*
H. K. Porter Co., Inc	Pascagoula, Miss.
Harbison-Walker Refractories Co. (Division of Dresser Industries, Inc.).	Baltimore, Md.
	Warm Springs, Calif.
	Hammond, Ind.
Kaiser Aluminum & Chemical Corp	Moss Landing, Calif.
	Columbiana, Ohio.
North American Refractories Co	Womelsdorf, Pa.
Ohio Fire Brick Co	Jackson, Ohio.
Chemical industry:	
Diamond Shamrock Corp	Kearny, N.Y.
	Painsville, Ohio.
Imperial Color & Chemical Department, Hercules Powder Co. Inc.	Glenns Falls, N.Y.
Allied Chemical Corp	Baltimore, Md.
Pittsburgh Plate Glass Co	Corpus Christi, Tex.

Domestic chromium alloy production returned to normal in the first quarter with the termination of labor problems at various ferrochromium producing plants of Union Carbide Corp. Work stoppages of 5 to 7½ months in 1966 and early 1967 reduced output of alloy production, although supervisory personnel continued to keep the plants operating.

Domestic chromium alloy production capacity was increased with the startup of a 25,000-kilowatt furnace by Union Carbide Corp. at its Alloy, W. Va., plant. The new furnace was of the rotating hearth type with an estimated annual capacity of 26,400 tons depending on type of alloy produced.

Airco Alloys Division, Air Reduction Co. Inc., planned to install a new furnace at its Charleston, S. C. plant. The furnace was scheduled for completion in 1968.

CONSUMPTION AND USES

More than 60 percent of the chromite consumption was in the metallurgical industry with the balance consumed in the refractory and chemical industries. The major metallurgical use of chromite was in conversion of ore to various types of chromium alloys, which in turn were used in the manufacture of stainless steel, other chromium-bearing steels, and chromium bearing alloys.

High alumina and Transvaal chromite ores were used in manufacturing basic refractories used in open-hearth steel furnaces, copper furnaces, glass-making furnaces, and other applications where a chemically neutral refractory was required.

High-iron friable chromite ore was used in the chemical industry for producing chromates and bichromates for direct use or for production of other chromium chemicals.

The metallurgical industry consumed 853,000 tons of chromite containing 290,000 tons of chromium in producing 426,000 tons of chromium ferroalloys and metal. An additional 13,000 tons of chromite containing 6,000 tons of chromium was added directly to steel. Of the total consumed in making chromium ferroalloys and metal, 818,000 tons (averaging 50.3 percent Cr_2O_3) was classified by consumers as metallurgical-grade ore; 5,000 tons (averaging 44.4 percent Cr_2O_3) as chemical-grade ore; and 30,000 tons (averaging 34.6 percent Cr_2O_3) as refractory-grade ore. Of the metallurgical-grade ore, 77 percent had a chromium-to-iron ratio of 3:1 and above; 14 percent between 3:1 and 2:1; and 9 percent less than 2:1.

Producers of chromite-bearing refractories consumed 308,000 tons of ore containing 72,000 tons of chromium. An additional 2,000 tons was used directly in furnace repairs.

Stainless and alloy steel accounted for 87 percent of chromium alloy end use consumption. Reduced output of these steels in 1967, reflected the decrease in consumption of chromium alloy products.

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)
1963	632	48.7	368	34.6	187	45.1	1,187	43.8
1964	832	49.0	430	33.8	189	45.1	1,451	44.0
1965	907	49.8	460	34.7	217	45.0	1,584	44.8
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

Table 4.—Production, shipments, and stocks of chromium ferroalloys and chromium metal in 1967

(Short tons)

Alloy	Production		Shipments	Producer stocks, Dec. 31
	Gross weight	Chromium content		
Low-carbon ferrochromium	112,699	79,572	110,118	15,445
High-carbon ferrochromium	201,094	135,683	195,533	22,290
Ferrochromium silicon	92,916	39,138	90,527	11,429
Other [1]	19,124	14,590	18,051	2,936
Total	425,833	268,983	414,229	52,100

[1] Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

Table 5.—Consumption of chromium ferroalloys and chromium metal in the United States, in 1967 by major end uses

(Short tons)

Use	Low carbon ferro-chromium	High carbon ferro-chromium	Ferro-chromium silicon	Ex-othermic ferro-chromium silicon	Chromium briquets	Other [1]	Total
Stainless steels	109,657	72,438	63,028	25	2,060	122	247,330
High-speed steels	766	1,617	51	4	-------	9	2,447
Other tool steels	1,052	1,591	620	-------	-------	13	3,276
Other alloy steels [2]	14,098	40,155	5,926	4,907	602	7,299	72,987
Gray and malleable castings	628	3,883	21	4	207	731	5,474
High-temperature alloys	8,669	1,012	509	-------	778	2,376	13,344
Nickel-base alloys	509	30	-------	-------	2	74	615
Miscellaneous [3]	6,213	11,030	1,230	834	72	2,817	22,196
Total	141,592	131,756	71,385	5,774	3,721	13,441	367,669

[1] Includes exothermic high- and low-carbon ferrochromium, chromium metal, and other chromium alloys.
[2] Includes carbon steel, and steel mill and other metal working rolls.
[3] Includes cutting and wear resistance materials, welding rods, alloy hard facing rods and materials, permanent magnet alloys, aluminum- and copper-base alloys, metal to glass seal materials, electrical resistance alloys, friction material, ceramic pigments, catalysts, and unspecified.

STOCKS

Industrial inventory of chromite decreased during the year, but the inventory remained at an adequate level. Stocks in the metallurgical industry decreased 4,000 tons as government stockpile releases offset reduced imports for consumption. Stocks at yearend, represented a 6-month supply. Stocks in the refractory industry were drawn down by 92,000 tons. This continued the trend of inventory reduction from the record level of 1962. At yearend, stocks represented a 19-month supply. Stocks in the chemical industry decreased 13,000 tons and at yearend represented a 17-month supply.

Producer's chromium alloy inventory increased 29 percent as the rate of demand slackened, owing to the slowdown in steel output.

Stocks of chromium chemicals at producer plants decreased from 13,060 tons in 1966 to 9,115 tons in 1967.

Table 6.—Consumers' stock of chromite, December 31

(Thousand short tons)

Industry	1963	1964	1965	1966	1967
Metallurgical	686	509	443	r 463	459
Refractory	723	600	526	578	486
Chemical	174	178	142	265	252
Total	1,583	1,287	1,111	r 1,306	1,197

r Revised.

Table 7.—Consumers' stocks of chromium ferroalloys and chromium metal, December 31

(Short tons)

	1963	1964	1965	1966	1967
Low-carbon ferrochromium	7,293	12,219	13,630	16,585	15,919
High-carbon ferrochromium	6,049	13,862	14,707	12,606	11,417
Ferrochromium silicon	2,558	6,455	4,673	4,838	6,610
Exothermic ferrochromium silicon	610	775	987	885	604
Chromium briquets	276	328	378	347	505
Other (including chromium metal, exothermic high- and low-carbon ferrochromium, and other chromium alloys	1,477	1,675	1,779	2,114	2,099
Total	18,263	35,314	36,154	37,375	37,154

PRICES

Quoted chromite ore prices remained unchanged during the first 6 months of 1967, after which the price of Turkish metallurgical-grade ore increased in July and again in August. The combined increase totaled $2 per long-ton. Also in August, the quoted price for high-quality Russian chromite was increased $6 to $7 per long-ton for 1968 contract delivery. Price of Transvaal chromite remained essentially unchanged during the year. Term contracts for chromite are subject to negotiation and price was said to be lower than that quoted.

Early in January, chromium alloy producers selectively increased the price of some chromium alloy products. Base price prevailing during the year for lump material in carload lots, f.o.b. shipping point with freight equalized to nearest main producer, per pound contained chromium was as follows: High-carbon ferrochromium (67 to 71 percent chromium, all grades carbon) 19 cents nominal; low-carbon ferrochromium (67 to 73 percent chromium, 0.05 percent carbon) 24.5 cents; charge chromium (63 to 71 percent chromium, 4.5 to 6.0 percent carbon, 3 percent maximum silicon) 15.3 cents; and blocking chromium (10 to 14 percent silicon) 17.9 cents.

Table 8.—Price quotations for various grades of foreign chromite in 1967

Source	Cr_2O_3 (percent)	Cr/Fe ratio	Price per long ton [1] Jan. 1	Price per long ton [1] Dec. 31
South Africa, Republic of (Transvaal)	44	----	$18.00–$21.50	$19.00–$21.50
Southern Rhodesia	48–50	3:1	31.00– 35.00	31.00– 35.00
Turkey	48	3:1	32.50– 33.50	34.50– 35.50
U.S.S.R	54–56	4:1	30.50– 33.00	36.50– 40.00

[1] Dry basis, subject to penalties if guarantees are not met, f.o.b. cars Atlantic ports, price nominal.
Source: Metals Week.

Electrolytic chromium metal (98.5 percent chromium) was priced at 95 cents per pound throughout the year.

The first movement in price since 1956 of sodium bichromate, base product of the chromium chemical industry, occurred in March 1966 when the price was increased from 13 cents to 14 cents per pound in carload lots. In October 1967 the quoted price was lowered to 13 cents per pound.

FOREIGN TRADE

Combined exports and reexports of chromite were the second highest on record, exceeded only by those of 1966. Canada and Mexico received the major quantity of the shipments.

In 1967, ferrochromium was exported to 13 countries and totaled 13,453 tons valued at $3,479,000 compared with 7,617 tons valued at $1,870,341 exported in 1966. Reexports of ferrochromium totaled 6,893 tons valued at $1,180,652. Canada, West Germany, and the United Kingdom received the majority of the exports while Canada was the main recipient of the reexports. Chromium and chromium alloys, wrought or unwrought, and waste and scrap exported in 1967 totaled 92 tons valued at $201,343 compared with 130 tons valued at $173,000 exported in 1966. Of the 19 countries receiving shipments in 1966, Brazil received 48 percent of the total. Canada, France, and Italy were the main recipients in 1967.

Exports of pigment-grade chromium chemicals decreased from 83 tons valued at $100,000 in 1966 to 37 tons valued at $56,000 in 1967. Exports of nonpigment-grade chromium chemicals decreased from 788 tons valued at $482,000 in 1966 to 706 tons valued at $392,000 in 1967. In both years, Canada, Mexico, and South American countries were the main recipients of the exported chromium chemicals.

Sodium bichromate and chromate exports increased to 3,309 tons valued at $684,000 in 1967 from 2,619 tons valued at $569,000 in 1966. Canada and Colombia were the main recipients of the 24 countries receiving shipments.

Table 9.—U.S. exports and reexports of chromite ore and concentrates

(Thousand short tons and thousand dollars)

Year	Exports		Reexports	
	Quantity	Value	Quantity	Value
1965	7	$285	95	$3,719
1966	19	740	173	7,119
1967	8	328	157	5,422

Imports of chromite ore and concentrate in 1967 decreased sharply compared with those of 1966. Metallurgical-grade ore (over 46 percent Cr_2O_3) comprised 44 percent of total imports, chemical-grade ore, (40–46 percent Cr_2O_3) comprised 39 percent, and refractory-grade ore (under 40 percent Cr_2O_3) 17 percent.

Both high-carbon and low-carbon ferrochromium imports dropped sharply compared with those of 1966, reflecting the settlement of the labor problems and the return to normal production levels of the major chromium alloy producer.

Table 10.—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 weght	Chromium content	
1966:						
Canada	1,680	974	$380	--------	--------	--------
France	2,595	1,904	552	28	19	$6
Germany, West	3,580	2,644	1,023	291	202	55
Italy	5	3	1	1,102	728	178
Japan	8,176	5,444	2,074	9,100	6,005	1,342
Norway	5,184	3,564	1,365	757	537	136
Rhodesia, Southern	5,223	3,777	1,340	--------	--------	--------
South Africa, Republic of	39,274	26,024	9,726	10,588	6,944	1,328
Sweden	4,281	3,156	1,269	--------	--------	--------
Turkey	3,922	2,760	952	--------	--------	--------
United Kingdom	------	--------	--------	2,017	1,415	291
Yugoslavia	57	55	24	--------	--------	--------
Zambia	134	94	34	--------	--------	--------
Total	74,111	50,399	18,740	23,883	15,850	3,336
1967:						
Belgium-Luxembourg	------	--------	--------	551	382	92
France	2,261	1,625	605	28	19	5
Germany, West	4,902	3,662	1,413	1,499	1,043	271
Italy	------	--------	--------	1,102	716	185
Japan	1,516	1,025	395	1,926	1,411	319
Norway	6,417	4,483	1,706	842	595	155
South Africa, Republic of	22,416	13,731	5,168	2,565	1,480	323
Sweden	7,347	5,410	2,098	--------	--------	--------
Turkey	3,792	2,662	942	--------	--------	--------
U.S.S.R.	164	120	42	--------	--------	--------
Yugoslavia	154	109	39	--------	--------	--------
Total	48,969	32,827	12,408	8,513	5,646	1,350

Imports of chromium containing pigments continued to increase as follows: (1966 imports in parenthesis) chrome green, 154 tons (67), chrome yellow, 3,535 tons (2,115), and chromium oxide green 491 tons (760). Japan, West Germany, and Poland supplied most of the imports.

Chromium carbide imports increased from 84 tons valued at $212,000 in 1966 to 101 tons valued at $269,000 in 1967.

Imports of sodium chromate and bichromate decreased sharply in 1967 compared with those of 1966. Imports totaled 8,224 tons valued at $1,438,000 compared with 24,135 tons valued at $4,142,000 in 1966.

Table 11.—U.S. imports for consumption of chromite, by grades and countries, in 1967

(Thousand short tons and thousand dollars)

Country	Not more than 40 percent chromic oxide (Cr_2O_3)			More than 40 percent but less than 46 percent chromic oxide (Cr_2O_3)			46 percent or more chromic oxide (Cr_2O_3)			Total		
	Quantity		Value	Quantity		Value	Quantity		Value	Quantity		Value
	Gross weight	Cr_2O_3		Gross weight	Cr_2O_3		Gross weight	Cr_2O_3		Gross weight	Cr_2O_3	
Albania	------	--------	--------	11	5	$211	--------	--------	--------	11	5	$211
Philippines	194	63	$3,630	--------	--------	--------	--------	--------	--------	194	63	3,630
Rhodesia, Southern	------	--------	--------	46	21	1,070	101	50	$2,287	147	71	3,357
South Africa, Republic of	14	6	122	372	165	4,309	95	46	1,429	481	217	5,860
Turkey	6	2	102	58	24	855	44	21	1,054	108	47	2,011
U.S.S.R.	--------	--------	------	--------	--------	--------	299	165	6,785	299	165	6,785
Total	214	71	3,854	487	215	6,445	539	282	11,555	1,240	568	21,854

WORLD REVIEW

Albania.—Production of chromite, mainly refractory-grade, has steadily increased since 1938. Chromite is reportedly produced at two mines in the Kukes area in the northeastern part of the country, and at Bulqiza where two mines at Klose and Kuesi were brought into production in the 1960's. Albania's major chromite markets are Mainland China, Czechoslovakia, East Germany, Hungary, Poland, and Yugoslavia.

Australia.—Self-sufficiency in chromite may result from a rediscovered chromite prospect in a remote area of Victoria near Licola. The deposit originally discovered in 1875, was rediscovered in 1950. Victorian Refining and Smelting Company Pty. Ltd. applied for a lease to exploit the deposit. A trial shipment of chromite was made to Japan for evaluation.

Canada.—Exploration drilling for chromite was conducted on a number of claims near Cascade, British Columbia, by Hunter Point Exploration Ltd., subsidiary of Chromex Nickel Mines Ltd. Chromite occurs in pods and disseminations throughout an ultrabasic formation.

Table 12.—World production of chromite by countries [1]

(Short tons)

Country	1963	1964	1965	1966	1967 p
North America: Cuba	r 62,422	r 36,213	e 33,000	e 33,000	e 33,000
South America:					
Brazil [2]	18,798	10,406	18,695	16,495	7,567
Colombia	121	441	287	----	----
Europe:					
Albania	323,657	338,213	r 342,000	r 345,000	e 349,000
Finland [3]	----	----	----	77,161	33,069
Greece [3]	56,415	r 44,200	r 46,700	e 44,000	e 55,000
U.S.S.R. e [4]	1,355,000	1,435,000	1,565,000	r 1,653,000	1,731,000
Yugoslavia	103,364	97,398	88,021	59,757	51,987
Africa:					
Malagasy Republic	12,346	12,974	2,628	----	----
Rhodesia, Southern	r 412,394	r 493,371	r 645,501	NA	NA
Sierra Leone	3,067	----	----	----	----
South Africa, Republic of	873,212	936,468	1,038,498	1,169,488	1,266,615
Sudan e	18,700	18,700	33,000	19,000	20,000
Asia:					
Cyprus	5,411	3,300	5,501	11,532	24,037
India	r 76,073	38,547	r 65,791	85,601	114,605
Iran e	110,000	132,000	165,000	193,000	198,000
Japan	48,205	48,452	46,114	36,192	49,837
Pakistan	16,023	14,884	15,972	29,924	e 34,000
Philippines	506,094	515,969	611,288	617,426	462,694
Turkey	312,817	454,907	625,078	r 583,232	[5] 678,412
Oceania:					
Australia	180	80	r 25	----	----
New Caledonia	----	----	----	----	2,010
Total [6]	r 4,314,299	r 4,631,523	r 5,348,099	r 4,973,808	5,110,833

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Chromite was also produced in Bulgara, Rumania, and North Viet-Nam, but data not available.
[2] Bahia only.
[3] Crude Ore.
[4] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[5] Probably crude ore.
[6] Total is of listed figures only; no undisclosed data included.

Finland.—A ferroalloy plant was under construction at Tornio, Finland, by Outukumpa Oy a state-owned company. Scheduled for completion by late 1967, plans call for producing a high-carbon low-chromium alloy for domestic consumption and export. The company's ore deposit near Kemi was estimated to contain 37 million tons of low-grade chromite. Metallurgical tests indicated recoverable concentrate would be about one-third of the ore mined.

Greenland.—Reports indicated that large deposits of chromite were discovered in a mountain range south of Godthaab on the west coast of Greenland near the Fiskenaesset Peninsula.

Greece.—Greece produced only refractory-grade chromite as the mine of Aspiote-Elka Chrome Mines, Ltd. which produced metallurgical-grade ore closed down early in the year.

Swedish interests were reportedly interested in developing chromite ore deposits on Mt. Vourinos, near Kozani.

Hungary.—A 6,500-ton-per-year sodium dichromate plant was ordered by the state-owned Hungarian trading organization, Chemokomplex.

India.—It has been indicated that India's reserve of all grades of chromite ore is much more extensive than the 4.9 million tons of proved reserves. Chromite occurrences throughout the country have been reported for a number of years, but most of the areas have not been studied in detail.

Proved reserve of 2 million tons of chromite occurs near Boula and Nashahi in the Keonjhar District of Orissa. There are other important deposits at Jojohatu, Singhbhum District, Bihar; Sukinda, Cuttack District, Orissa; Bryapur, Hassan District, Mysore; Sinduvalli, Tallur, and Doddakattur, Mysore; Pauni, Bhandara District, Maharashtra; and Kankauli and Vagda, Ratnagiri District, Maharashtra. The ores of Orissa are generally metallurgical grade while those of Bihar and Mysore range from high-quality chemical grade to refractory grade.

A ferrochromium plant under construction at Jaipur Road, Orissa, was scheduled for completion in 1968. The plant was designed for output of 10,000 tons of low-carbon ferrochromium annually with provision for expansion to 25,000 tons.

Iran.—An accelerated highway construction program and the opening of the new port at Bandar Abbas, Iran, which has an ore-loading jetty that will be used exclusively for chromite ore, places Iran in a position to take full advantage of the favorable world chromite market. The new facilities are able to support an increase in exportation of Iran's chromite ore. The major chromite producing areas in southern Iran, the Abdasht and Fariab mines, were attempting to increase production and improve mining techniques.

Japan.—Showa Denko K.K. completed construction of a new low-carbon ferrochromium plant with a capacity of 10,000 tons per year. The firm plans to use a modification of the conventional three-stage process currently used. Japan produced 151,296 tons of ferrochromium in 1966 and 217,603 tons in 1967.

Malagasy Republic.—Work was initiated to develop chromite deposits at Andriamena west of Lake Alatora. The deposits contain about 6 million tons of low-grade (up to 40 percent Cr_2O_3) chromite. Plans call for production of 85,000 tons per year of low-ratio concentrate with startup of the mine scheduled in 1969.

New Caledonia.—New Caledonia exported 1,362 tons of chromite to Japan. This was the first chromite exported from New Caledonia since 1964, and the first mine production since 1962. The ore was reportedly from two surface mines in the Tontouta region and contained 49 percent Cr_2O_3 with a chromium-to-iron ratio of 2.66.

Pakistan.—Pakistan's chromite production has steadily increased from 15,000 short tons in 1964 to 30,000 tons in 1966. Production in 1967 has been estimated at 34,000 tons. Pakistan Chrome Mines, Ltd., currently the country's only producer of chromite, plans to increase production by an additional 10 percent in 1968.

Philippines.—Of the total chromite ore produced in the Philippines, refractory-grade chromite amounted to 81 percent in 1966 and 68 percent in 1967. Exports totaled 325,000 tons in 1967; 55 percent was shipped to the United States; 18 percent to Europe; 17 percent to Japan; 6 percent to Canada; and 4 percent to other countries. Virtually all of the metallurgical-grade chromite production was exported to Japan. Acoje Mining Co., main producer of metallurgical-grade chromite, began mining chromite by open-cut methods late in 1966 in order to increase production.

Rhodesia, Southern.—Voluntary sanctions imposed by various countries in 1966, at the request of the British Government, were not entirely effective as total exports decreased only 36 percent. On December 16, 1966, the United Nations Security Council passed a resolution which imposed mandatory sanctions against Southern Rhodesia. Under terms of the resolution, all member states were to prohibit imports of chromite along with 11 other commodities.

Operations of Rhodesia Chrome Mines Ltd. and African Chrome Mines Ltd., both Union Carbide subsidiaries, were placed under the direction of a new company, Union Carbide Southern Africa, Inc., early in 1967. Union Carbide's ferrochromium subsidiary, Union Carbide Rhomet at Que Que also comes under the new company.

The Anglo-American Corp. carried out studies on three concessions covering two chemical-grade chromite seams in the central and southern portions of the Great Dyke to determine whether the ore was suitable for metallurgical purposes.

Sudan.—Chromite deposits in the Sudan are located in three principal areas: The Ingessana Hills south of Roseiris; Guala en Nahl area, Kassala Province; and in the northern part of the Red Sea Hills. The Ingessana deposits appear to be higher grade and more economical to operate although the Red Sea Hills area has not been explored thoroughly.

Turkey.—In 1966 Turkish exports of chromite reached the highest level since 1958 totaling 550,000 tons. In 1967, exports decreased to 358,000 tons of which the United States received about 30 percent compared with 42 percent in 1966. The decrease in exports was attributed to various factors including the exhaustion of accumulated stocks.

United Kingdom.—Union Carbide UK Ltd. closed down its high-carbon ferrochromium plant at Wincobank near Sheffield due to economic factors. Small furnaces, high power costs, and loss of Rhodesian ore contributed to the decision for closure.

Associated Chemical Companies (Mfg.) Ltd. transferred its chromium compound manufacturing operations to its Urlay Nook works, making it the sole producing plant in Britain.

Yugoslavia.—Chromite production in Yugoslavia primarily came from one mine where two grades of lump ore and concentrate are produced. The lump ores produced contain 50 and 44 percent Cr_2O_3, whereas concentrates contain 48 percent Cr_2O_3 or higher. Because of the friability of the ore, only about 60 percent of the production is lump ore, the balance is concentrated.

TECHNOLOGY

Advantages and technical details of the use of chromite sand in foundry applications were described.[2] In certain applications, chromite sand outperforms both silica and zircon as a molding and coremaking medium to produce better castings.

Crucible Steel Co. announced [3] a process for the direct production of stainless steel from ores. The process includes blast furnace reduction of chromite and iron ore to form a molten chromium-bearing pig iron. An induction furnace receives the tapped hot metal and acts as a holding furnace while temperature and composition are adjusted. An oxygen converter refines the alloyed iron to the final composition prior to casting.

Furnace equipment and operating results for the production of charge-grade high-carbon ferrochromium in an electric furnace were described.[4] The three-phase stationary furnace with 35-inch diameter electrodes was powered by an 11,250-kilovolt-ampere transformer. During a 2-month operating period, production of shippable alloy averaged 55.6 tons per day with an 85.8 percent chromium recovery. Power consumption averaged 3,375 kilowatt-hours per ton of shippable alloy.

Evidence in recent years indicates that trace amounts of chromium, along with other elements, plays an important role in animal nutrition.[5] Trivalent chromium acts as a cofactor with insulin for optimum glucose utilization. Chromium deficiency can impair glucose tolerance which can be reversed by chromium supplements.

The Bureau of Mines studied the effect of temperature upon the reduction of chromite by carbon and the relative reducibility of chromite as a function of its composition.[6]

Recrystallization studies were made by Bureau researchers on chromium-bearing spinel to determine the effects of certain fluxing agents and cooling rates on the chromium-to-iron ratio of recrystallized spinel.[7]

A laboratory study investigated the fundamental flotation characteristics of

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[2] Raglin, Edward F. Chromite Sand. Foundry, v. 94, No. 9, September 1966, pp. 177–186.

[3] Steel. V. 158, No. 19, May 9, 1966, pp. 46–48.

[4] Leeper, R. A., and T. J. Dyrdek. Smelting of High-Carbon Ferrochromium in a Three-Phase Electric Furnace J. Metals, v 18, No. 3, March 1966, pp. 353–356.

[5] Chemical & Engineering News. V. 44, No. 20, May 16, 1966, pp. 48–50.

[6] Hunter, Willard L., and Danton L. Paulson. Carbon Reduction of Chromite. BuMines Rept. of Inv. 6755, 1966, 20 pp.

[7] Town, J. W., W. A. Stickney, G. T. Engel, and P. E. Sanker. Recrystallization of Chrome Spinel. BuMines Rept. of Inv. 6923, 1967, 30 pp.

chromite and serpentine.[8] Floatability curves were developed from data secured by varying sodium oleate, used as a collector, and the pH of the system. Effective flotation occurred when the collector concentration was 10 to 100 milligrams per liter at pH values of between 3 to 11. The effect of dissolved metal ions in the pulp filtrate on the floatability of chromite was also investigated.

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[8] Sagheer, M. Flotation Characteristics of Chromite and Serpentine. Trans. Soc. of Min. Eng., v. 235, No. 1, March 1966, pp. 60–67.

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Clays

By James D. Cooper [1]

Clay production was down 4 percent in quantity in 1967, but due to higher unit prices for all clays except bentonite, the total value was up about 1 percent. Only one type of clay, fuller's earth, registered a gain in tonnage produced, while all other types showed declines ranging from 1 to 9 percent. Since 1960, the net exportation of clays has doubled in quantity and tripled in value, and in 1967 clay exports exceeded imports by more than 1 million tons and over $30 million. More than half of the exported clays went to Canada.

Georgia maintained its predominant position in the domestic clay industries in 1967, and although Ohio and Texas produced almost equal quantities, the value of Georgia clays was more than one third of the national total, and was several times the value reported for clays in any other State.

Table 1.—Salient clay and clay products statistics in the United States
(Thousand short tons and thousand dollars)

	1963	1964	1965	1966	1967
Domestic clays sold or used by producers	50,135	52,947	55,126	r 56,713	54,664
Value	$180,810	$192,631	$204,932	r $221,714	$223,987
Exports	739	848	850	1,074	1,149
Value	$21,374	$24,973	$25,595	$31,135	$32,432
Imports for consumption	126	137	110	139	108
Value	$2,413	$2,638	$2,137	$2,883	$2,235
Clay refractories, shipments (value)	$179,512	$205,267	$228,876	$243,516	$197,863
Clay construction products, shipments (value)	$538,600	$569,200	$578,190	$554,667	$538,110

r Revised.

REVIEW OF DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE, BY TYPE OF CLAY

KAOLIN

Kaolin production declined appreciably in quantity in 1967, due to a return to normal demand for refractory grade material. A shortage of calcined bauxite in 1966 had created an abnormal demand for substitute materials, causing refractory grade kaolin output to more than double. The average unit value of kaolin sold or used in 1967 increased by 9 percent, so that in spite of a 9 percent decrease in volume for the year the total value was down less than 1 percent.

Imports of kaolin, mostly from the United Kingdom, declined in 1967, following a longstanding general downward trend. In 1967, a total of 92,096 tons, valued at $1.8 million, was obtained from foreign producers compared with imports of 116,826 tons worth $2.4 million in 1966. Exports of kaolin, which have grown rapidly during the past decade, continued to increase in 1967 for a total of 321,929 tons valued at $9.9 million compared with exports of 253,408 tons valued at $8.4 million in 1966. Canada was the major importing country, accounting for 180,000 tons, followed by Japan, (38,000 tons), Italy, (31,000 tons), and Mexico, (13,000 tons).

[1] Commodity specialist, Division of Mineral Studies.

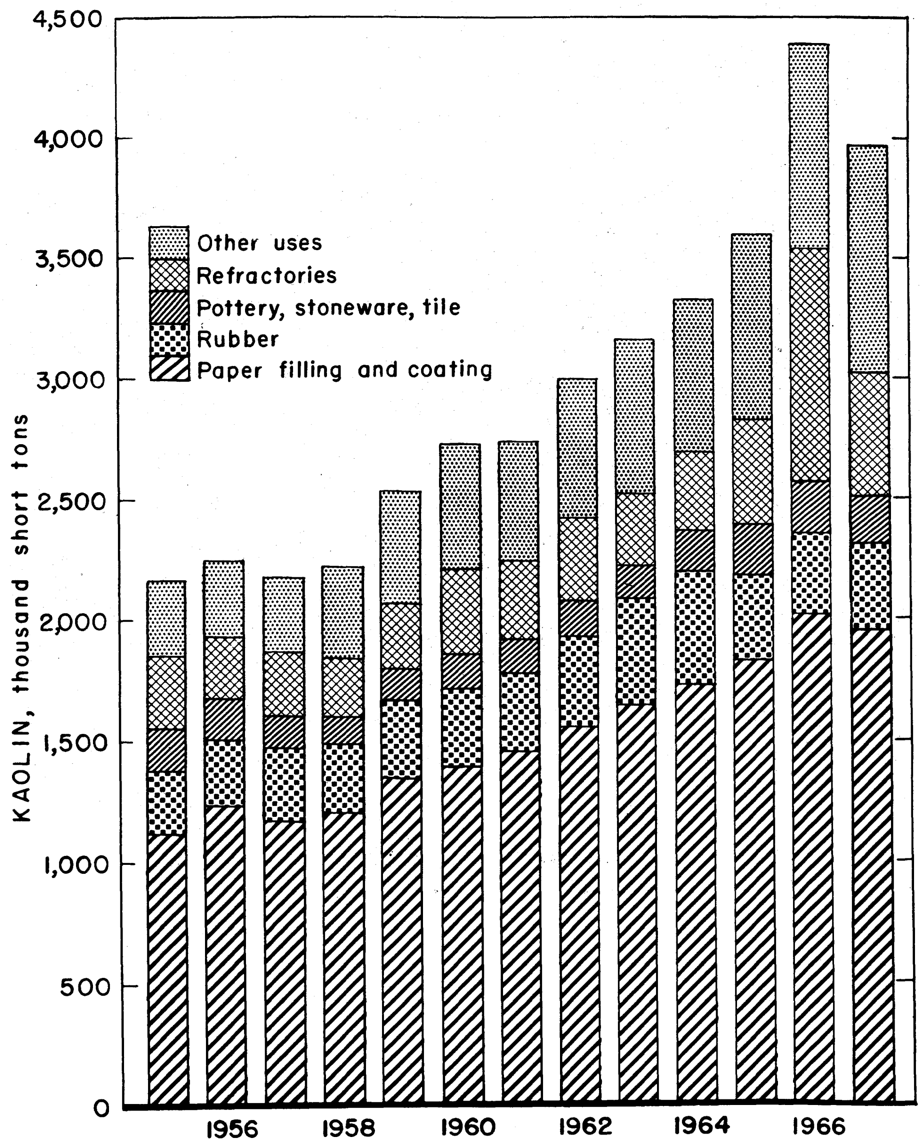

Figure 1.—Kaolin sold or used by domestic producers for specified uses.

Kaolin prices, as quoted in Oil, Paint and Drug Reporter at the end of 1967, were as follows:

Water washed, calcined, bulk, carload lots, f.o.b. Ga	$54–$55
Water washed, partially calcined, same basis	41– 42.50
Water washed, paper grade, uncalcined, same basis:	
No. 1 coating	34– 35.50
No. 2 coating	26– 27.50
No. 3 coating	25– 26.50
Water washed, delaminated, 1-micron average, same basis	56
Dry ground, air floated, soft, same basis	12.50
National Formulary, powder, fiber drums, per pound	0.10– 0.12
National Formulary, colloidal, 50 bags, per pound	0.155–0.175

Price increases were scheduled to go into effect sometime early in 1968.

BALL CLAY

Ball clay production declined 2 percent in quantity in 1967, the second consecutive annual drop, but increased 2 percent in value. The use pattern remained essentially unchanged, except for whiteware requirements which decreased by 20 thousand tons, and for clay construction products requirements which increased about 10 thousand tons. The three major uses, whiteware, floor and wall tile, and refractories, accounted for 85 percent of the total quantity sold or used, with lesser quantities going into enamel, fillers and several miscellaneous products.

Production of ball clay was from six States, with Tennessee alone accounting for two-thirds of the total, and together with Kentucky and Mississippi, the two other major producing States, for 94 percent. California, Maryland, and Texas together were responsible for about 6 percent of the output.

Imports in 1967 consisted of 10,064 tons of unbeneficated ball clay valued at $143,384 and 3,038 tons of beneficiated material valued at $123,403. In 1966 the quantities were 11,733 tons of unbeneficiated, and 3,936 tons of beneficiated ball clay, worth $146,155 and $111,939 respectively. Virtually all of the material came from the United Kingdom.

Price quotations for ball clay published in Oil, Paint and Drug Reporter remained unchanged during 1967, as follows: Domestic, air floated, bags, carload lots, Tennessee, $18 to $22 per ton; domestic, bulk, crushed, moisture repellent, carload lots, Tennessee, $8 to $11.25 per ton; imported, air floated, bags, carload lots, Atlantic ports, $46.50 to $48.25 per ton; imported, lump, bulk, carload lots, Atlantic ports, $31.50 to $37.50 per ton.

FIRE CLAY

The downward trend in fire clay output continued, with production down 9 percent in 1967; however, the total value in 1967 was essentially unchanged from the 1966 figure reflecting the substantial price increases announced in 1967 for various refractories and other products made from fire clays. The major uses remained essentially unchanged, with 50 percent of the fire clay output going into refractories, 45 percent into heavy clay products, and 5 percent into a variety of nonrefractory products.

Fire clay exports decreased in 1967, totaling 176,367 tons worth $2,789,361, compared with 215,534 tons valued at $3,396,176 in 1966. The major recipient countries in 1967 were Canada and Mexico, which took 55 percent and 39 percent respectively of the tonnage. Imports of fire clay were insignificant.

Kaiser Refractories was expanding and improving its facilities throughout the world. In the United States a $7.5 million expansion was under way at Mexico, Mo., and a $2 million addition was being installed at Columbiana, Ohio, for production of basic-oxygen-furnace refractories. Construction of a new research center was started in California. A. P. Green Refractories Co. had a $13 million expansion program in progress, including a new $2 million refractories plant at Eufaula, Ala. A. P. Green purchased the H. K. Porter Co. Inc. plant at Canyon City, Colo., and planned to use the facilities for grinding and treating bone ash for use in cupels and other assay equipment which is manufactured at the firm's Denver plant. Near the end of 1967, A. P. Green announced plans to merge with United States Gypsum Co. Other major plant construction during the year included a $6 million expansion by The Chas. Taylor Sons Co. at South Shore, Ky; completion of a $3.5 million new modern plant at Newell, W. Va., by Globe Refractories, Inc.; and a new plant at Fulton, Mo., built by H. K. Porter Co., Inc., to replace an older facility at St. Louis. Walsh Refractories Corp. had a plant modernization program in progress at Vandalia, Mo. New research laboratories of The Babcock & Wilcox Co. at Alliance, Ohio, were dedicated in May 1967.

Several ownership changes were accomplished or in process in 1967. Harbison-Walker Refractories Co. and Dresser Industries, Inc. announced approval by the boards of directors of a joint plan to merge Harbison-Walker into Dresser. The Ramtite Co. and Refractory & Insulation Corp. were combined into a new firm, R & I-Ramtite Co. by the parent company, Combustion Engineering, Inc. Electro Refractories & Abrasives Corp. changed ownership when it was sold for $8.8 million to Ferro Corp. E. J. Lavino & Co., with plants in Pennsylvania, California, and Indiana, was acquired by International Minerals & Chemical Corp. early in the year.

BENTONITE

Bentonite output was down 1 percent in quantity and 7 percent in value in 1967. The quantities for major uses declined, with the exception of that produced for iron ore pelletizing, which rose significantly. Activity in the bentonite industry remained high, with new or expanded mines and processing plants completed or under construction in Wyoming, Montana, California, and Missouri.

The Quantity of bentonite used for pelletizing in the United States and Canada has grown rapidly since 1960, but pellet capacity is rapidly leveling off, and bentonite production for this use should follow suit. Barring major increases in demand for existing uses or for major new uses, the growth rate for bentonite should slow down appreciably by 1970.

A total of 318,653 tons of bentonite valued at $7,701,766 was exported in 1967, compared with 302,797 tons worth $8,001,547 in 1966. The drop in total value of exports in 1967 was apparently due to increased shipments of the lower-unit-cost iron ore pelletizing clays and decreased shipments of the more expensive qualities, such as those used for drilling muds and for filtering and clarifying oil. Significant increases in the quantities shipped to Australia and West Germany off set the drop in Canadian purchases. The largest recipients in 1967 were, Canada, 183,323 tons; Australia, 31,198 tons; United Kingdom, 25,392 tons; and West Germany, 22,153 tons. Equivalent figures for 1966 were, Canada, 207,495 tons; Australia, 14,442 tons; United Kingdom, 29,719 tons; and West Germany, 3,598 tons. Imports of bentonite in 1967 were very small, with Italy supplying 120 tons worth $5,823 and West Germany 1 ton worth $540.

Prices for bentonite during 1967, as quoted in Oil, Paint and Drug Reporter, were as follows: Domestic, 200 mesh, in bags, carload lots, f.o.b. mines, $14 per ton; imported Italian, white, high gel, in bags, 5-ton lots, ex-warehouse, $91 per ton. The average unit value of domestic output was $10.03 per ton, a substantial reduction from the figure of $10.69 in 1966. Greater domestic sales of low-cost bentonite for iron ore pellet binder and lower sales of other qualities affected the average unit value adversely.

New developments in the industry included completion of a processing plant at Colony, Wyo., by International Minerals & Chemical Corp., and opening of a vertical bentonite bed by Wyo-Ben Products, Inc. A new clay mining and processing firm, Missouri Clay Products Co., was formed; plans were announced for producing Porter's Creek montmorillonitic clays for use as iron ore pellet binder at the Pea Ridge plant of Meramec Mining Company. A D M Chemicals division of Ashland Oil and Refining Co. purchased bentonite claims covering about 25 square miles near Glasgow, Mont., and announced plans for a 300,000-ton-per-year bentonite mining and processing facility. In California, Baroid Division of National Lead Co. was expanding its bentonite processing facilities at Newberry. New spray dryers and drum dryers were to be added as well as wet-room facilities for handling clay in slurry form.

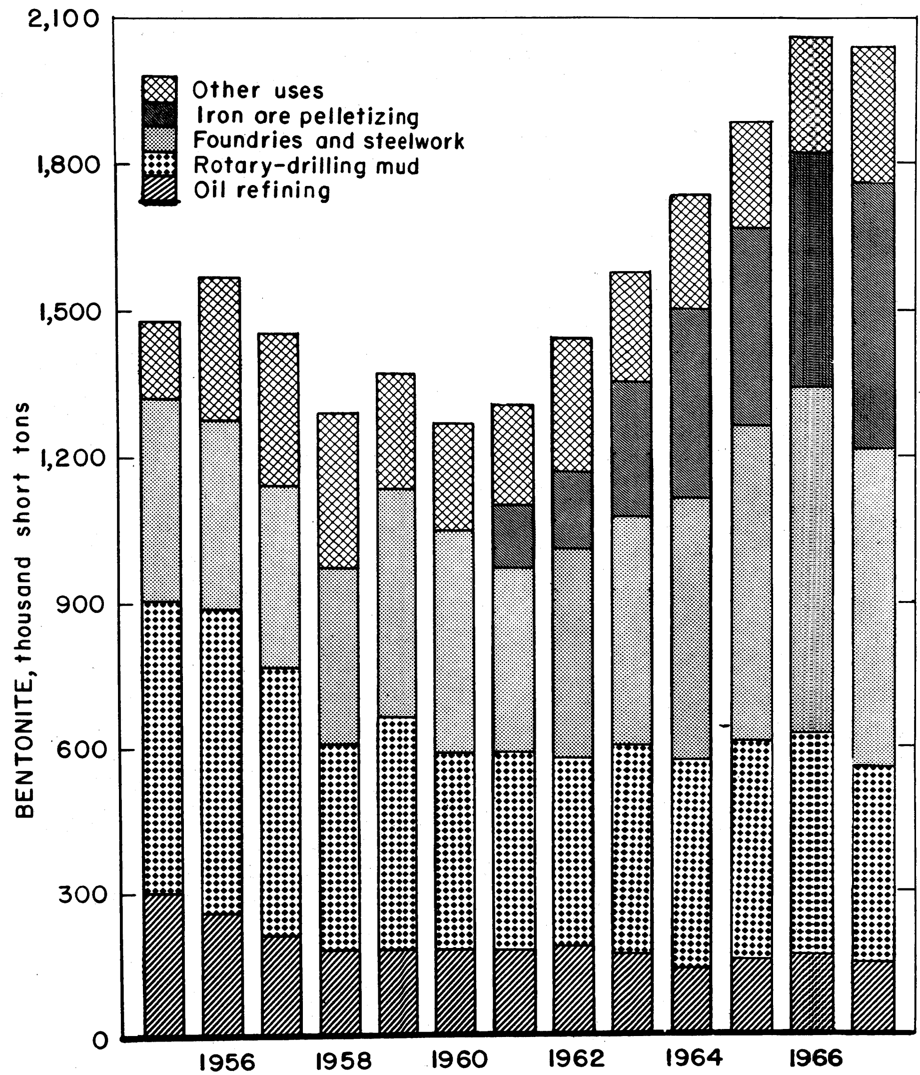

Figure 2.—Bentonite sold or used by domestic producers for specified uses.

FULLER'S EARTH

Fuller's earth was the only type of clay to register a production increase in 1967. The quantity sold for absorbent uses continued to grow, more than enough to compensate for decreases in all other use categories. Approximately half of the quantity sold for absorbent uses was estimated to be for animal litter, a market which has grown from a few thousand tons in 1960 to an estimated 230,000 tons in 1967. Sales for other absorbent uses, principally floor sweeping compounds, were estimated at about 250,000 tons in 1967. Demand for fuller's earth as a carrier for insecticides and fungicides, which has shown rapid growth in recent years, continued high in 1967 with a total of 180,500 tons sold or used by producers, slightly under the record 189,758 tons sold or used in 1966.

Prices for fuller's earth are not quoted in the trade journals. The average value increased from $24.16 per ton in 1966 to $25.55 per ton in 1967.

Imports of fuller's earth were 80 tons valued at $6,594 in 1967, supplied by United Kingdom, Italy and West Germany. Surinam shipped over 2,000 tons of material classified as fuller's earth to the United States in 1966, but no shipments were received from Surinam in 1967. Exports increased from 23,278 tons valued at $1,164,311 in 1966, to 30,347 tons worth $1,497,674 in 1967. Canada and the European countries took about 90 percent of the exports, with Australia and

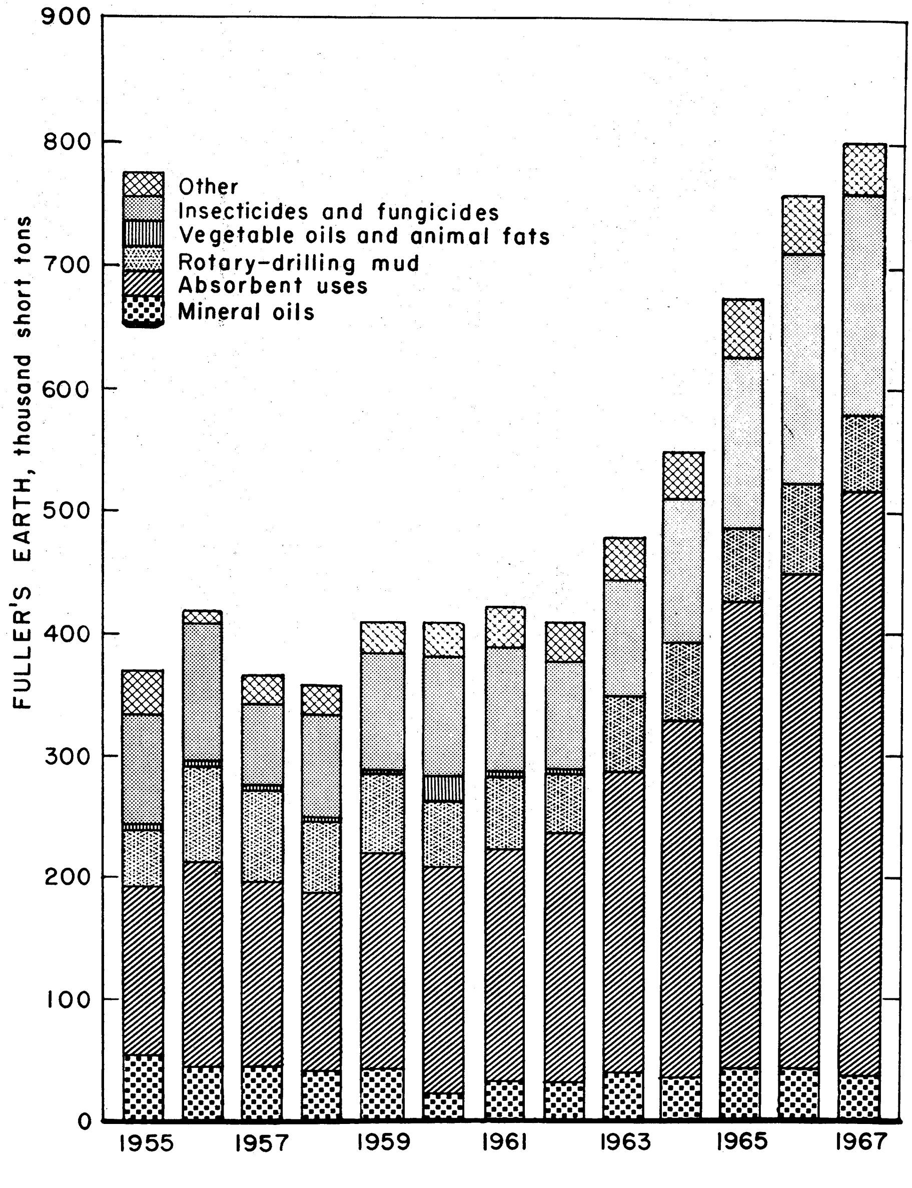

Figure 3.—Fuller's earth sold or used by producers for specified uses.

the Republic of South Africa accounting for most of the balance.

Southern Clay Co., Inc., Paris, Tenn., acquired Star Enterprises, Inc., a fuller's earth producer in Pulaski County, Ill., and Tennessee Absorbent Clay Company of Paris, Tenn. The processing facilities of the latter firm were closed down. Mid America Clay and Minerals Corp. was installing equipment for a new fuller's earth plant at Oran, Mo. Principal sales outlets were to be producers of insecticides and other agricultural chemicals.

MISCELLANEOUS CLAY

Miscellaneous clays are the common clays and shales used for making brick, other heavy clay construction products, lightweight aggregates, and cement. Output in 1967 decreased 2 percent in quantity but increased 4 percent in value. A significant increase was registered for the quantity used for production of lightweight aggregates. The quantity used in cement remained essentially the same as in 1966, and the quantity for heavy clay construction products declined. These major uses accounted for more than 98 percent of the total production in 1967. Most producers of miscellaneous clay also manufacture clay products, and in 1967 more than 97 percent of all of the miscellaneous clay output was captive.

Exports of clays as to type are included in a basket category by the Bureau of the Census. These are for the most part high-quality clays but export data are included in this section for convenience. In 1967 a total of 302,146 tons of such clays, worth $10,522,428 was exported to many countries throughout the world, with Canada, Japan, The Netherlands, and Italy receiving the largest quantities and together accounting for 55 percent of the total.

A number of new structural clay products plants were completed or under construction during the year. Glen-Gery Shale Brick Corp. started a $7.5 million expansion program to increase brick-making capacity from 300 million to 450 million brick per year. In addition to expansion and modernization of existing facilities, three new plants were included in the program. Belden Brick Co. was building a new 75-million-brick-per-year plant at Sugarcreek, Ohio. In Pennsylvania, Manor Brickcrafters completed a new plant for production of molded brick at New Oxford, and Milliken Brick Co. was building a new face brick plant at Harmarville. Expansion to double the capacity of the Darlington Brick Co. in Beaver County to 100,000 glazed brick per day was in progress.

An Economic Development Administration (EDA) loan was instrumental in establishing a new face brick plant at Myrtle Beach S.C. The plant, which can produce 25 million distinctive face brick per year, was built by Waccamaw Clay Products Co. Another EDA loan was made to United Clay Pipe Co., Seminole, Okla., to build a $2 million plant for manufacture of 40,000 tons of vitrified clay sewer pipe per year.

Hydraulic Press Brick Co. closed its brick plant in St. Louis, Mo. The firm has five other brick plants in Illinois and Indiana, and has kept its St. Louis warehousing and distribution facilities.

During 1967 only one major new plant was completed, that of Kaiser Sand and Gravel Division of Kaiser Industries at Sunol, Calif. The intensive preliminary planning, for minimizing undesirable operating conditions and for eventual rehabilitation of the 120-acre area for benefit of the residents of the area, exemplifies the type of long range study which is becoming essential to optimal use of mineral resources in urban areas.

Although the normal economical shipping distance for lightweight aggregates is about 200 miles, much greater hauls are feasible under certain circumstances. A substantial quantity was shipped by low cost barge freight from the Big River Industries plant at Erwinville, La., to Chicago, Ill., in 1967.

CONSUMPTION AND USES

Heavy clay construction products accounted for 41 percent of the total clay output in 1967, compared with 43 percent in 1966. Cement manufacture required slightly over 20 percent of the total in 1967, little change from 1966, and 16 percent went into lightweight aggregate production, against 15 percent in 1966. Clays used in refractories dropped to less than 10 percent of total output in 1967, compared with more than 11 percent in 1966.

Refractories.—The quantity of clay used in refractories in 1967 declined by 15 percent; kaolin use fell by 443,000 tons, representing nearly half of the decrease, and fire clay use dropped by 401,000 tons. Production of fire clay refractories dropped by 19 percent in value in 1967.

Nonclay refractories shipments were down 14 percent in value in 1967, with brick and shapes showing the most significant decreases. Shipments of silica refractories, once very important to the steel industry, slipped by 27 percent, and in 1967 totaled only 71 million 9-inch equivalents compared with over 300 million 9-inch equivalents per year in the 1950's.

Heavy Clay Products.—Shipments of heavy clay products declined in both quantity and value in 1967, with all major categories of products showing declines in volume; only one category, vitrified sewer pipe and fittings, registered a slight increase in total value. In spite of the decreases in shipments, the major producers continued to improve and modernize their production, sales, and distribution facilities; to produce more attractive and more economical building products; and to support more active promotion of clay construction products for both conventional and important new applications.

Lightweight Clay and Shale Aggregates.—Production of lightweight aggregate from clay and shale rose 5 percent in 1967 compared with a 13-percent increase in 1966. A total of 54 firms operated 69 plants in 32 States during 1967.

Output of lightweight aggregate from slate is not included with the figures for clay and shale. The quantity of slate used in 1967 was 649,000 tons, compared with 758,000 tons in 1966. Total plant capacity for production of lightweight clay, shale, and slate aggregates was about 13 million tons at the end of 1967.

WORLD REVIEW

Australia.—At Port Adelaide, South Australia, Kaiser Refractories (Pty.) Ltd. completed and started operating its second specialty refractories plant for production of fire clay and basic refractory products. A substantial investment was made during the year by A. P. Green Refractories Co. in Newbold General Refractories, Ltd., New South Wales.

Canada.—The Algoma Central Railway was reported to be developing a large kaolin deposit in the Hearst area of northern Ontario to supply a substantial part of Canada's needs, particularly in the paper industry. Also in Ontario, Kaiser Refractories started construction of a new refractory brick plant at Oakville.

Czechoslovakia.—Plans were announced for increasing annual kaolin output at the mining center of Horni Briza from 145,000 tons to at least 220,000 tons. Equipment was to be purchased from European and British firms.

France.—Kaolin deposits in western France were under development by or subsidiary of Compagnie de Mokta. Kaolin from the deposits was intended to replace the substantial quantities of high-quality paper coating clay that are presently imported.

Greece.—Output of bentonite, which nearly doubled in 1966, experienced a substantial increase again in 1967, from about 100,000 tons in 1966 to 132,000 tons in 1967.

Italy.—Bentonite output, second only to the United States, totaled 270,000 tons in 1967, a substantial increase over the 1966 figure of 237,000 tons. Bleaching clay production also rose from 96,000 tons in 1966 to 102,000 tons in 1967. Fire clay production, however, dropped from 319,000 tons in 1966 to 310,000 tons in 1967.

Mexico.—Bentonite production rose from 28,000 tons in 1966, to 36,000 tons in 1967. Fuller's earth output more than tripled, from 6,700 tons in 1966 to 20,000 tons in 1967. More than 100,000 tons of fire clay was produced in 1967.

Morocco.—Morocco produced a significant quantity of montmorillonitic clays, of which 28,000 tons was classified as smectite, 7,500 tons as bentonite, and 4,500 tons as ghassoul.

Mozambique.—A new firm, Mineira Industrial, was authorized to produce bentonite from deposits west of Lourenco Marques containing 5 to 10 million tons. Monthly output was to be about 150 tons.

New Zealand.—A detailed drilling program and feasibility study were under way on bentonite in the Coalgate area to determine if an economic bentonite export business could be established to furnish clay binder for the growing iron ore pelletizing industry. Pilot plant tests were to be made in New Zealand and in the United States.

Peru.—Peru has developed bentonite clay deposits in order to furnish binder clay for iron ore pelletizing by Marcona Mining Co. at San Nicolas. A total of 18,500 tons of bentonite was produced in 1967 compared with only 1,800 tons in 1966. About 350,000 tons of miscellaneous clay and 5,500 tons of fire clay was mined in 1967.

Senegal.—Opening of a new plant for production of attapulgite was announced early in 1967. The plant, which is about 60 miles from Dakar, will produce material primarily for export to Europe.[2] Output during the first year of operation was 1,650 tons.

United Kingdom.—To meet the need for improved port facilities, English China Clay Lovering and Pochin, Ltd., was considering leasing and improving the port of Fowley. Exports of 2.5 million tons of kaolin per year by the firm were projected for the mid-1970's.

TECHNOLOGY

The Bureau of Mines continued research on a number of problems related to clay resources. Field and laboratory studies on Minnesota glacial lake clay deposits resulted in development of a potential iron ore pellet binder using Minnesota clay alone, or equal parts of western bentonite and Minnesota clay. The glacial lake deposit, near Cook, Minnesota, contains several hundred million tons of clay, and use of the local clay by Minnesota taconite pelletizing plants would result in substantial savings in freight costs.

The Bureau's cooperative studies on clay included work with 13 State mineral resource agencies in 1967. The work varied from state to state depending on the resources problems involved. Some studies were statewide and general, while others were designed to solve more specific and restricted problems, such as those arising from urban encroachment into active or potential clay mining areas. Efforts were made during the year to improve the cooperative work by including a greater variety of minerals, by bringing more States into the program, and by improving testing and reporting methods and procedures. A report on the clays in the eastern counties of Virginia was published.[3]

Bureau of Mines research continued on fine attrition grinding of minerals, which has been successfully applied for commercial processing of high-grade kaolin products. During 1967 successful grinding tests were made on clays other than kaolin and on a variety of other minerals. Research underway for many years on methods of extracting alumina from clay was continued, and a report on evaluation of a lime-soda sinter process was published.[4] A Bureau of Mines study of potential aluminum ores culminated in publication of a report that included extensive reporting on large reserves of fire clay, kaolin, ball clay and bauxitic clay throughout the United States and possessions.[5]

The last in a series of reports on clays and shales in the North Central States suitable for production of expanded lightweight aggregates was published. This paper reports that of 10 large channel samples taken in Michigan, two from Presque Isle County showed the most favorable characteristics for production of acceptable expanded aggregates meeting American Society for Testing and Materials specifications under designation C 330–60T for strength and

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[2] Mining Journal (London). V. 268, No. 6858, Jan. 27, 1967, p. 64.

[3] Johnson, Stanley S., and Miles E. Tyrell. Analyses of Clay and Related Materials—Eastern Counties. Virginia Division of Mineral Resources, Miner. Res. Rept. 8, 1967, 232 pp.

[4] Peters, Frank A., Paul W. Johnson, John J. Henn, and Ralph C. Kirby. Methods For Producing Alumina From Clay, An Evaluation of a Lime-Soda Sinter Process. BuMines Rept. of Inv. 6927, 1967, 38 pp.

[5] Bureau of Mines. Potential Sources of Aluminum. BuMines Inf. Cir. 8335, 1967, 148 pp.

weight. Four of the other samples were found to be suitable for production of structural clay products.[6]

Irreversible thermal expansion was described as a valuable tool in predicting behavior of various clays and ceramic body formulations. This method can be used for choosing proper ceramic raw materials to achieve specified results, for preliminary evaluation of deposits of clay or other ceramic raw materials, and for developing firing curves for the most efficient production of ceramic products.[7]

An instrument using a laser beam for alining clay sewer pipe was produced. A rear reference beam permitted continuing line checks to maintain accuracy. Faster installation, up to 50 percent above normal, was reported.[8]

Lightweight aggregate wall, floor, and roof panels were to be used in an experimental group of low-cost housing units to be constructed in a Washington, D.C., urban renewal site. Fire protection, long life, and low maintenance costs were cited as the reasons for choice of lightweight aggregate.[9]

In studying the formation of kaolinite at low temperatures, experiments showed that by introduction of Al–OH polymers into montmorillonite interlayers kaolin was readily formed at 175° to 220°C and 4,000 to 8,000 psi under slightly acid conditions. Introduction of aluminum in other forms did not result in more than small amount of kaolin formation even under strongly acid conditions.[10]

New data were obtained on the properties of bentonite which are important in determining its suitability for iron ore pellet binder. The electrokinetic forces between the clay and the iron ore exhibited a direct relationship with the green and dry strength of pellets formed using several domestic and foreign bentonites as binder. Additives, particularly those with sodium, effected the zeta potential and improved the pellet strength significantly.[11]

A high-energy, mechanically generated, ultrasonic vibration device for use in rapid and complete dispersion of clay bodies and glazes was described. Reuse of dried scrap from trimming operations and breakage of clay bodies was made possible by one pass through the device at the high rate of 50 gallons per minute of a ground and premixed scrap-water slurry containing 50 percent solids. The device, consisting essentially of a high pressure orifice and a specially designed blade for the slurry to impinge upon, takes up little space, requires very little power to operate and is much more rapid than conventional dispersion methods.[12]

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[6] Aase, James H. Lightweight Aggregates, Expansion Properties of Selected Michigan Shales. BuMines Rept. of Inv. 7055, 1967, 23 pp.

[7] Hanks, Charles F. Jr. Irreversible Thermal Expansion. Ceramic Age, v. 83, No. 8, August 1967, pp. 12–18.

[8] Brick & Clay Record. V. 151, No. 2 August 1967 pp. 22–23.

[9] Brick & Clay Record. V. 151, No. 2, August 1967, p. 22.

[10] Poncelet, G. M. and G. W. Brindley. Experimental Formation of Kaolinite from Montmorillonite at Low Temperatures. Am. Miner., v. 52, Nos. 7–8, July–August 1967, pp. 1161–1173.

[11] Stone, R. L. Relation Between the Zeta Potential of Bentonite and the Strength of Unfired Pellets. Trans. Soc. Min. Eng., v. 28, No. 3, September 1967, pp. 284–492.

[12] Walker, H. N., and W. W. McCarthy. Ultrasonic Dispersion of Clay Bodies. Am. Ceram. Soc. Bull., v. 46, No. 2, Feb. 1967, pp. 188–190.

———. Sonolation Cuts Scrap Reprocessing Time. Ceram. Ind. v. 88, No. 3, March 1967, pp. 46, 48.

Table 2.—Value of clays produced in the United States, by States

(Thousand dollars)

State	1966	1967	Kind of clay produced in 1967					
			Kaolin	Ball clay	Fire clay	Bentonite	Fuller's earth	Miscellaneous
Alabama	$5,142	$7,422	x		X	x		X
Arizona [1]	121	37	x			x		x
Arkansas	[2,3] 776	1,740	x		x			X
California	6,708	6,037	x	x	X	x	x	X
Colorado	r 1,315	1,274			x	x		x
Connecticut	296	334						x
Delaware	11	11						x
Florida	11,408	11,574	x				X	x
Georgia	73,685	77,314	X				X	X
Idaho	[1,2,3] 22	[2,3] 16	x		x			x
Illinois [4]	3,996	3,799			X		x	X
Indiana	2,196	2,126			X			X
Iowa	1,438	1,643						X
Kansas	1,006	1,339			x			X
Kentucky [5]	2,277	2,066		X	x			X
Louisiana	983	1,260						X
Maine	58	54			x			x
Maryland	[5] 1,084	1,462		x	x			X
Massachusetts	260	W						x
Michigan	2,620	2,636						X
Minnesota [3]	336	342			x			x
Mississippi	7,489	7,852		X	X	X	X	X
Missouri	5,989	6,220			X			X
Montana [1]	56	50			x	x		x
Nebraska	153	142						x
New Hampshire	51	42						x
New Jersey	1,319	1,189			x			x
New Mexico	W	74			x			x
New York	1,726	1,814						X
North Carolina [2]	2,241	2,012	x					X
North Dakota	r 100	W				x		x
Ohio	14,522	15,185			X			X
Oklahoma [1]	754	869			x	x		X
Oregon	362	[3] 295			x	x		x
Pennsylvania [2]	17,033	16,703	x		X			X
South Carolina	8,830	8,048	X					X
South Dakota	870	799				x		x
Tennseess [4]	4,909	5,152		X			x	X
Texas	7,187	8,081	x	x	X	X	x	X
Utah [2,3]	r 240	288	x		x	x	x	x
Virginia	1,813	1,623						X
Washington [3]	249	203			x			x
West Virginia [3]	334	254			X			x
Wisconsin	148	112						x
Wyoming	15,874	14,313			x	X		x
Other [6]	13,727	10,181						
Total	r 221,714	223,987						
Puerto Rico	271	244						x

r Revised. W Withheld to avoid disclosing individual company confidential data, included in "Other."
X Major producing States which account for approximately 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 kaolin included with "Other" to avoid disclosing individual company confidential data.
[3] Value of fire clay included with "Other" to avoid disclosing individual company confidential data.
[4] Value of fuller's earth included wth "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 Hawaii, Nevada and Vermont, value indicated by footnotes 1 through 6, and value indicated by W.

Table 3.—Kaolin sold or used by producers in the United States, by States

Year and State	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1963	2,911,926	$57,239,980	251,647	$2,530,294	3,163,573	$59,770,274
1964	3,119,922	62,621,540	211,420	1,985,452	3,331,342	64,606,992
1965	3,214,473	66,058,179	389,480	3,403,264	3,603,953	69,461,443
1966:						
Florida and North Carolina	38,241	849,924	------	---------	38,241	849,924
Georgia	3,002,230	65,766,471	204,224	1,389,886	3,206,454	67,156,357
South Carolina	W	W	W	W	538,426	7,433,792
Other States [1]	623,638	8,701,559	517,113	5,275,935	602,325	6,543,702
Total	3,664,109	75,317,954	721,337	6,665,821	4,385,446	81,983,775
1967:						
Arizona	62	1,531	-------	---------	62	1,531
California	22,431	229,308	-------	---------	22,431	229,308
Florida and North Carolina	38,267	922,159	-------	---------	38,267	922,159
Georgia	2,679,757	66,209,370	329,126	3,117,554	3,008,883	69,326,924
South Carolina	473,704	6,649,251	66,731	321,220	540,435	6,970,471
Other States [1]	121,527	1,635,721	241,314	2,234,490	362,841	3,870,211
Total	3,335,748	75,647,340	637,171	5,673,264	3,972,919	81,320,604

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Alabama, Arkansas, California (1966), Idaho, Pennsylvania, Texas, Utah, Vermont, and States indicated by symbol W.

Table 4.—Georgia kaolin sold or used by producers, by uses

(Thousand short tons and thousand dollars)

Year	China clay paper clay, etc.	Refractory uses	Total kaolin		
				Value	
	Quantity	Quantity	Quantity	Total	Average per ton
1963	2,276	214	2,490	$50,294	$20.20
1964	2,389	195	2,584	54,520	21.10
1965	2,478	243	2,721	57,411	21.10
1966	2,719	487	3,206	67,156	20.95
1967	2,708	301	3,009	69,327	23.04

Table 5.—Ball clay sold or used by producers in the United States

Year	Short tons	Value
1963	547,668	$7,541,471
1964	567,315	7,829,841
1965	590,717	8,197,474
1966	570,807	7,322,140
1967	559,165	7,445,652

Table 6.—Fire clay, including stoneware clay,[1] sold or used by producers in the United States, by States

Year and State	Sold by Producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1963	2,454,714	$9,392,863	5,935,460	$30,165,007	8,390,174	$39,557,870
1964	2,615,102	9,705,844	5,933,588	31,286,962	8,548,690	40,992,806
1965	2,823,837	10,581,447	6,191,812	32,532,388	9,015,649	43,113,835
1966:						
Alabama	W	W	W	W	455,113	2,174,120
California	W	W	W	W	476,262	1,417,520
Colorado	r 71,525	r 291,376	r 95,334	r 408,137	r 166,859	r 699,513
Illinois	W	W	W	W	264,036	1,562,439
Indiana	246,029	374,742	68,354	136,708	314,383	511,450
Kansas	W	W	W	W	126,681	271,362
Kentucky	W	W	W	W	177,612	1,086,000
Maine	---------	---------	30	87	30	87
Maryland	W	W	W	W	28,201	152,618
Missouri	W	W	W	W	1,285,159	4,898,181
New Jersey	W	W	W	W	108,874	830,104
Ohio	919,600	2,567,525	1,353,789	8,174,881	2,273,389	10,742,406
Oklahoma	---------	---------	370	3,700	370	3,700
Pennsylvania	504,403	1,298,566	1,115,838	9,157,121	1,620,241	10,455,687
Texas	W	W	W	W	859,367	2,057,041
Other States [2]	854,913	4,336,616	r 3,547,980	r 15,429,955	r 621,588	r 5,317,186
Total	r 2,596,470	r 8,868,825	r 6,181,695	r 33,310,589	r 8,778,165	r 42,179,414
1967:						
Alabama	W	W	W	W	622,484	3,855,928
California	W	W	W	W	420,985	1,140,011
Colorado	46,899	225,954	95,776	409,584	142,675	635,538
Illinois	92,192	892,035	152,170	480,731	244,362	1,372,766
Indiana	193,086	311,762	54,205	108,410	247,291	420,172
Kansas	W	W	W	W	142,897	312,054
Kentucky	W	W	W	W	144,296	926,484
Maine	---------	---------	34	99	34	99
Missouri	86,666	204,664	1,043,907	4,542,159	1,130,573	4,746,823
Montana	119	477	---------	---------	119	477
New Jersey	W	W	W	W	99,527	765,906
New Mexico	410	3,690	60	300	470	3,990
Ohio	839,614	2,668,634	1,175,025	7,561,430	2,014,639	10,230,064
Oklahoma	---------	---------	376	3,760	376	3,760
Pennsylvania	489,512	1,212,509	945,714	9,743,259	1,435,226	10,955,768
Texas	W	W	W	W	747,909	1,861,986
Other States [2]	763,913	4,469,811	1,992,735	9,318,160	578,550	4,925,602
Total	2,512,411	9,989,536	5,460,002	32,167,892	7,972,413	42,157,428

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes stoneware clay as follows, in short tons: 1963, 44,798; 1964, 45,679; 1965, 49,517; 1966, 45,887; 1967, 51,579.
[2] Includes Arkansas, Idaho, Maryland (1967), Minnesota, Mississippi, New Mexico (1966), North Dakota (1966), Oklahoma (1967), Utah, Washington, West Virginia, and Wyoming, and States indicated by symbol W.

Table 7.—Bentonite sold or used by producers in the United States, by States

Year and State	Short tons	Value	Year and State	Short tons	Value
1963	1,584,516	$18,536,229	1967:		
1964	1,729,503	19,413,396	Colorado	1,663	$13,250
1965	1,887,947	20,406,968	Mississippi	259,133	3,067,207
			Oregon	799	9,588
1966:			Texas	97,211	660,205
Colorado	800	$8,700	Utah	2,508	24,768
Mississippi	291,313	3,614,653	Wyoming	1,454,670	14,223,137
Oregon	656	7,872	Other States [1]	226,857	2,492,166
North Dakota	10	200			
Texas	107,443	875,896	Total	2,042,841	20,490,321
Utah	2,541	r 23,933			
Wyoming	1,506,579	15,753,520			
Other States [1]	151,274	1,725,045			
Total	2,060,616	r 22,009,819			

r Revised.
[1] Alabama, Arizona, California, Idaho (1966), Montana, Nevada, North Dakota (1967), Oklahoma, and South Dakota.

Table 8.—Fuller's earth sold or used by producers in the United States, by States

Year and State	Short tons	Value	Year and State	Short tons	Value
1963	481,817	$11,210,618	1967:		
1964	551,886	12,742,897	Florida and Georgia	655,990	$17,537,864
1965	674,422	15,795,385	Utah	2,645	44,905
			Other States [1]	145,284	2,955,823
1966:			Total	803,919	20,538,592
Florida and Georgia	633,899	16,006,985			
Utah	4,254	66,222			
Other States [1]	121,485	2,280,677			
Total	759,638	18,353,884			

[1] Includes California, Illinois, Mississippi, Nevada, Tennessee, and Texas.

Table 9.—Miscellaneous clay, including shale and slip clay sold or used by producers in the United States, by States

Year and State	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1963	1,041,823	$1,190,063	34,926,431	$43,004,301	35,968,254	$44,194,364
1964	1,365,870	1,610,590	36,852,775	45,435,871	38,218,645	47,046,461
1965	1,310,360	1,462,703	38,043,204	46,494,208	39,353,564	47,956,911
1966:						
Alabama	W	W	W	W	18,68,820	1,859,663
Arizona	---------	---------	89,014	119,758	89,014	119,758
Arkansas	---------	---------	775,125	776,335	775,125	776,335
California	157,815	271,659	2,291,663	4,505,302	2,449,478	4,776,961
Colorado	46,031	137,997	385,214	469,091	431,245	607,088
Connecticut	W	W	W	W	192,240	295,500
Delaware	---------	---------	11,400	11,400	11,400	11,400
Georgia	---------	---------	1,685,765	1,040,053	1,685,765	1,040,053
Idaho	---------	---------	23,463	22,075	23,463	22,075
Illinois	6,000	6,000	1,623,572	2,427,831	1,629,572	2,433,831
Indiana	187,770	190,217	988,825	1,494,484	1,176,595	1,684,701
Iowa	---------	---------	1,130,405	1,437,686	1,130,405	1,437,686
Kansas	W	W	W	W	720,108	734,814
Kentucky	---------	---------	974,376	1,191,091	974,376	1,191,091
Louisiana	W	W	W	W	1,005,200	982,531
Maine	---------	---------	44,865	58,290	44,865	58,290
Maryland	W	W	W	W	827,529	931,557
Massachusetts	---------	---------	201,754	260,247	201,754	260,247
Michigan	---------	---------	2,449,801	2,619,691	2,449,801	2,619,691
Minnesota	---------	---------	224,080	336,145	224,080	336,145
Missisppi	---------	---------	1,156,328	1,201,313	1,156,328	1,201,313
Missouri	W	W	W	W	1,043,695	1,091,274
Montana	---------	---------	53,386	56,160	53,386	56,160
Nebraska	---------	---------	152,806	152,806	152,806	152,806
New Hampshire	---------	---------	50,790	50,790	50,790	50,790
New Jersey	---------	---------	378,999	488,823	378,999	488,823
New York	W	W	W	W	1,463,856	1,725,979
North Carolina	---------	---------	3,380,712	2,241,051	3,380,712	2,241,051
Ohio	234,012	214,771	2,581,786	3,565,302	2,815,798	3,780,073
Oklahoma	---------	---------	745,073	750,048	745,073	750,048
Oregon	W	W	W	W	360,351	354,345
Pennsylvania	87,816	65,471	1,585,057	6,511,680	1,672,873	6,577,151
South Carolina	---------	---------	1,600,372	1,395,997	1,600,372	1,395,997
Tennessee	---------	---------	973,612	363,813	973,612	363,813
Texas	1,240	1,488	3,521,263	3,932,262	3,522,503	3,933,750
Utah	W	W	W	W	82,295	150,071
Virginia	---------	---------	1,486,344	1,813,396	1,486,344	1,813,396
Washington	W	W	W	W	185,118	248,794
West Virginia	20,111	21,522	280,210	312,709	300,321	334,231
Wisconsin	---------	---------	122,799	147,849	122,799	147,849
Undistributed [1]	415,215	489,456	8,035,868	8,713,305	701,871	828,233
Total	1,156,010	1,398,581	39,004,727	48,466,783	40,160,737	49,865,364

See footnotes at end of table.

Table 9.—Miscellaneous clay, including shale and slip clay sold or used by producers in the United States, by States—Continued

Year and State	Sold by producers		Used by producers		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1967:						
Alabama	W	W	W	W	1,917,395	$2,173,067
Arizona	---------	----------	66,575	$ 35,003	66,575	35,003
Arkansas	---------	----------	810,702	1,066,036	810,702	1,066,036
California	195,495	$337,736	1,922,853	3,693,864	2,118,348	4,031,600
Colorado	72,521	145,042	379,639	479,869	452,160	624,911
Connecticut	---------	----------	191,000	334,200	191,000	334,200
Delaware	---------	----------	11,000	11,000	11,000	11,000
Georgia	---------	----------	1,673,390	1,093,765	1,673,390	1,093,765
Idaho	---------	----------	19,065	15,615	19,065	15,615
Illinois	---------	----------	1,636,963	2,245,806	1,636,963	2,425,806
Indiana	191,037	193,606	1,050,796	1,512,695	1,241,833	1,706,301
Iowa	---------	----------	1,207,693	1,642,879	1,207,693	1,642,879
Kansas	---------	----------	791,977	1,027,069	791,977	1,027,069
Kentucky	W	W	W	W	1,050,944	1,139,675
Louisiana	---------	----------	995,225	1,260,128	995,225	1,260,128
Maine	---------	----------	41,590	54,340	41,590	54,340
Maryland	W	W	W	W	969,572	1,145,091
Michigan	---------	----------	2,465,692	2,635,970	2,465,692	2,635,970
Minnesota	---------	----------	227,651	341,501	227,651	341,501
Mississippi	---------	----------	1,088,873	1,479,413	1,088,873	1,479,413
Missouri	---------	----------	1,174,285	1,473,064	1,174,285	1,473,064
Montana	---------	----------	46,036	49,493	46,036	49,493
Nebraska	---------	----------	125,906	141,596	125,906	141,596
New Hampshire	---------	----------	42,350	42,350	42,350	42,350
New Jersey	---------	----------	337,632	423,027	337,632	423,027
New Mexico	1,249	12,025	44,553	58,048	45,802	70,073
New York	W	W	W	W	1,506,333	1,814,271
North Carolina	---------	----------	2,976,661	2,012,077	2,976,661	2,012,077
Ohio	257,683	198,265	2,397,720	4,757,105	2,655,403	4,955,370
Oklahoma	---------	----------	743,810	865,033	743,810	865,033
Oregon	W	W	W	W	294,138	285,196
Pennsylvania	85,222	61,958	1,473,643	5,685,903	1,558,865	5,747,861
South Carolina	---------	----------	1,192,543	1,077,514	1,192,543	1,077,514
Tennessee	---------	----------	1,201,861	533,231	1,201,861	533,231
Texas	---------	----------	3,597,572	4,882,301	3,597,572	4,882,301
Utah	W	W	W	W	108,716	218,667
Virginia	---------	----------	1,382,302	1,623,037	1,382,302	1,623,037
Washington	W	W	W	W	138,862	202,737
West Virginia	W	W	W	W	244,756	253,904
Wisconsin	---------	----------	88,790	111,887	88,790	111,887
Undistributed [1]	250,375	317,830	6,852,413	7,923,428	872,072	1,008,650
Total	1,053,582	1,266,462	38,258,761	50,768,247	39,312,343	52,034,709

W Withheld to avoid disclosing individual company confidential data.
[1] Includes States indicated by symbol W and Florida, Hawaii, Massachusett (1967), Nevada, New Mexico (1966), North Dakota, South Dakota, Vermont, and Wyoming.

Table 10.—Clay sold or used by producers in the United States in 1967, by kinds

(Short tons)

Uses	Kaolin	Ball clay	Fire clay and stoneware clay	Bentonite	Fuller's earth	Miscellaneous clay including slip clay	Total
Pottery and stoneware:							
Whiteware, etc	[1] 137,320	[1] 254,665					[1] 391,985
Stoneware, art pottery, flower pots, and glaze slip	(1)	(1)	51,579			77,567	[1] 129,146
Total	137,320	254,665	51,579			77,567	521,131
Floor and wall tile	54,045	114,564	214,316			101,979	484,904
Refractories:							
Firebrick and block	433,778	(2)	2,852,167			(2)	3,324,249
Bauxite, high-alumina brick	(2)		86,106				[3] 86,106
Fire-clay mortar	(2)	(2)	153,947			(2)	178,177
Clay crucibles			(2)				(2)
Glass refractories	(2)	(2)	(2)				(2)
Foundries and steel works	(2)	(2)	528,542	[4] 652,305		(2)	1,209,236
Zinc retorts			(2)				(2)
Saggers, pins, stilts, and wads	(2)	(2)	(2)				198,432
Other refractories	83,933	106,401	403,102	(4)		22,142	326,223
Total	517,711	106,401	4,023,864	652,305		22,142	5,322,423
Heavy clay products: Building brick, paving brick, drain tile, sewer pipe, and kindred products		(5)	3,560,043			18,932,716	[6] 22,492,759
Architectural terra cotta	(5)		(5)				(5)
Lightweight aggregates			(5)			8,779,428	[6] 8,779,428
Filler:							
Paper filling	688,501			(5)			[3] 688,501
Paper coating	1,258,276				(5)		[3] 1,258,276
Rubber	365,112						365,112
Paint	111,152						111,152
Fertilizers	82,931		(2)			6,180	[3] 89,111
Insecticides and fungicides	12,644		(2)	10,342	180,500	(5)	[3] 203,486
Other fillers	79,097	(5)	27,422	(5)	4,502	(5)	130,221
Total	2,597,713	(5)	27,422	10,342	185,002	6,180	2,845,859
Portland and other hydraulic cements	101,546			(5)	(5)	11,096,125	[6] 11,197,671
Miscellaneous:							
Filtering, decolorizing and clarifying				150,695	34,996		185,691
Rotary-drilling mud			5,856	413,133	62,735	(5)	[6] 481,724
Chemicals	(5)		(5)	(5)	(5)		120,536
Animal feed				39,765	(5)		[6] 39,765
Absorbent uses			(5)	(5)	482,272	(5)	[6] 482,272
Enameling	(5)	(5)		(5)			18,530
Catalysts (oil refining)	(5)						(5)

Pelletizing:							
Iron ore	---	---	---	548,947	---	---	548,947
Other	---	---	---	15,739	---	---	15,739
Reservoir, pond and ditch lining	---	---	---	(5)	---	---	(5)
Other uses	564,584	83,535	89,333	211,915	38,914	296,206	1,126,221
Total	564,584	83,535	95,189	1,380,194	618,917	296,206	3,019,425
Grand total:							
1967	3,972,919	559,165	7,972,413	2,042,841	803,919	39,312,343	54,663,600
1966	4,385,446	570,807	r 8,778,165	2,060,616	759,638	40,160,737	r 56,715,409

r Revised.
1 Some stoneware, art pottery, etc., included with whiteware.
2 Included with "Other."
3 Incomplete figure; remainder included with "Other."
4 Some "Other refractories" included with foundries.
5 Included with miscellaneous "Other Uses."
6 Incomplete figure; remainder included with miscellaneous "Other uses."

Table 11.—Shipments of refractories in the United States, by kinds

Product	Unit of quantity	Shipments 1966 Quantity	Shipments 1966 Value (thousands)	Shipments 1967 Quantity	Shipments 1967 Value (thousands)
Clay refractories:					
Fire-clay (including semisilica) brick and shapes, except super-duty.	1,000 9-inch equivalent	311,934	$50,375	276,242	53,357
Superduty fire-clay brick and shapes	do	91,147	26,674	79,078	24,463
High-alumina brick and shapes (50 percent Al_2O_3 and over) made substantially of calcined diaspore or bauxite.[1]	do	51,364	26,951		
Insulating firebrick and shapes	do	77,638	20,268	59,363	17,528
Ladle brick	do	210,995	26,296	185,314	23,766
Sleeves, nozzles, runner brick and tuyeres	do	51,222	12,919	45,033	12,232
Glasshouse pots, tank blocks, feeder parts and upper structure shapes used only for glass tanks.[1]	Short ton	14,572	5,284		
Hot-top refractories	do	66,460	5,074	48,436	4,015
Clay-kiln furniture, radiant-heater elements, potters' supplies, and other miscellaneous shaped refractory items.		NA	8,238		7,851
Refractory bonding mortars, airsetting (wet and dry types).	Short ton	63,541	7,560	62,715	8,692
Refractory bonding mortars, except air-setting types.[2]	do	16,372	1,804	14,556	1,692
Ground crude fire clay, high-alumina clay and silica fire clay.	do	531,061	6,000		
Plastic refractories and ramming mixes.[2]	do	201,518	18,677	188,692	16,855
Castable refractories (hydraulic-setting)	do	175,232	17,562	158,256	16,163
Insulating castable refractories (hydraulic-setting).	do	34,160	4,505	38,615	5,082
Other clay refractory materials sold in lump or ground form.[3 4]	do	199,291	5,329	280,792	6,167
Total clay refractories		XX	243,516	XX	197,863
Nonclay refractories:					
Silica brick and shapes	1,000 9-inch equivalent	97,244	19,057	71,191	14,701
Magnesite and magnesite-chrome brick and shapes (magnesite predominating) (excluding molten cast and fused magnesia).	do	106,697	100,446	94,082	90,200
Chrome and chrome-magnesite brick and shapes (chrome predeominating (excluding molten cast).	do	34,878	27,209	22,312	18,923
Graphite crucibles, retorts, stopper heads, and other shaped refractories, containing natural graphite.	Short ton	19,525	14,964	16,587	13,727
Mullite brick and shapes made predominantly of kyanite, silimanite, and alusite or synthetic mullite (excluding molten-cast).	1,000 9-inch equivalent	7,929	10,246	6,566	9,241
Extra-high alumina brick and shapes made predominantly of fused bauxite, fused or dense-sintered alumina (excluding molten-cast).	do	3,802	9,484	2,861	6,932
Silicon carbide brick and shapes made predomnantly of silicon carbide.	do	3,996	12,415	1,201	4,136
Zircon and zirconia brick and shapes made predominantly of either of these materials.	do	1,958	5,973	1,435	5,397
Forsterite, pyrophyllite, molten,cast, dolomite, dolomite-magnesite, and other nonclay brick and shapes.[5]	do	26,847	40,207	25,760	41,659
Mortars:					
Basic bonding mortars (magnesite or chrome ore predominating).	Short ton	90,312	7,385	79,886	6,634
Other nonclay refractory mortars	do	41,103	5,983	38,221	5,713
Nonclay refractory castables (hydraulic-setting)	do	27,331	5,439	31,246	6,786

Table 11.—Shipments of refractories in the United States, by kinds—Continued

Product	Unit of quantity	Shipments 1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
Nonclay refractories—Continued					
Plastic refractories and ramming mixes (wet and dry types):					
Basic (magnesite, dolomite, or chrome ore predominating).	----do ----	174,787	19,691	153,455	17,261
Other nonclay plastic refractories and ramming mixes.	----do ----	46,881	11,433	57,564	12,603
Dead-burned magnesia or magnesite------	----do ----	137,060	8,933	100,774	6,241
Carbon refractories; brick, blocks and shapes, excluding those containing natural graphite.	----do ----	434,441	44,969	(6)	(6)
Other nonclay refractory materials sold in lump or ground form.[3]	----do ----			257,101 99,360	22,195 13,438
Total nonclay refractories-------------	-----------	XX	343,834	XX	295,784
Grand total refractories---------------	-----------	XX	587,350	XX	493,647

NA Not available. XX Not applicable.
[1] Excludes data for mullite and extra-high alumina refractories. These products are included with millite and extra-high alumina brick and shapes in the nonclay refractories section.
[2] 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 refra tories section.
[3] Represents only shipments by establishments classified in "manufacturing" industries, and excludes shipments to refractory producers for the manufacture of brick and other refractories.
[4] Includes data for calcined clay, ground brick, and siliceous and other gunning mixes.
[5] Includes carbon refractories, 1967.
[6] Included with fosterite, etc.

Table 12.—Shipments of principal structural clay products in the United States

Product	1963	1964	1965	1966	1967
Unglazed brick (building) 1,000 standard brick--	7,405,000	7,743,800	8,089,131	7,606,237	7,117,353
Value--------------------thousands--	$267,100	$284,600	$301,038	$292,914	$285,630
Unglazed structural tile--------short tons--	342,800	311,400	313,260	267,431	234,517
Value--------------------thousands--	$5,600	$5,400	$5,128	$5,317	$4,900
Vitrified clay sewer pipe and fittings short tons--	1,771,900	1,837,200	1,732,159	1,610,318	1,572,167
Value--------------------thousands--	$97,700	$104,000	$103,420	$96,707	$97,330
Facing tile, seramic glazed, including glazed brick-----------1,000-brick equivalent--	352,900	332,700	307,944	292,525	230,064
Value--------------------thousands--	$28,600	$27,500	$25,430	$25,179	$21,274
Facing tile, unglazed and salt glazed 1,000-tile, 8-by 5- by 12-inch, equivalent--	8,500	6,900	6,327	5,207	3,352
Value--------------------thousands--	$1,700	$1,500	$1,435	$1,284	$837
Clay floor and wall tile and accessories, including quarry tile ----1,000 square feet--	267,100	288,800	283,385	272,688	257,532
Value--------------------thousands--	$137,900	$146,200	$141,739	$133,266	$128,139
Total value------------thousands--	$538,600	$569,200	$578,190	$554,667	$538,110

Table 13.—World production of china clay, by countries [1] [2]

(Short tons)

Country	1963	1964	1965	1966	1967 p
North America:					
Mexico	51,325	70,796	89,436	106,473	86,632
United States	3,163,573	3,331,342	3,603,953	4,385,446	3,973,143
South America:					
Argentina	39,572	47,098	80,411	r 79,366	NA
Chile	40,674	50,665	r 33,813	r 44,561	32,434
Colombia	r 82,673	r 88,945	r 91,492	r 17,976	NA
Ecuador	418	370	215	982	890
Peru	58	364	430	460	NA
Europe:					
Austria (marketable)	r 115,528	r 119,873	r 115,953	r 112,664	e 115,000
Belgium	55,910	NA	NA	199,659	108,914
Bulgaria	85,000	91,000	105,000	e 110,000	NA
Czechoslovakia	350,000	345,000	365,000	e 370,000	NA
Denmark:					
Crude	13,296	8,818	7,548	16,535	16,535
Washed and pressed	r 7,275	NA	2,756	3,307	3,307
France [3]	299,599	316,887	325,614	r 479,994	NA
Germany, West (marketable)	427,414	451,371	440,462	r 448,640	397,071
Greece	r 33,807	r 54,600	e 60,600	e 77,000	e 77,000
Hungary	48,760	55,488	59,525	r 68,343	NA
Italy:					
Crude	r 109,129	107,352	78,704	r 76,443	96,742
Kaolinic earth	111,978	103,881	51,082	NA	NA
Portugal	41,871	r 42,211	r 44,527	r 37,551	39,882
Spain (marketable)	228,849	155,345	r 161,723	NA	NA
Sweden	34,969	48,544	r 46,004	r 30,093	NA
U.S.S.R. e	1,650,000	1,650,000	r 1,750,000	r 1,750,000	1,900,000
United Kingdom	r 2,125,254	r 2,277,372	r 2,473,584	e 2,712,000	2,935,000
Yugoslavia	4,500	5,500	5,500	5,500	4,400
Africa:					
Eritrea	NA	NA	e 200	r 94,962	8,311
Kenya	7,345	1,420	1,889	984	1,605
Mozambique	6	11	165	386	636
Nigeria	17	3	29	22	358
Rhodesia, Southern	12,240	21,000	NA	NA	NA
South Africa, Republic of	37,412	43,495	45,629	44,664	36,194
Swaziland	2,211	344	830	647	2,050
Tanzania	201	122	----------	342	344
United Arab Republic	23,158	69,221	52,663	55,101	NA
Asia:					
Hong Kong	5,621	5,648	5,277	6,463	9,447
India [4]	r 554,462	r 572,099	647,313	709,533	710,990
Japan	109,381	118,333	98,415	r 129,591	165,838
Korea, South	57,609	66,729	79,635	123,717	113,181
Malaysia	1,317	1,591	1,749	1,765	1,969
Pakistan	----------	1,084	1,421	3,308	3,187
Taiwan e	47,000	47,000	56,000	65,000	67,000
Vietnam, South	4,928	2,283	NA	NA	NA
Oceania: Australia [5]	49,889	r 50,532	r 66,845	r 56,123	NA
Total [6]	r 10,034,229	r 10,423,737	r 11,051,392	r 12,425,601	NA

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

[1] China clay is also produced in Brazil, China (Mainland), East Germany, Israel, Rumania, and Thailand, but data on production are not available; a negligible quantity is produced in Malagasy and Paraguay.

[2] Compiled mostly from data available June 1968.

[3] Includes kaolinic clay.

[4] Includes sold or used as such (both saleable and non-saleable varieties).

[5] Includes ball clay.

[6] Total is of listed figures only; no undisclosed data included.

Coal—Bituminous and Lignite

By W. H. Young [1] and J. J. Gallagher [2]

There was general improvement in the bituminous coal and lignite industry in 1967, compared with 1966. Preliminary figures indicated that most of the major items in the industry increased. Though production increased, consumption declined slightly, resulting in a buildup of stockpiles.

This chapter includes all coal produced in the United States except Pennsylvania anthracite, Texas lignite, and bituminous coal and lignite from mines that produced less than 1,000 tons per year. All quantity figures refer to marketable coal and exclude washery and other refuse, and all figures are preliminary except those on distribution, exports, imports, and world production. Final detailed figures will be published as a supplement to the Mineral Industry Survey, the Weekly Coal Report, and in the 1968 Minerals Yearbook.

[1] Assistant chief, Section of Fuels, Division of Statistics.
[2] Supervisory industry economist, Division of Mineral Studies.

Table 1.—Salient statistics of the bituminous coal and lignite industry in the United States

Item	1966	1967 p	Change (percent)
Production ... thousand short tons	533,881	[1] 551,000	+ 3.2
Consumption ... do	486,266	480,255	− 1.2
Stocks at end of year:			
Industrial consumers and retail yards ... do	74,466	93,128	+25.1
Stocks on upper lake docks ... do	2,342	2,280	− 2.6
Imports and exports: [2]			
Imports ... do	178	227	+27.5
Exports ... do	49,302	49,510	+ .4
Price indicators, average per net ton:			
Cost of coking coal at merchant coke ovens	$9.81	$10.50	+ 7.0
Railroad freight charge [3]	$3.01	([4])	--------
Value f.o.b. mines	$4.54	$4.77	+ 5.1
Method of mining:			
Hand loaded underground ... thousand short tons	28,243	27,947	− 1.0
Mechanically loaded underground ... do	310,281	321,387	+ 3.6
Percentage of total underground production mechanically loaded	91.7	92.0	+ .3
Mined by stripping ... thousand short tons	180,058	185,687	+ 3.1
Mined at auger mines ... do	15,299	15,979	+ 4.4
Mechanically cleaned ... do	340,626	352,640	+ 3.5
Number of mines	6,749	6,800	+ .8
Average number of days worked	219	([4])	--------
Average number of men working daily	131,752	([4])	--------
Production per man per day ... short tons	18.52	([4])	--------
Fuel efficiency indicator: Pounds of coal per kilowatt-hour at electric powerplants [5]	0.87	0.87	--------

p Preliminary.
[1] Revision based on later and more complete information.
[2] Bureau of the Census, U.S. Department of Commerce.
[3] Average compiled by the Bureau of Mines from Interstate Commerce Commission Freight Commodity Statistics. Effective January 1, 1965, the Interstate Commerce Commission redefined Class I railroads as those having annual operating revenues of 5 million dollars or more instead of 3 million dollars or more. On the reclassified basis the average freight charge in 1965 would have been $3.13, 1964 would have been $3.16 and in 1963, $3.26. In the years 1957 through 1962, under the new classification the average freight charges remain unchanged.
[4] Data not available.
[5] Federal Power Commission.

DISTRIBUTION AND SHIPMENTS

Total shipments of bituminous coal and lignite in 1967 increased 3.8 percent over those of 1966, with most geographic divisions sharing in the increase. The greatest gains were in the South Atlantic, East South Central, East North Central, and Middle Atlantic geographic divisions. Of the total increase in shipments in 1967 over the 1966 level, amounting to a net gain of over 20 million tons, electric utilities gained 25 million tons, coke and gas plants were down 0.8 million tons, retail dealers were down 2 million tons. "All others" declined 2 million tons, and exports were unchanged.

ECONOMIC ADVANCES

The symbiotic relationship between growth in the coal industry and growth in the electric utilities continued through 1967. New coal-fired steam generating units on order or announced during 1967 totaled 134 units with a total capacity of 57,223 megawatts that will result in a total additional coal demand of 157 million tons. A considerable proportion of this demand will be met by new mines supplying new generating plants at or nearby the mine site, while new mines shipping by unit-train will supply another segment of this demand. Some 22 mines with an annual capacity of 49 million tons that will provide coal for mine-site generating plants were planned or under construction during 1967. Twenty-one mines capable of annually producing 42 million tons to be shipped by unit-train were in the planning stage or under construction.

Growth in the metallurgical market does not parallel growth in the electric utility market although 17 new metallurgical coal mines capable of producing 26 milion tons annually were planned or under construction during 1967. Although the majority of these new metallurgical coal mines will replace obsolete or worked-out mines, some of the new capacity will be destined for the export market.

TECHNOLOGY

Noteworthly among the developments in underground coal mining during 1967 was the publication of Schedule 2 G in the Federal Register by the Bureau of Mines, paving the way for utilization of higher voltages on face mining equipment. The new proposed voltage limits increase the maximum allowable alternating current voltage from 650 to 660 volts, and to 4,160 volts provided certain conditions are met. Adoption of this proposed limit will lead to installation of higher horsepower motors on face mining equipment and to reduction in the size of trailing cables that lead from section power distribution boxes to mining equipment. The need for higher permissible voltage at the mining face became apparent as the horsepower of equipment increased and the size of trailing cables increased to supply the necessary power under existing voltage limitations.

During 1967, equipment manufacturers continued to increase the horsepower of drive motors used on face mining equipment. In anticipation of higher permissible face voltages, some manufacturers delivered machines that operated at 550 volts alternating current but could, by a relatively simple change of connections, be modified to operate at 975 volts alternating current.

Advances continued in the field of underground mine safety with at least three manufacturers producing methane-monitors for installation on face mining equipment following the successful test period of initial units. Testing continued on a face-mining-machine-mounted device designed to depress ignitions of gas or coal dust by automatically dispersing a cloud of flame-quenching dust upon being activated by a detector that senses ultra-violet portion of the spectrum from light emitted by the ignition. A new approach to solving the problem of anchoring roof bolts in soft strata was introduced while another approach received increasing attention. A new type of roof bolt that consists of two half-bolts stepped throughout the entire length of both halves is designed to expand to provide anchorage for the entire length of the bolt. After a period of testing in previous years, the resin-seated roof bolt was being commercially produced.

One of the outstanding contributions announced in the field of mining research during 1967 was the development of a method to predict the sulfur and ash content of coal in place from the computer analysis of core-hole sample analyses. This technique can be used to predict sulfur distribution and washability characteristics from exploration core drill data ahead of mining. Selective mining can then follow predicted distribution to produce a uniform metallurgical coal product.

Modern longwall mining continued to find acceptance in the coal industry during 1967. At least 13 installations employing either shearers or plows were operated during the year. A survey of the equipment manufacturers indicated that equipment for at least eight new installations were ordered during the year, some by companies with no previous experience with this method of mining. Originally designed and manufactured for use under European mining conditions that include pack walls to support a portion of the caved strata, face support units have been modified for U.S. mining applications that involve complete caving of the undermined strata. Support units in some U.S. installations employ jacks with as great as 140 tons maximum yielding resistance. With such high yielding resistance, the support bases have been enlarged to provide larger floor-bearing surfaces to reduce the incidence of floor penetration by the prop bases. To alleviate methane liberation problems on longwall faces, at least two operators of longwall installations are practicing methane control methods in addition to normal bleeding of methane from virgin longwall panels. At one installation, which had previously experimented with water infusion, bleeder holes are drilled to depths as great as 152 feet in the developed longwall panel in advance of mining by the longwall face machine. At another installation water infusion of bleeder holes was practiced to liberate the entrapped methane in advance of the retreating longwall face.

Treatment of airbone dust continued during the year along two veins—collection at the face and dilution by inert dust. Efforts of one research organization show promise for solving the problem of airborne dust at the face through the development of a collection system. To be installed on face equipment, the system employs several intake collection points and wet cyclones to concentrate the dust. Automatic trickle dusters mounted on face exhaust fans were manufactured to disperse inert rock dust in the return airways to dilute float dust produced by face mining machines.

Continuing the trend in underground haulage, higher powered models of battery-powered tractors and larger capacity trailers were introduced. Battery-powered rubber-tired tractors with a gross weight in excess of 12 tons were available while rubber-tired trailers were available with a maximum capacity of 16 tons. The number of large-capacity mines opened that employ this type of haulage equipment exclusively continued to increase.

Emphasis in surface mining continued to be on large-capacity earth-moving equipment. While no new marks were set in the maximum size of shovels used in overburden removal, the upper limit in sizes of draglines used for this purpose continued to rise. A 130-cubic-yard dragline of U.S. manufacture was placed in operation in Australia, surpassing the previous limit of 85 cubic yards. The beginning of construction on a 145-cubic-yard model in Indiana and a 220-cubic-yard model in Ohio portends new records in the capacity of earth-moving equipment. The new 220-cubic-yard dragline, with a 315-foot boom and a total weight of 27 million pounds, is scheduled for completion in 1968. Known as the "Big Muskie," this behemoth will remove 325 tons of overburden in one pass. Built as a part of a $40 million expansion progam, the shovel will uncover coal that will be transported by two 1,500-ton-capacity trains shuttling over an electric railway system between the mine and an electric power generating plant. Although no coal-hauling trucks larger than the 240-ton capacity unit announced in 1965 were built in 1967, haulage units in the 100- to 120-ton capacity range are being selected for new surface mines and to replace smaller-sized haulage units at existing mines. Of concern to manufacturers of coal-loading shovels was the swing to articulated front-end loaders for coal loading. Being more versatile than coal loading shovels, these machines serve multiple purposes such as coal loading, overburden removal, coalbed cleaning, and general grading. They are ideally suited for selective mining where the coalbed consists of several benches separated by partings that the operator wishes to discard prior to loading. The capacity of end-loader followed the trend toward large-sized surface mining equipment with 10-cubic-yard-capacity loaders becoming commonplace while a 30-cubic-yard-capacity end-loader was displayed at an equipment show.

Interest in the environment effects of surface mining and surface mine reclamation increased. The Department of the Interior released a report [3] that presents the results of a nationwide survey of the effects of surface mining and sets forth recommendation that presaged increased surface mine reclamation legislation. In keeping with these recommendations, the Department issued standards for reclamation of surface mining operations on Interior-administered public lands, Indian lands, and acquired areas. Bills were introduced in Congress that generally followed the recommendations of the report. In line with increased interest in surface mine reclamation, a number of legislative bodies in States with no reclamation laws introduced or enacted surface mining laws during 1967 while similar bodies in several States with existing reclamation laws enacted or introduced more stringent requirements.

Several imaginative approaches to problems of both surface mining reclamation and solid waste disposal were initiated. Plans were formulated by officials of a major Eastern city, a railroad, and a strip mining company to embark on a program in which refuse from the city would be carried by unit-trains to abandoned anthracite strip mines where it would be deposited and covered with earth from the strip-mine spoil bank. A somewhat similar plan was initiated in the bituminous-coal fields of northwestern Maryland where a pilot project of sanitary landfill in abandoned strip mines was started by the Maryland Health Service. In another approach, addition of fly ash to spoil was shown to assist in reclamation of strip mine spoil by increasing the pH and making the spoil texture more amenable to plant growth. The first surface mine reclamation project submitted under the provisions of the Appalachian Regional Development Act of 1965 was approved by the Appalachian Regional Commission. The project called for the restoration of 177 acres of strip-mined land in the Moraine State Park in Butler County, Pa.

Coal preparation advances followed evolutionary lines established in prior years with increasing emphasis on heavy-medium equipment. The first heavy-medium unit for producing three products—clean coal, middlings, and refuse—completed a full year of operation. Removal of sulfur from fine coal sizes received increasing attention, with hydrocyclones being used to concentrate the sulfur, and sieve bends being used to isolate it for removal. Flotation was increasingly used to clarify preparation plant treatment water in closed and open circuits and to beneficiate fine sizes. Increasing emphasis was placed on reducing particulate matter in thermal dryer stacks and dust collectors to meet the requirements of new regulations enacted by the States. Both dry-type collectors and wet scrubbers were being investigated.

In keeping with the trend toward unit-train shipments of coal in the last several years, new preparation facilities were constructed in 1967 with special coal handling and storage facilities designed for unit-train loading. Some older preparation plants were equipped for unit-train handling to enable operators to compete with newer facilities. Although track storage still is being used by some operators, in order to adapt their operations to unit-train movement, many producers have been installing large new silo- or bin-type storage facilities. Of the types of storage available, ground storage appears to be most popular because of the low capital investment required and the inherent flexibility of capacity.

Although the unit-train concept has been thought practicable for only large tonnage producers, the transloading principle has been applied to demonstrate the possibilities for small producers to ship by unit-train. The first coal storage and loading facility using this principle

[3] U.S. Department of the Interior. Surface Mining and Our Environment. 1967, 124 pp.

operated throughout 1967. Through a unique combination of unloading, storage and unit-train loading units, this facility enables a number of mines within a 25-mile radius of the site to ship by unit-train that might not otherwise be able to reap the benefits of unit-train shipping rates. Comprised of three silos, with a total capacity of 42,000 tons, and appropriate conveying units, the complex is capable of loading unit-trains with a capacity of up to 10,000 tons at a rate of 4,000 tons per hour.

Significant gains continued in the trend toward unit-train shipments of coal that started in 1962. Spokesman for the coal and transportation industries estimated that at least a third of the coal produced in 1967 traveled by unit-train. In a series of continuing experiments on the efficient use of locomotive power with maximum train tonnage, a major coal-carrying railroad operated a 500-car super train over a distance of 157 miles. The train was about 4 miles long and weighed more than 47,000 tons for a new record in bulk train shipments.

Increased application of new technology in transportation was also in evidence in water transportation. The building of powerplants adjacent to waterways, to take advantage of low transportation costs, was on the increase. To meet the need for decreased handling time in barge unloading at powerplants, one equipment manufacturer designed and built a continuous bucket barge unloader with an average design capacity of 800 tons per hour. Among the advantages cited for this new system were lower maintenance cost, lower power consumption, and lower manpower requirements. Ocean transportation continued to follow the trend in other forms of transportation toward large shipments. The record for coal loading into single ships continued to be broken as it has been repeatedly in recent years. After setting a record for loading in January of 83,868 tons on its maiden voyage, the Cetra Columba set a new record of 91,443 tons in June.

Announcement of an agreement between a coal company planning to open a mine in the virtually virgin coal area of the Black Mesa field in Arizona and a newly formed pipeline company foretold renewed interest in slurry pipeline transportation in the United States. To be in operation sometime during 1970, the pipeline will transport coal about 275 miles from a mine in northeastern Arizona to an electric power generating plant in southern Nevada. This pipeline development was part of the largest coal contract to be signed in the history of the industry; the contract called for a minimum supply of 117 million tons over a period of 35 years, and amounted to a $500 million coal purchase.

Of major importance to the coal industry during 1967 was the accelerated movement in mergers of oil companies and coal companies toward a "total energy" company concept. In addition to mergers with existing coal companies, this movement was broadened with the purchase of leasing of coal reserves by oil companies and the formation of coal mining branches within oil company organizational structures. One major oil company announced the acquisition of "several hundred thousand acres" of coal lands in five States as a part of a $20 million coal program that is being supplemented at the rate of about $12 million per year.

Sparking the trend toward coal as a supplemental source of hydrocarbon raw materials was the dedication of the coal-to-gasoline conversion pilot plant, built by a major coal company under a research contract with the Department of the Interior. Engineering evaluations of the coal liquefaction process utilized at the pilot plant indicate that the resulting synthetic gasoline can be produced for 10 to 12 cents per gallon. The pilot plant will be operated for 2 to 3 years to provide data that can be used for construction of a commercial plant by private industry. A contract amendment that provides for the construction and operation of a pilot plant for the production of pipeline-quality gas was executed by the Department of the Interior and the Institute of Gas Technology. Based on the conversion of coal, process estimates based on laboratory performance indicate that gas completely interchangeable with natural gas can be produced from coal for 35 to 40 cents per million cubic feet. The process used is hydrogasification and consumes only coal, air, and water. Char produced by the reaction will be consumed in a magnetohydrodynamic generator to provide energy for the reaction.

Interest in lignite reserves was boosted by the signing of a $8.5 million amendment to the Department's contract with a major coal company to provide for the construction of a lignite gasification pilot plant at Rapid City, S. D. The future utilization of vast remaining reserves of lignite in the Montana, North Dakota, and South Dakota area will be influenced by the successful performance of this pilot plant. The process, to be employed at the plant known as the CO_2 (carbon dioxide) Acceptor Process, produced in laboratory tests a low-cost pipeline gas suitable for use in the Nation's existing gas systems.

Promise for future increased markets for lignite was indicated in the results of research on production of carbon disulfide—a chemical essential in manufacturing rayon and cellophane. Cost estimates from laboratory data indicated a favorable outlook for industrial application of the process. The process consists essentially of the controlled reaction of sulfur from natural gas with lignite char. Both natural gas and lignite occur in North Dakota in quantities suitable for future industry based on this process. Annual carbon disulfide production is over 660 million pounds, worth approximately $30 million.

With the signing of Air Quality Act of 1967, the adoption and proposed adoption of air quality regulations by several States and the publication of criteria for Sulfur dioxide emissions from federal facilities in three metropolitan areas, research on the environmental aspects of coal utilization received increased impetus. Emphasis of research by federal agencies and private industry is primarily placed on removal of sulfur dioxide from stack effluent following combustion. However, the removal of sulfur from coal prior to combustion received attention. Preliminary results fom a pilot plant operation indicated 90 percent removal of sulfur oxides by the alkalized alumina process. Even higher rates of removal were claimed by a process that utilizes a dolomite additive. Sponsored by 12 electric utility companies, a pilot plant was installed at an electric generating station to study the reduction of sulfur in coal prior to combustion. Initial laboratory tests demonsstrated the removal of 60 to 70 percent of the sulfur in coal at the powerplant site during pulverization, using existing coal-cleaning processes in a novel combination. An entirely different approach to sulfur removal was taken by a coal company that announced the selection of an engineering firm to design a pilot plant to produce deashed, low-sulfur coal. To be constructed under contract with the Department of the Interior, the pilot plant will develop engineering data for design and construction of commercial-size units and will produce deashed, low-sulfur coal for market testing. Other means of assuring high ambient air quality receiving attention were the location of coal-burning powerplants outside heavily populated areas and the use of high stacks.

Solid emissions from coal-burning powerplants were not overlooked during 1967. Papers presented at the first Fly Ash Symposium[4] foreshadowed the eventual increased use of fly ash and bottom ash. Some 20 million tons of fly ash is collected annually and research efforts are continuing to develop economically marketable products. Industry spokesman projected the amount produced annually by coal-burning powerplants to reach 45 million tons by 1980. Only 1.25 million tons is being used annually as a construction-material additive, while the balance presents a waste disposal problem for the utilities industry and the public.

A pilot plant began operations to develop engineering costs and design factors for a commercial plant to produce brick from fly ash. The process involves the use of a combination of fly and bottom ash in predetermined amounts to yield acceptable bricks of high quality. Cost studies indicate that the pilot plant, which is designed to produce hollow block and paving tile as well as brick, will demonstrate that brick can be produced at a commercial scale for less than $30 per 1,000. A corporation was formed to process fly ash from a major electric utility company's powerplant while a coal company acquired a fly ash processing company as the opening gambit of a market widening program.

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[4] Faber, John H., John P. Capp, and John D. Spencer (comps.). Fly Ash Utilization. Proceedings: Edison Electric Institute-National Coal Association-Bureau of Mines Symposium, Pittsburgh Pennsylvania, March 14-16, 1967. BuMines Inf. Circ. 8348, 1967, 345 pp.

Research promoted by utility and coal companies and Federal and State agencies include the use of fly ash in construction materials, in soil stabilization, and as a source of common and rare metals. In line with the use of solid wastes in building materials as a means of alleviating disposal problems, a contract between the Department of the Interior and a private research firm was announced to study the use of coal washery wastes in building materials. Although about 20-million tons of coal dusts is generated annually at washeries, only about half that amount is recovered and sold. As well as producing a valuable product, successful research results would offer promise for reducing stream pollution from waste discharges.

Concern with water pollution spurred additional efforts to establish effective control techniques. Agencies of Federal and State Governments, industry, and private research groups continued efforts to reduce stream pollution. A contract was signed for the design of the first plant to produce potable water by flash-distillation with coal-supplied power. A neutralization technique for treating mine effluent with inexpensive coarse limestone was announced. A major coal company announced plans for two research projects at mine sites to determine costs and develop data for treating acid mine water. The practicability of lime neutralization plants under certain conditions continued to be demonstrated at pioneer installations. Additional research grants were awarded for studies of the complex nature of acid mine drainage and of various treatment techniques, including bacterial action as a means for removing iron compounds from mine effluent.

Coal research continued at a high pace in other areas to develop new markets for coal, and to eliminate or reduce problems associated with the utilization of coal. A process for producing hydrogen cyanide from the reaction of coal with ammonia was announced. Projected yields of hydrogen cyanide range from 140 to 220 pounds per ton of coal while cost projections indicate that a plant using 20,000 tons of coal per year could produce hydrogen cyanide profitably, as a coproduct with thermal grade carbon black, for about 7 cents per pound. Construction began on a coal-based, sewage-treatment plant that will develop costs for future commercial adaption of this process. A pilot boiler was developed to provide preliminary parameters and prove the economic feasibility of fluidized-bed combustion. The ash-fouling tendencies of certain elements in lignite continued to receive the attention of coal researchers. Development began on a process for treating coal in a high-temperature gas stream to produce useful gaseous, liquid, and chemical products. A study was initiated to determine potential markets for char derived from coal conversion processes developed for producing liquid and gaseous hydrocarbons.

With the upswing in coal demand and installation of new mines to meet these demands, coal industry spokesmen voiced fears of an acute shortage in manpower of the type necessary to operate and maintain increasingly complex coal production equipment. One survey indicated that at least 30,000 men would be needed for each succeeding year of a 4-year period. Public officials, both Federal and State, are working in conjunction with industry to assure a sufficient supply of trained labor. Manpower training programs were started in one major coal-producing State to train needed mechanics and electricians. Vocational schools in concerned coal-producing States initiated courses to provide students with the necessary skills. Several large coal producing companies started training programs, with the aid of State educational facilities and personnel, to upgrade the skills of existing maintenance personnel and to train new mechanics and electricians. Broader use was made of Federal and State programs to upgrade the skills of supervisors and to train supervisor candidates in mine safety. To encourage men to remain in the coalfields and follow a career in mining, companies embarked on a concerted campaign to publicize the benefits of a mining career. One coal company started construction on two model towns near new mines as part of a campaign to recruit new employees. Modeled after typical urban development, complete with shopping centers, schools, and recreational areas, these "new" towns will be constructed and managed by companies other than the coal company to avoid the pitfalls associated with past "company" towns.

Promise for increased interchange of coal research information in future years between coal producing Nations was evident during 1967. Recognizing the universal problems in air pollution abatement and coal research, arrangements were made for exchange of information with coal research groups in the Economic Commission for Europe (ECE) Nations. A group of specialists from seven member Nations of the Organization for Economic and Cooperative Development (OECD) toured coal production and transportation facilities in the United States. The first Fly Ash Utilization Symposium was preceded by a U.N. sponsored conference on the same subject and was attended by members of ECE's Group of Experts on the Utilization of Ash. Consideration by the Government of Czechoslovakia of an American-developed process for sintering fly ash was a direct consequence of this meeting. Scientists from Poland's Central Mining Institute at Katowice toured both Government and industry coal research establishments. Similar arrangements were made with coal research groups from other nations as an important step in the development of an international information exchange program on natural resources.

Table 2.—Estimated monthly production [1] of bituminous coal and lignite, 1967, by States

(Thousand short tons)

State	January	February	March	April	May	June	July	August	September	October	November	December	Total: Short tons	Total: Percentage
Alabama	1,332	1,172	1,458	1,273	1,440	1,264	830	1,376	1,245	1,373	1,301	1,236	15,300	2.78
Alaska	101	95	103	74	55	39	59	56	81	90	87	100	940	.17
Arkansas	28	22	24	22	21	20	18	19	16	17	19	19	245	.04
Colorado	558	468	471	363	462	383	264	419	425	528	544	540	5,425	.98
Illinois	5,670	5,250	6,064	5,332	5,804	5,237	4,476	5,691	5,230	5,620	5,687	5,139	65,200	11.83
Indiana	1,515	1,449	1,758	1,534	1,627	1,436	1,240	1,669	1,667	1,718	1,655	1,532	18,800	3.41
Iowa	67	86	65	76	55	95	64	90	87	81	71	63	900	.16
Kansas	84	93	112	79	109	89	76	138	87	85	73	80	1,105	.20
Kentucky:														
Eastern	4,421	3,705	4,410	4,544	5,087	4,806	3,964	5,350	4,606	4,701	4,588	3,818	54,000	9.80
Western	4,119	3,627	3,992	3,629	3,803	3,468	2,962	4,098	3,762	4,170	4,215	3,655	45,500	8.26
Total Kentucky	8,540	7,332	8,402	8,173	8,890	8,274	6,926	9,448	8,368	8,871	8,803	7,473	99,500	18.06
Maryland	97	87	93	115	115	125	86	115	106	104	106	101	1,250	.23
Missouri	325	279	236	260	292	292	279	315	264	266	265	277	3,350	.61
Montana:														
Bituminous	6	6	6	4	6	4	4	6	5	6	6	6	65	.01
Lignite	28	27	30	21	27	18	17	26	24	25	27	30	300	.06
Total Montana	34	33	36	25	33	22	21	32	29	31	33	36	365	.07
New Mexico	285	259	321	301	263	252	203	344	372	324	276	300	3,500	.64
North Dakota (lignite)	454	319	298	198	252	237	222	294	286	486	543	511	4,100	.75
Ohio	3,161	2,861	3,675	4,104	4,549	4,394	3,673	4,521	3,672	4,031	3,914	3,245	45,800	8.31
Oklahoma	75	68	75	73	74	55	45	55	47	56	82	95	800	.15
Pennsylvania	7,177	6,715	6,771	6,551	6,867	6,440	4,858	7,201	6,609	7,105	6,551	6,555	79,400	14.41
South Dakota (lignite)	2	2	1	------	------	------	------	------	------	1	2	2	10	------
Tennessee	596	516	608	579	619	585	462	661	572	575	523	454	6,750	1.22
Utah	458	355	314	359	378	293	133	332	354	382	393	399	4,150	.75
Virginia	3,153	2,850	3,319	3,018	3,340	3,077	2,862	3,471	3,275	3,327	3,316	2,892	37,900	6.88
Washington	11	9	6	4	3	2	1	2	2	4	6	10	60	.01
West Virginia	13,374	12,242	13,745	12,444	14,247	12,332	9,892	14,378	12,417	13,199	12,567	11,663	152,500	27.68
Wyoming	405	279	262	222	194	231	179	256	269	419	487	447	3,650	.66
Total	47,502	42,841	48,217	45,179	49,689	45,174	36,869	50,883	45,480	48,693	47,304	43,169	551,000	100.00

[1] Figures are based principally upon railroad carloadings and shipments on the Allegheny and Monongahela Rivers, supplemented by direct reports from certain local sources. These estimates include coal both shipped by truck, and used at the mines, and the totals represent output for all mines producing 1,000 tons or more per year.

Table 3.—Estimated monthly production [1] of bituminous coal and lignite, 1967, by districts [2]

(Thousand short tons)

District [2]	January	February	March	April	May	June	July	August	September	October	November	December	Total: Short tons	Total: Percentage
1. Eastern Pennsylvania	3,810	3,557	3,620	3,506	3,689	3,464	2,605	3,845	3,515	3,768	3,488	3,479	42,346	7.69
2. Western Pennsylvania	3,713	3,474	3,503	3,389	3,552	3,331	2,513	3,725	3,419	3,675	3,389	3,391	41,074	7.46
3. Northern West Virginia	4,276	3,935	4,451	3,944	4,449	3,957	2,990	4,367	3,762	4,024	3,790	3,685	47,630	8.64
4. Ohio	3,161	2,861	3,675	4,104	4,549	4,394	3,673	4,521	3,672	4,031	3,914	3,245	45,800	8.31
5. Michigan	------	------	------	------	------	------	------	------	------	------	------	------	------	------
6. Panhandle	547	504	570	506	570	507	383	559	481	515	486	472	6,100	1.11
7. Southern Numbered 1	3,376	3,073	3,430	3,143	3,630	3,107	2,599	3,737	3,234	3,446	3,326	3,023	39,124	7.10
8. Southern Numbered 2	12,948	11,444	13,221	12,619	14,232	12,854	10,919	14,779	13,032	13,440	13,042	11,321	153,851	27.92
9. West Kentucky	4,119	3,627	3,992	3,629	3,803	3,468	2,962	4,098	3,762	4,170	4,215	3,655	45,500	8.26
10. Illinois	5,670	5,250	6,064	5,332	5,804	5,237	4,476	5,691	5,230	5,620	5,687	5,139	65,200	11.83
11. Indiana	1,515	1,449	1,758	1,534	1,627	1,436	1,240	1,669	1,667	1,718	1,655	1,532	18,800	3.41
12. Iowa	67	86	65	76	55	95	64	90	87	81	71	63	900	.16
13. Southeastern	1,480	1,300	1,609	1,417	1,593	1,409	945	1,540	1,387	1,516	1,431	1,348	16,975	3.08
14. Arkansas-Oklahoma	64	55	60	57	57	46	40	46	39	44	59	65	632	.12
15. Southwestern	448	407	387	377	439	410	378	481	375	380	380	406	4,868	.88
16. Northern Colorado	93	71	70	44	45	33	3	37	42	65	76	93	672	.12
17. Southern Colorado	519	446	461	376	467	397	299	447	453	524	520	504	5,413	.98
18. New Mexico	231	210	261	244	213	205	165	279	302	263	224	243	2,840	.52
19. Wyoming	405	279	262	222	194	231	179	256	269	419	487	447	3,650	.66
20. Utah	458	355	314	359	378	293	133	332	354	382	393	399	4,150	.75
21. North-South Dakota	456	321	299	198	252	237	222	294	286	487	545	513	4,110	.75
22. Montana	34	33	36	25	33	22	21	32	29	31	33	36	365	.07
23. Washington	112	104	109	78	58	41	60	58	83	94	93	110	1,000	.18
Total	47,502	42,841	48,217	45,179	49,689	45,174	36,869	50,883	45,480	48,693	47,304	43,169	551,000	100.00

[1] Figures are based principally upon railroad carloadings and shipments on the Allegheny and Monongahela Rivers, supplemented by direct reports from certain local sources. These estimates include coal both shipped by truck, and used at the mines, and the totals represent output for all mines producing 1,000 tons or more per year.

[2] Districts as defined in the Coal Act of 1937 and modifications thereto.

Table 4.—Estimated weekly production [1] of bituminous coal and lignite in 1967 and final production in 1966

(Thousand short tons)

1966				1967			
Week ended—	Production	Maximum number of working days	Average production per working day	Week ended—	Production	Maximum number of working days	Average production per working day
Jan. 1	[2]89	[2]0.1	[3]1,946				
Jan. 8	10,281	6	1,714	Jan. 7	9,644	5	1,929
Jan. 15	10,722	6	1,787	Jan. 14	11,270	6	1,878
Jan. 22	10,607	6	1,768	Jan. 21	11,149	6	1,858
Jan. 29	10,116	6	1,686	Jan. 28	11,275	6	1,879
Feb. 5	8,842	6	1,474	Feb. 4	10,817	6	1,803
Feb. 12	10,171	6	1,695	Feb. 11	10,531	6	1,755
Feb. 19	10,238	6	1,706	Feb. 18	11,125	6	1,854
Feb. 26	10,805	6	1,801	Feb. 25	10,645	6	1,774
Mar. 5	10,325	6	1,721	Mar. 4	10,630	6	1,772
Mar. 12	10,464	6	1,744	Mar. 11	9,191	6	1,532
Mar. 19	10,809	6	1,802	Mar. 18	10,403	6	1,734
Mar. 26	10,710	6	1,785	Mar. 25	10,937	6	1,823
Apr. 2	9,372	5.3	1,768	Apr. 1	11,198	5.5	2,036
Apr. 9	10,476	6	1,746	Apr. 8	10,914	6	1,819
Apr. 16	6,295	6	1,049	Apr. 15	11,185	6	1,864
Apr. 23	5,741	6	957	Apr. 22	11,393	6	1,899
Apr. 30	7,355	6	1,226	Apr. 29	11,432	6	1,905
May 7	10,519	6	1,753	May 6	11,368	6	1,895
May 14	10,923	6	1,821	May 13	11,082	6	1,847
May 21	11,006	6	1,834	May 20	10,917	6	1,820
May 28	11,444	6	1,907	May 27	11,639	6	1,940
June 4	9,686	5.1	1,899	June 3	9,593	5.1	1,881
June 11	11,495	6	1,916	June 10	11,543	6	1,924
June 18	11,624	6	1,937	June 17	11,510	6	1,918
June 25	11,383	5.8	1,963	June 24	11,497	6	1,916
July 2	5,271	2.9	1,818	July 1	6,010	2.4	2,504
July 9	3,782	1.8	2,101	July 8	3,963	1.5	2,642
July 16	8,940	4.4	2,032	July 15	9,720	4.5	2,160
July 23	9,766	5.3	1,843	July 22	9,526	5.2	1,832
July 30	11,504	6	1,917	July 29	11,281	6	1,880
Aug. 6	10,679	6	1,780	Aug. 5	10,994	6	1,832
Aug. 13	10,913	6	1,819	Aug. 12	11,187	6	1,865
Aug. 20	11,482	6	1,914	Aug. 19	11,132	6	1,855
Aug. 27	11,506	6	1,918	Aug. 26	10,957	6	1,826
Sept. 3	11,492	6	1,915	Sept. 2	11,305	6	1,884
Sept. 10	9,887	5	1,977	Sept. 9	9,447	5	1,889
Sept. 17	11,298	6	1,883	Sept. 16	11,212	6	1,869
Sept. 24	11,163	6	1,861	Sept. 23	11,114	6	1,852
Oct. 1	10,753	6	1,792	Sept. 30	11,098	6	1,850
Oct. 8	11,429	6	1,905	Oct. 7	11,001	6	1,834
Oct. 15	11,677	6	1,946	Oct. 14	11,075	6	1,846
Oct. 22	11,520	6	1,920	Oct. 21	10,993	6	1,832
Oct. 29	11,673	6	1,946	Oct. 28	11,330	6	1,888
Nov. 5	11,530	6	1,922	Nov. 4	10,987	6	1,831
Nov. 12	10,092	5.3	1,904	Nov. 11	11,020	5.6	1,968
Nov. 19	11,354	6	1,892	Nov. 18	11,451	6	1,909
Nov. 26	10,015	5	2,003	Nov. 25	9,538	5	1,908
Dec. 3	11,241	6	1,874	Dec 2	11,131	6	1,855
Dec. 10	11,373	6	1,896	Dec. 9	11,122	6	1,854
Dec. 17	11,655	6	1,943	Dec. 16	10,635	6	1,773
Dec. 24	11,400	6	1,900	Dec. 23	10,611	6	1,769
Dec. 31	8,988	5	1,798	Dec. 30	8,272	5	1,654
Total	533,881	297.0	1,798	Total	551,000	295.8	1,863

[1] Figures are based principally upon railroad carloadings and shipments on the Allegheny and Monongahela Rivers, supplemented by direct reports from certain local sources. These estimates include coal both shipped by truck, and used at the mines, and the totals represent output for all mines producing 1,000 tons or more per year.

[2] Figures represent output and number of working days in that part of week included in calendar year shown. Total production for the week ending January 1, 1966, was 8,950,000 net tons.

[3] Average daily output for the entire week and not for working days in the calendar year shown.

CONSUMPTION AND STOCKS

Table 5.—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]	Cement mills	Other manufacturing and mining industries [4]	Retail deliveries to other consumers [5]	Total of classes shown [6]
1963	209,038	670	1,613	76,020	7,401	8,138	82,797	23,548	409,225
1964	223,032	711	2,025	86,732	7,394	8,679	82,928	19,615	431,116
1965	242,729	655	2,693	92,086	7,466	8,873	85,614	19,048	459,164
1966:									
January	24,063	1	161	7,377	764	924	8,663	3,189	45,142
February	21,263	----	160	7,041	724	649	7,771	2,947	40,555
March	21,631	4	188	7,988	696	663	7,981	1,865	41,016
April	20,324	54	175	7,645	599	731	7,398	1,102	38,028
May	19,972	82	185	8,080	556	740	7,080	706	37,401
June	21,269	78	200	7,951	504	789	6,684	498	37,973
July	22,962	68	169	8,048	420	763	6,316	474	39,220
August	22,684	77	237	8,084	433	745	6,600	938	39,798
September	20,990	72	233	7,833	478	788	6,640	1,432	38,466
October	22,009	76	231	7,975	584	778	7,583	2,023	41,259
November	22,433	77	222	7,718	607	789	8,023	2,163	42,032
December	24,602	20	208	7,783	752	790	8,593	2,628	45,376
Total	264,202	609	2,369	93,523	7,117	9,149	89,332	19,965	486,266
1967:									
January	24,723	1	200	7,746	716	692	8,335	2,610	45,023
February	22,758	----	153	7,096	661	647	7,643	2,550	41,508
March	22,910	4	103	7,876	633	732	7,773	1,680	41,711
April	20,955	47	99	7,508	518	701	6,809	729	37,366
May	21,543	69	96	7,740	513	789	6,707	693	38,150
June	22,318	69	90	7,237	424	688	6,331	433	37,590
July	21,999	53	78	7,289	396	681	5,755	473	36,724
August	22,922	61	98	7,430	413	703	6,313	895	38,835
September	21,133	56	93	7,345	418	767	6,010	1,311	37,133
October	22,528	55	120	7,709	494	795	6,821	1,592	40,114
November	23,364	43	122	7,718	552	943	7,339	1,985	42,066
December	24,631	9	122	8,043	592	784	7,706	2,148	44,035
Total	271,784	467	1,374	90,737	6,330	8,922	83,542	17,099	480,255

[1] Federal Power Commission.
[2] Bureau of the Census, U.S. Department of Commerce, Ore and Coal Exchange.
[3] Estimates based upon reports collected from a selected list of representative steel and rolling mills.
[4] Estimates based upon reports collected from a selected list of representative manufacturing plants.
[5] Estimates based upon reports collected from a selected list of representative retailers. Includes some coal shipped by truck from mine to final destination.
[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 year-end 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 6.—Stocks of bituminous coal and lignite in the hands of commerical consumers and in the retail dealers' yards in the United States

Date	Total stocks (thousand short tons)	Days' supply at current rate of consumption on date of stocktaking							
			Manufacturing and mining industries						
		Electric power utilities	Oven coke plants	Steel and rolling mills	Cement mills	Other manufacturing and mining industries	Retail dealers	Total
1966:								
Jan. 31	71,889	64	43	16	33	37	3	49
Feb. 28	69,055	62	39	13	39	38	2	48
Mar. 31	73,526	70	44	17	43	46	3	56
Apr. 30	68,115	69	34	16	41	45	6	54
May 31	69,761	75	33	18	43	48	10	58
June 30	73,173	71	34	20	46	52	17	58
July 31	65,344	63	26	26	46	51	19	52
Aug. 31	68,558	67	28	27	50	50	10	53
Sept. 30	72,471	74	29	23	48	49	6	56
Oct. 31	75,336	77	32	19	51	44	4	57
Nov. 30	75,534	73	33	17	51	39	4	54
Dec. 31	74,466	67	37	16	51	38	3	51
1967:								
Jan. 31	72,951	64	37	17	54	39	3	50
Feb. 28	70,196	61	37	14	45	36	2	47
Mar. 31	71,231	69	37	17	39	38	3	53
Apr. 30	74,696	77	39	19	36	43	6	60
May 31	80,209	84	42	20	37	46	9	65
June 30	85,234	83	46	26	49	51	16	68
July 31	80,621	85	37	25	53	54	15	68
Aug. 31	86,726	88	39	28	58	50	8	69
Sept. 30	90,707	97	40	25	51	52	5	73
Oct. 31	94,467	98	43	22	57	49	4	73
Nov. 30	95,001	92	42	18	49	44	3	68
Dec. 31	93,128	88	42	18	58	42	3	66

Table 7.—Distribution of bituminous coal and lignite, 1967, 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	296,177	99,786	18,789	99,895	1,179	1,678
Shipments to all destinations in the United States, Canada, and Mexico by specific method of movement and consumer use:						
Method of movement:						
All-rail	152,940	50,951	10,984	61,925	-------	---------
River and ex-river	63,296	27,959	1,245	6,896	-------	---------
Great Lakes [1]	23,947	13,456	3,173	12,502	-------	---------
Tidewater [2]	14,527	6,266	4	573	-------	---------
Truck	25,119	1,154	3,383	17,941	-------	---------
Tramway, conveyor, and private railroad	16,348	--------	--------	58	-------	---------
Method of movement and/or consumer uses unknown	-------	--------	--------	--------	1,179	1,678
Total	296,177	99,786	18,789	99,895	1,179	1,678

Shipments	Canadian Great Lakes commerical docks [3]	U.S. Great Lakes dock storage [3]	U.S. tidewater dock storage [3]	Overseas exports [4]	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	368	−62	--------	34,174	663	552,647
Shipments to all destinations in the United States, Canada, and Mexico by specific method of movement and consumer use:						
Method of movement:						
All-rail	-------	--------	--------	--------	-------	276,800
River and ex-river	-------	--------	--------	--------	-------	99,396
Great Lakes [1]	-------	--------	--------	--------	-------	53,078
Tidewater [2]	-------	--------	--------	--------	-------	21,370
Truck	-------	--------	--------	--------	-------	47,597
Tramway, conveyor, and private railroad	-------	--------	--------	--------	-------	16,406
Method of movement and/or consumer uses unknown	368	−62	--------	34,174	663	38,000
Total	368	−62	--------	34,174	663	552,647

[1] 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.
[2] Excludes overseas exports and U.S. tidewater dock storage for which consumer uses are not available; however, includes bunker fuel, the destinations of which are not available.
[3] Consumer use unknown.
[4] Excludes Canada; consumer use unknown.

Table 8.—Distribution of bituminous coal and lignite, 1967, 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	29,038	3,870	444	8,280	191	455
2	8,689	24,663	564	6,924	3	24
3 and 6	37,766	7,025	538	8,122	40	20
4	31,630	--------	1,579	12,198	159	32
7	2,124	17,607	1,528	2,650	151	628
8	60,739	32,824	8,074	30,699	233	396
9	41,206	194	1,557	4,670	52	--------
10	45,909	2,108	2,253	15,631	160	45
11	12,279	--------	450	6,137	115	9
12	683	--------	--------	191	-------	--------
13	9,006	6,139	136	813	-------	2
14	-------	435	--------	62	-------	--------
15 [2]	4,472	128	81	480	2	--------
16	549	--------	43	77	-------	4
17	2,040	2,876	294	313	-------	2
18	2,860	--------	5	34	-------	--------
19	2,821	27	114	624	31	2
20	784	1,890	757	577	3	31
21	3,119	--------	293	575	36	24
22 and 23	463	--------	79	838	3	4
Total	296,177	99,786	18,789	99,895	1,179	1,678

District of origin [1]	Canadian Great Lakes commercial docks [3]	U.S. Great Lakes dock storage [3]	U.S. tidewater dock storage [3]	Overseas exports [4]	Net change in mine inventory	Total
1	15	−2	--------	1,339	68	43,698
2	77	−13	--------	--------	−41	40,890
3 and 6	96	92	−5	714	62	54,470
4	59	−147	--------	--------	140	45,650
7	3	119	14	15,708	441	40,973
8	118	−86	−9	16,413	−89	149,312
9	-------	16	--------	--------	33	47,728
10	-------	−41	--------	--------	−42	66,023
11	-------	--------	--------	--------	16	19,006
12	-------	--------	--------	--------	-------	874
13	-------	--------	--------	--------	−5	16,091
14	-------	--------	--------	--------	-------	497
15 [2]	-------	--------	--------	--------	−28	5,135
16	-------	--------	--------	--------	2	675
17	-------	--------	--------	--------	21	5,546
18	-------	--------	--------	--------	−7	2,892
19	-------	--------	--------	--------	-------	3,619
20	-------	--------	--------	--------	18	4,060
21	-------	--------	--------	--------	74	4,121
22 and 23	-------	--------	--------	--------	-------	1,387
Total	368	−62	--------	34,174	663	552,647

[1] Source for producing districts: Bureau of Mines. Bituminous Coal and Lignite Distribution Calendar Year 1967. Mineral Industry Survey, March 1968, 39 pp.
[2] Excludes Texas.
[3] Consumer use unknown.
[4] Excludes Canada; consumer use unknown.

Table 9.—Distribution of bituminous coal and lignite, 1967, by destination and consumer use

(Thousand short tons)

Destination	Total	Electric utilities	Coke and gas plants	Retail dealers	All others [1]
New England:					
Massachusetts	4,022	3,418	---------	110	494
Connecticut	4,793	4,030	483	12	268
Maine, New Hampshire, Vermont, and Rhode Island	926	719	---------	42	165
Middle Atlantic:					
New York	27,300	14,330	5,980	165	6,825
New Jersey	7,865	6,403	490	15	957
Pennsylvania	61,197	23,595	27,369	781	9,452
East North Central:					
Ohio	58,726	30,086	11,610	2,191	14,839
Indiana	40,441	20,624	12,321	1,070	6,426
Illinois	46,710	29,497	3,449	4,074	9,690
Michigan	34,959	19,605	4,591	1,485	9,278
Wisconsin	15,581	8,358	497	1,914	4,812
West North Central:					
Minnesota	7,142	4,137	929	685	1,391
Iowa	5,549	3,227	---------	355	1,967
Missouri	9,389	6,944	219	189	2,037
North Dakota and South Dakota	3,427	2,622	---------	367	438
Nebraska and Kansas	1,254	861	---------	46	347
South Atlantic:					
Delaware and Maryland	14,954	8,713	5,393	93	755
District of Columbia	[2] 886	546	---------	89	[2] 251
Virginia	14,854	8,896	72	753	5,133
West Virginia	23,244	12,671	4,885	392	5,296
North Carolina	17,515	14,349	---------	636	2,530
South Carolina	5,554	3,877	---------	269	1,408
Georgia and Florida	11,492	10,519	---------	177	796
East South Central:					
Kentucky	19,046	14,087	1,958	498	2,503
Tennessee	18,185	14,777	174	555	2,679
Alabama and Mississippi	24,081	14,550	7,932	97	1,502
West South Central:					
Arkansas, Louisiana, Oklahoma, and Texas	955	---------	822	23	110
Mountain:					
Colorado	4,720	2,919	1,057	289	455
Utah	2,853	479	1,865	193	316
Montana and Idaho	968	328	---------	427	213
Wyoming	2,494	2,291	---------	28	175
New Mexico	2,526	2,504	---------	5	17
Arizona and Nevada	700	661	---------	25	14
Pacific:					
Washington and Oregon	541	---------	---------	191	350
California	2,051	---------	2,017	14	20
Alaska	952	135	---------	43	774
Canada [3]	14,856	4,932	5,513	442	3,969
Mexico	62	---------	---------	---------	62
Destinations not revealable	994	487	160	49	298
Destinations and/or consumer uses not available:					
Great Lakes movement:					
Canadian commercial docks	368	---------	---------	---------	---------
Vessel fuel	878	---------	---------	---------	---------
U.S. dock storage	−62	---------	---------	---------	---------
Tidewater movement:					
Overseas exports (except Canada)	34,174	---------	---------	---------	---------
Bunker fuel	5	---------	---------	---------	---------
U.S. dock storage	-------	---------	---------	---------	---------
Railroad fuel:					
U.S. companies	1,146	---------	---------	---------	---------
Canadian companies	33	---------	---------	---------	---------
Coal used at mines and sales to employees	1,678	---------	---------	---------	---------
Net change in mine inventory	663	---------	---------	---------	---------
Total	552,647	---------	---------	---------	---------

[1] Excludes vessel fuel and bunker fuel, the destinations of which are not available.
[2] A considerable block of tonnage is included under "Destinations not revealable."
[3] Excludes shipments to Canadian Great Lakes commercial docks and Canadian railroad companies.

Table 10.—Total bituminous coal and lignite shipments and percent of grand total shipments, by geographic division and States of destinations [1]

Geographic division and State of destination	Thousand short tons					Percent of total				
	1963	1964	1965	1966	1967	1963	1964	1965	1966	1967
Total	456,137	485,465	512,525	532,366	552,647	100.0	100.0	100.0	100.0	100.0
New England	10,017	10,007	10,640	10,877	9,741	2.2	2.0	2.1	2.0	1.8
Massachusetts	4,346	4,160	4,681	4,415	4,022	1.0	.8	.9	.8	.7
Connecticut	4,341	4,767	4,870	5,434	4,793	.9	1.0	1.0	1.0	.9
Maine, New Hampshire, Vermont, and Rhode Island	1,330	1,080	1,089	1,028	926	.3	.2	.2	.2	.2
Middle Atlantic	79,492	90,150	95,721	93,918	96,362	17.4	18.6	18.7	17.6	17.4
New York	22,417	25,932	27,025	25,314	27,300	4.9	5.3	5.3	4.8	4.9
New Jersey	6,874	7,526	9,000	8,692	7,865	1.5	1.6	1.8	1.6	1.4
Pennsylvania	50,201	56,692	59,696	59,907	61,197	11.0	11.7	11.6	11.2	11.1
East North Central	164,423	173,307	182,072	192,251	196,417	36.0	35.7	35.5	36.1	35.5
Ohio	49,157	51,092	52,756	57,622	58,726	10.8	10.5	10.3	10.8	10.6
Indiana	33,124	35,885	36,885	38,424	40,441	7.2	7.4	7.2	7.2	7.3
Illinois	39,086	41,466	44,356	46,382	46,710	8.6	8.5	8.6	8.7	8.5
Michigan	29,888	30,936	33,411	34,770	34,959	6.5	6.4	6.5	6.6	6.3
Wisconsin	13,168	13,928	14,664	15,053	15,581	2.9	2.9	2.9	2.8	2.8
West North Central	23,242	23,918	24,978	25,977	26,761	5.1	4.9	4.9	4.9	4.8
Minnesota	6,143	7,077	7,406	7,680	7,142	1.3	1.4	1.5	1.4	1.3
Iowa	5,271	4,849	5,508	5,440	5,549	1.2	1.0	1.1	1.0	1.0
Missouri	7,896	8,154	8,243	8,494	9,389	1.7	1.7	1.6	1.6	1.7
North Dakota and South Dakota	2,113	2,191	2,211	2,996	3,427	.5	.5	.4	.6	.6
Nebraska and Kansas	1,819	1,647	1,610	1,367	1,254	.4	.3	.3	.3	.2
South Atlantic	63,816	67,866	72,052	80,491	88,499	14.0	14.0	14.1	15.1	16.0
Delaware and Maryland	10,968	12,317	13,288	14,082	14,954	2.4	2.6	2.6	2.6	2.7
District of Columbia	[2] 718	[2] 638	[2] 541	[2] 897	[2] 886	[2] .2	[2] .1	[2] .1	[2] .2	[2] .1
Virginia	13,323	13,787	13,887	14,279	14,854	2.9	2.8	2.7	2.7	2.7
West Virginia	16,742	18,205	19,337	20,159	23,244	3.7	3.8	3.8	3.8	4.2
North Carolina	11,187	11,595	12,376	15,852	17,515	2.4	2.4	2.4	2.9	3.2
South Carolina	4,442	4,401	4,301	5,118	5,554	1.0	.9	.9	.9	1.0
Georgia and Florida	6,436	6,923	8,322	10,604	11,492	1.4	1.4	1.6	2.0	2.1

See footnotes at end of table.

Table 10.—Total bituminous coal and lignite shipments and percent of grand total shipments, by geographic division and States of destinations[1]—Continued

Geographic division and State of destination	Thousand short tons					Percent of total				
	1963	1964	1965	1966	1967	1963	1964	1965	1966	1967
East South Central	47,418	49,849	52,103	54,929	61,312	10.4	10.3	10.2	10.3	11.1
Kentucky	15,453	16,148	16,834	17,644	19,046	3.4	3.3	3.3	3.3	3.4
Tennessee	14,952	14,075	13,896	14,811	18,185	3.3	2.9	2.7	2.8	3.3
Alabama and Mississippi	17,013	19,626	21,373	22,474	24,081	3.7	4.1	4.2	4.2	4.4
West South Central: Arkansas, Louisiana, Oklahoma, and Texas	802	1,099	1,166	1,084	955	0.2	0.2	0.2	0.2	0.2
Mountain	10,823	12,455	13,866	14,098	14,261	2.4	2.6	2.7	2.7	2.6
Colorado	3,752	3,877	4,500	4,705	4,720	.8	.8	.9	.9	.9
Utah	2,334	2,706	2,868	2,974	2,853	.5	.6	.6	.6	.5
Montana and Idaho	1,066	1,190	1,075	995	968	.3	.3	.2	.2	.2
Wyoming	1,977	1,936	2,196	2,601	2,494	.4	.4	.4	.5	.4
New Mexico	1,132	2,169	2,505	2,084	2,526	.3	.4	.5	.4	.5
Arizona and Nevada	562	577	722	739	700	.1	.1	.1	.1	.1
Pacific	2,518	2,789	3,176	2,575	2,592	.6	.6	.6	.5	.5
Washington and Oregon	828	774	798	687	541	.2	.2	.2	.1	.1
California	1,690	2,015	2,378	1,888	2,051	.4	.4	.4	.4	.4
Alaska	855	842	789	858	952	.2	.2	.1	.2	.2
Canada [4]	13,724	14,180	15,634	15,807	15,257	3.0	2.9	3.0	3.0	2.8
Mexico	48	54	60	54	62	([3])	([3])	([3])	([3])	([3])
Destinations not revealable	1,350	1,496	1,385	1,211	994	.3	.3	.3	.2	.2
U.S. railroad fuel	1,452	1,321	1,241	1,260	1,146	.3	.3	.2	.2	.2
U.S. Great Lakes dock storage	70	−327	−252	−6	−62	([3])	−.1	([3])	([3])	([3])
U.S. tidewater dock storage	6	9	10	4	--------	([3])	([3])	([3])	([3])	-------
Vessel fuel	1,090	1,106	1,004	1,054	878	.2	.2	.2	.2	.1
Bunker fuel	18	17	13	13	5	([3])	([3])	([3])	([3])	([3])
Overseas exports	33,317	33,733	34,746	33,527	34,174	7.3	7.0	6.8	6.3	6.2
Coal used at mines and sales to employees	1,753	1,956	1,969	2,098	1,678	.4	.4	.4	.4	.3
Net change in mine inventory	−97	−362	152	291	663	([3])	−.1	([3])	.1	.1

[1] The regional and State data exclude shipments for U.S. railroad fuel, vessel fuel, bunker fuel, coal used at mines and sales to employees, overseas exports, and net change in mine inventory, because the ultimate destinations of these tonnages are not available.
[2] A considerable block of tonnage is included under "Destinations not revealable."
[3] Less than 0.1 percent.
[4] Includes shipments to Canadian Great Lakes commercial docks and Canadian railroad companies.

Table 11.—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, 1957 and 1963–67, by geographic division, States of destination, and consumer use

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957 = 100 (except where noted)				
		1963	1964	1965	1966	1967
Total	493,895	92.4	98.3	103.8	107.8	111.9
Electric utilities	160,754	131.5	142.7	155.1	169.0	184.2
Coke and gas plants	112,901	73.3	84.7	89.0	89.1	88.4
Retail dealers	39,230	66.3	58.4	58.2	52.7	47.9
All others (includes vessel and bunker fuel)	108,711	90.8	92.2	92.8	93.7	91.9
Railroad fuel (U.S. and Canada)	9,581	16.1	15.0	13.7	13.7	12.3
Canadian Great Lakes commercial docks (consumer use not available)	2,785	21.3	30.0	38.6	15.4	13.2
U.S. Great Lakes dock storage (consumer use not available) [1]	NA	23.0	−207.6	−182.9	−102.0	−120.4
U.S. tidewater dock storage (consumer use not available) [2]	NA	23.1	34.6	38.5	15.4	-----
Coal used at mines and sales to employees	3,125	56.1	62.6	63.0	67.1	53.7
Net change in mine inventory	1,142	−108.5	−131.7	13.3	25.5	58.1
Overseas exports (excludes Canada—consumer use not available)	55,666	59.9	60.6	62.4	60.2	61.4
New England	11,909	84.1	84.0	89.3	91.3	81.8
Electric utilities	6,012	129.2	136.4	149.8	157.3	135.8
Coke and gas plants	1,345	35.1	35.4	35.1	33.8	35.9
Retail dealers	1,279	23.5	19.2	16.7	14.5	12.8
All others	3,273	45.1	33.2	29.1	23.8	28.3
Massachusetts	5,354	81.2	77.7	87.4	82.5	75.1
Electric utilities	2,575	133.3	133.0	159.5	156.1	132.7
Coke and gas plants	751	.0	.0	.0	.0	.0
Retail dealers	755	21.5	21.2	16.0	14.4	14.6
All others	1,273	59.0	45.1	35.7	22.5	38.8
Connecticut	4,105	105.7	116.1	118.6	132.4	116.8
Electric utilities	2,567	136.0	155.2	159.8	182.1	157.0
Coke and gas plants	594	79.5	80.1	79.5	76.4	81.3
Retail dealers	139	34.5	18.7	9.4	8.6	8.6
All others	805	41.0	34.8	35.3	36.4	33.3
Maine, New Hampshire, Vermont, and Rhode Island	2,450	54.3	44.1	44.4	42.0	37.8
Electric utilities	870	97.2	90.7	91.5	87.8	82.6
Retail dealers	385	23.4	15.6	20.5	16.9	10.9
All others	1,195	33.0	19.3	17.9	16.7	13.8
Middle Atlantic	92,596	85.8	97.4	103.4	101.4	104.1
Electric utilities	31,662	108.3	121.4	134.0	132.8	140.0
Coke and gas plants	38,448	68.0	83.5	90.1	87.1	88.0
Retail dealers	2,498	54.3	45.8	53.0	43.8	38.5
All others	19,988	88.5	92.3	86.8	86.5	86.2
New York	26,753	83.8	96.9	101.0	94.6	102.0
Electric utilities	12,335	91.1	104.4	112.2	101.2	116.2
Coke and gas plants	5,693	70.6	100.5	109.7	103.3	105.0
Retail dealers	769	48.5	39.9	47.9	33.8	21.5
All others	7,956	85.3	88.2	82.7	84.0	85.8
New Jersey	7,814	88.0	96.3	115.2	111.2	100.7
Electric utilities	4,284	115.1	133.7	168.2	166.9	149.5
Coke and gas plants	1,249	31.8	28.0	35.0	40.9	39.2
Retail dealers	130	44.6	20.0	31.5	12.3	11.5
All others	2,151	69.2	66.1	61.3	47.1	44.5
Pennsylvania	58,029	86.5	97.7	102.9	103.2	105.5
Electric utilities	15,043	120.6	131.9	142.1	148.9	156.9
Coke and gas plants	31,506	68.9	82.6	88.7	86.0	86.9
Retail dealers	1,599	57.9	50.0	57.2	51.1	48.8
All others	9,881	95.3	101.3	95.6	97.0	95.7
East North Central	[3] 170,697	96.3	101.5	106.7	112.6	115.1
Electric utilities	66,436	118.8	128.1	138.2	151.7	162.8
Coke and gas plants	38,757	71.5	80.9	83.1	86.6	83.8
Retail dealers	21,321	66.7	58.7	59.8	54.9	50.3
All others	[3] 44,183	98.6	100.3	102.5	104.5	102.0
Ohio	55,612	88.4	91.9	94.9	103.6	105.6
Electric utilities	20,193	113.9	117.7	122.8	140.3	149.0
Coke and gas plants	15,661	57.9	66.8	69.1	78.1	74.1
Retail dealers	5,077	51.7	49.3	50.6	45.9	43.2
All others	14,681	98.6	97.8	99.1	100.4	101.1
Indiana	34,938	94.8	102.7	105.6	110.0	115.8
Electric utilities	12,853	119.5	132.4	139.7	144.7	160.5
Coke and gas plants	13,736	77.9	86.3	86.8	89.2	89.7
Retail dealers	2,796	62.2	48.7	44.6	41.6	38.3
All others	5,553	96.0	101.7	103.7	115.5	115.7
Illinois	[3] 42,718	91.5	97.1	103.8	108.6	109.3
Electric utilities	18,584	112.6	123.7	135.5	149.6	158.7
Coke and gas plants	3,925	71.3	84.3	91.9	92.4	87.9

See footnotes at end of table.

Table 11.—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, 1957 and 1963–67, by geographic division, States of destination, and consumer use—Continued

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957 = 100 (except where noted) 1963	1964	1965	1966	1967
Illinois—Continued						
Retail dealers	8,623	61.3	55.8	52.9	49.4	47.2
All others	[3] 11,586	87.0	89.4	95.0	92.2	83.6
Michigan	26,255	113.8	117.8	127.3	132.4	133.2
Electric utilities	9,839	138.0	149.3	172.4	187.7	199.3
Coke and gas plants	4,877	98.7	108.9	109.5	102.8	94.1
Retail dealers	3,368	64.0	52.6	60.3	54.4	44.1
All others	8,171	114.3	112.2	111.1	115.8	113.5
Wisconsin	11,174	117.8	124.6	131.2	134.7	139.4
Electric utilities	4,967	122.6	134.1	139.3	152.7	168.3
Coke and gas plants	558	60.9	74.7	92.8	83.0	89.1
Retail dealers	1,457	166.0	142.5	160.1	145.2	131.4
All others	4,192	103.1	113.8	116.7	116.6	114.8
West North Central	[3] 20,824	111.6	114.9	119.9	124.7	128.5
Electric utilities	8,278	159.2	166.9	178.3	198.8	214.9
Coke and gas plants	1,518	51.1	78.3	75.0	76.5	75.6
Retail dealers	4,079	63.8	53.4	52.8	46.3	40.3
All others	[3] 6,949	96.2	96.9	99.6	93.2	88.9
Minnesota	5,332	115.2	132.7	138.9	144.0	133.9
Electric utilities	1,810	176.7	212.7	223.4	255.5	228.6
Coke and gas plants	1,206	55.0	85.5	78.9	78.9	77.0
Retail dealers	553	122.1	105.1	128.9	128.8	123.9
All others	1,763	91.1	91.7	96.3	79.0	78.9
Iowa	[3] 4,878	108.1	99.4	112.9	111.5	113.8
Electric utilities	1,846	137.3	125.6	149.7	157.9	174.8
Retail dealers	1,254	56.9	43.7	45.1	35.2	28.3
All others	[3] 1,778	113.7	111.5	122.6	117.2	110.6
Missouri	6,862	115.1	118.1	120.1	123.8	136.8
Electric utilities	2,605	200.2	208.0	212.7	228.3	266.6
Coke and gas plants	312	36.2	50.6	59.6	67.0	70.2
Retail dealers	1,495	36.2	30.6	23.3	18.5	12.6
All others	2,450	82.8	86.6	88.5	84.2	83.1
North Dakota and South Dakota	2,416	87.5	90.7	91.5	124.0	141.8
Electric utilities	1,378	89.5	94.6	98.5	157.7	190.3
Retail dealers	517	101.4	93.0	84.5	77.0	71.0
All others	521	68.3	77.9	80.0	81.6	84.1
Nebraska and Kansas	1,336	136.2	123.3	120.5	102.3	93.9
Electric utilities	639	156.2	144.8	165.6	124.6	134.7
Retail dealers	260	56.9	43.1	34.6	23.1	17.7
All others	437	154.0	139.6	105.7	116.9	79.4
South Atlantic	52,560	121.4	129.1	137.1	153.1	168.4
Electric utilities	22,251	161.7	174.0	192.5	231.5	267.7
Coke and gas plants	11,321	79.6	90.5	95.5	92.0	91.4
Retail dealers	4,765	67.2	66.3	55.5	52.6	50.6
All others	14,223	109.9	110.7	110.8	112.9	113.7
Delaware and Maryland	10,358	105.9	118.9	128.3	136.0	144.4
Electric utilities	3,000	167.3	192.5	233.1	270.3	290.4
Coke and gas plants	5,414	81.5	92.8	94.5	91.7	99.6
Retail dealers	420	80.2	84.3	53.3	26.4	22.1
All others	1,524	78.9	76.4	62.6	58.8	49.5
District of Columbia	1,097	[4] 65.5	[4] 58.2	[4] 49.3	[4] 81.8	[4] 80.8
Electric utilities	609	59.1	61.4	49.4	81.6	89.7
Retail dealers	188	80.3	72.3	63.8	53.7	47.3
All others	300	[4] 69.0	[4] 42.7	[4] 40.0	[4] 99.7	[4] 83.7
Virginia	10,553	126.2	130.6	131.6	135.3	140.8
Electric utilities	4,435	166.9	176.4	170.8	185.9	200.6
Coke and gas plants	165	30.3	76.4	161.2	157.6	43.6
Retail dealers	1,756	59.3	61.4	51.8	47.3	42.9
All others	4,197	115.1	113.4	122.4	117.8	122.3
West Virginia	15,771	106.2	115.4	122.6	127.8	147.4
Electric utilities	6,290	114.2	121.3	138.3	152.5	201.4
Coke and gas plants	5,742	79.2	88.7	94.6	90.4	85.1
Retail dealers	302	94.0	85.4	92.4	101.7	129.8
All others	3,437	137.5	152.0	143.3	147.4	154.1
North Carolina	8,716	128.4	133.0	142.0	176.1	201.0
Electric utilities	4,953	160.0	171.4	189.1	246.8	289.7
Retail dealers	1,248	63.9	59.8	50.2	51.2	51.0
All others	2,515	98.0	93.9	94.7	98.9	100.6
South Carolina	3,050	145.6	144.3	141.0	167.8	182.1
Electric utilities	856	289.0	303.9	278.9	378.5	452.9
Retail dealers	321	91.0	94.1	82.2	92.2	83.8
All others	1,873	89.5	80.0	88.1	84.5	75.2
Georgia and Florida	3,015	213.5	229.6	276.0	351.7	381.2
Electric utilities	2,108	266.4	286.1	356.4	455.3	499.0
Retail dealers	530	56.4	53.8	42.1	42.1	33.4
All others	377	138.2	160.7	155.4	208.0	211.1

See footnotes at end of table.

Table 11—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, 1957 and 1963–67, by geographic division, States of destination, and consumer use—Continued

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957 = 100 (except where noted)				
		1963	1964	1965	1966	1967
East South Central	43,283	109.6	115.2	120.4	126.9	141.7
Electric utilities	23,572	137.6	145.3	149.5	159.8	184.2
Coke and gas plants	10,380	73.6	81.7	88.6	90.0	97.0
Retail dealers	2,494	80.2	62.1	56.0	50.7	46.1
All others	6,837	78.1	81.5	91.5	97.3	97.8
Kentucky	11,167	138.4	144.6	150.7	158.0	170.6
Electric utilities	6,758	154.4	165.4	176.6	187.6	208.4
Coke and gas plants	1,683	111.5	110.9	114.0	104.0	116.3
Retail dealers	834	95.3	77.3	62.4	66.2	59.7
All others	1,892	123.9	129.8	129.9	140.0	132.3
Tennessee	15,104	99.0	93.2	92.0	98.1	120.4
Electric utilities	9,876	119.4	112.1	107.6	115.7	149.6
Coke and gas plants	258	84.5	59.3	70.2	69.8	67.4
Retail dealers	1,206	72.1	61.2	63.2	50.4	46.0
All others	3,764	55.0	56.2	61.9	69.0	71.2
Alabama and Mississippi	17,012	100.0	115.4	125.6	132.1	141.6
Electric utilities	6,938	147.1	173.0	182.9	195.3	209.7
Coke and gas plants	8,439	65.7	76.5	84.1	87.8	94.0
Retail dealers	454	73.8	36.6	25.1	22.9	21.4
All others	1,181	78.6	84.8	124.4	119.5	127.2
West South Central: Arkansas, Louisiana, Oklahoma, and Texas	1,868	42.9	58.8	62.4	58.0	51.1
Electric utilities [5]	65	100.0	75.0	.0	.0	.0
Coke and gas plants	1,050	58.7	82.5	94.9	90.3	78.3
Retail dealers	161	23.0	19.3	17.4	17.4	14.3
All others	592	22.3	31.1	24.0	18.2	18.6
Mountain	8,779	123.3	141.9	157.9	160.6	162.4
Electric utilities	1,437	405.8	485.0	572.5	605.0	639.0
Coke and gas plants	3,772	65.3	74.1	85.3	83.9	77.5
Retail dealers	1,350	83.1	86.3	85.0	77.3	71.6
All others	2,220	63.2	68.7	57.3	53.9	53.6
Colorado	3,264	115.0	118.8	137.9	144.1	144.6
Electric utilities	687	264.3	281.2	357.5	401.5	424.9
Coke and gas plants	1,324	85.6	83.5	99.8	93.1	79.8
Retail dealers	326	87.7	102.1	113.2	105.2	88.7
All others	927	55.7	54.7	38.1	40.1	49.1
Utah	3,748	62.3	72.2	76.5	79.3	76.1
Electric utilities	367	118.8	111.7	102.7	132.4	130.5
Coke and gas plants	2,448	54.4	69.0	77.5	78.9	76.2
Retail dealers	334	73.1	69.5	62.6	55.7	57.8
All others	599	53.9	62.4	64.3	61.9	52.8
Montana and Idaho	923	115.5	128.9	116.5	107.8	104.9
Electric utilities [6]	1	160.3	164.2	165.9	181.6	183.2
Retail dealers	593	80.8	80.6	72.8	63.6	72.0
All others	329	91.2	127.1	105.2	89.1	64.7
Wyoming	607	325.7	318.9	361.8	428.5	410.9
Electric utilities	340	520.3	518.2	597.4	716.8	673.8
Retail dealers	61	86.9	82.0	82.0	63.9	45.9
All others	206	75.2	60.2	55.8	60.7	85.0
New Mexico [7]	92	100.0	191.6	221.3	184.1	223.1
Electric utilities [7]	37	100.0	195.0	227.8	190.2	230.8
Retail dealers	12	183.3	150.0	108.3	58.3	41.7
All others	43	58.1	81.4	46.5	30.2	39.5
Arizona and Nevada	145	387.6	397.9	497.9	509.7	482.8
Electric utilities [8]	5	131.0	136.1	177.3	186.3	197.3
Retail dealers	24	158.3	225.0	308.3	383.3	104.2
All others	116	73.3	57.8	46.6	19.8	12.1
Pacific	3,142	80.1	88.8	101.1	82.0	82.5
Electric utilities	4	.0	.0	.0	.0	.0
Coke and gas plants	1,708	96.8	115.7	137.1	107.7	118.1
Retail dealers	377	72.4	75.9	87.8	71.1	54.4
All others	1,053	56.2	50.0	47.9	44.4	35.1
Washington and Oregon	1,324	62.5	58.5	60.3	51.9	40.9
Electric utilities	3	.0	.0	.0	.0	.0
Retail dealers	367	73.3	75.7	86.6	69.2	52.0
All others	954	58.6	52.0	50.3	45.4	36.7
California	1,818	93.0	110.8	130.8	103.9	112.8
Electric utilities	1	.0	.0	.0	.0	.0
Coke and gas plants	1,708	96.8	115.7	137.1	107.7	118.1
Retail dealers	10	40.0	80.0	130.0	140.0	140.0
All others	99	33.3	31.3	24.2	35.4	20.2
Alaska	829	103.1	101.6	95.2	103.5	114.8
Electric utilities	470	71.5	75.3	92.3	43.4	28.7
Retail dealers	49	108.2	89.8	81.6	89.8	87.8
All others	310	150.3	143.2	101.6	196.8	249.7

See footnotes at end of table.

Table 11.—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, 1957 and 1963–67, by geographic division, States of destination, and consumer use—Continued

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957 = 100 (except where noted)				
		1963	1964	1965	1966	1967
Canada [9]	17,878	76.8	79.3	87.4	88.4	85.3
Electric utilities	567	437.9	560.0	705.6	794.7	869.8
Coke and gas plants	4,602	122.8	120.5	115.0	127.2	119.8
Retail dealers	857	94.6	64.4	83.8	65.1	51.6
All others	7,183	57.0	55.0	62.2	61.4	55.3
Canadian Great Lakes commerical docks (consumer use not available)	2,785	21.3	30.0	38.6	15.4	13.2
Canadian railroad companies	1,884	4.9	6.2	4.0	2.5	1.8
Mexico [10]	NA	84.2	94.7	105.3	94.7	108.8
All others [10]	NA	84.2	94.7	105.3	94.7	108.8
Destinations not revealable [11]	-------	97.8	108.4	100.4	87.8	72.0
Electric utilities [11]	-------	34.2	61.8	105.0	62.0	98.0
Coke and gas plants [11]	-------	161.0	161.5	54.8	83.4	42.8
Retail dealers [11]	-------	32.3	35.4	89.8	80.8	49.5
All others [11]	-------	133.2	134.1	138.8	124.6	72.7
Destinations not available:						
Great Lakes vessel fuel [12]	1,859	58.6	59.5	54.0	56.7	47.2
Tidewater bunker fuel [12]	41	43.9	41.5	31.7	31.7	12.2
Railroad fuel, United States companies [13]	7,697	18.9	17.2	16.1	16.4	14.9

NA Not available.
[1] For Great Lakes dock storage the annual base period is 1959 = 100. The 1959 annual tonnage was 304 tons.
[2] For tidewater dock storage the annual base period is 1959 = 100. The 1959 annual tonnage was 26 tons.
[3] District 15 shipments to Illinois included with Iowa.
[4] A considerable block of tonnage is included under "Destinations not revealable."
[5] 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.
[6] 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.
[7] 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.
[8] 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.
[9] Includes shipments to Canadian Great Lakes commercial docks and Canadian railroad companies.
[10] Since tonnages for Mexico were first published in 1960, yearly indexes are based on 1960 = 100. In thousands of tons, 1960 tons were total 57, all others 57.
[11] Since "Destinations not revealable" were first published during 1960, the calendar year indexes are based on 1960 = 100. In thousands of tons these figures are as follows: Calendar year 1960 total not revealable 1,380, electric utilities 497, coke and gas plants 374, retail dealers 99, all others 410.
[12] Included in summary at beginning of table in "All others."
[13] Included in summary at beginning of table in "Railroad fuel."

Table 12.—Exports of bituminous coal, by country groups

(Thousand short tons)

Country group	1965	1966	1967
Canada (including Newfoundland) and Mexico	15,721	15,882	15,328
Overseas (all other countries):			
West Indies and Central America	2	(1)	6
Bermuda, Greenland, and Territory of St. Pierre and Miquelon	3	5	6
South America	1,996	2,613	2,562
Europe	24,957	22,984	19,370
Asia	7,491	7,794	12,232
Africa	11	9	6
Oceania	------	15	------
Total overseas	34,460	33,420	34,182
Grand total	50,181	49,302	49,510

[1] Less than ½ unit.

Table 13.—Bituminous coal exported from the United States, by countries[1]

(Short tons)

Country	1965	1966	1967
Argentina	619,662	662,523	590,348
Australia	----------	15,130	----------
Belgium-Luxembourg	2,214,749	1,840,544	1,422,246
Brazil	1,210,517	1,739,113	1,734,561
Canada	15,660,773	15,828,528	15,265,502
Chile	126,194	156,182	193,141
Denmark	5,833	1,855	----------
Dominican Republic	984	----------	----------
France	2,069,602	1,573,517	2,130,969
Germany, East	120,614	157,559	77,345
Germany, West	4,729,895	4,894,331	4,693,782
Greece	26,328	----------	----------
Ireland	313,115	355,516	267,236
Italy	8,930,666	7,805,553	5,816,341
Japan	7,491,114	7,790,585	12,226,739
Mexico	60,439	52,535	61,648
Netherlands	3,371,223	3,165,221	2,227,488
Nigeria	3,912	5,730	6,064
Norway	164,663	220,484	245,874
Portugal	103,604	120,598	85,897
Saint Pierre and Miquelon, Territory of	2,832	5,028	6,354
Spain	1,376,609	1,193,662	1,011,928
Sweden	870,398	951,280	813,261
Switzerland	38,816	24,116	38,669
Trinidad and Tobago	1,082	----------	252
United Kingdom	5,917	----------	8,141
Uruguay	37,015	54,075	43,306
Yugoslavia	558,394	596,095	532,094
Other	66,411	92,630	11,195
Total	50,181,361	49,302,390	49,510,381

[1] Amounts stated do not include fuel or bunker coal loaded on vessels engaged in foreign trade, which aggregated 242,833 tons in 1965, 214,515 tons in 1966, and 145,497 tons in 1967.

Table 14.—Bituminous coal exported from the United States, by customs districts

(Short tons)

Customs district	1965	1966	1967
Baltimore, Md	2,791,262	2,389,902	1,943,826
Boston, Mass	15,659	----------	----------
Buffalo, N.Y	r 1,755,870	1,005,646	557,577
Chicago, Ill	53,672	73,549	62,488
Cleveland, Ohio	13,106,688	13,884,336	14,043,606
Detroit, Mich	117,380	122,158	65,905
Duluth, Minn	7,123	3,710	3,360
El Paso, Tex	49,079	49,024	46,586
Galveston, Tex	17,340	----------	----------
Great Falls, Mont	1,309	----------	----------
Houston, Tex	----------	52	260
Laredo, Tex	10,168	3,392	14,927
Los Angeles, Calif	30	10,027	265
Mobile, Ala	321	308	355
New Orleans, La	4,867	6,771	6,312
New York City	6,355	16,606	236
Nogales, Ariz	207	----------	----------
Norfolk, Va	31,933,465	31,473,385	32,607,361
Ogdensburg, N.Y	257,244	167,565	129,125
Pembina, N. Dak	1,272	430	520
Philadelphia, Pa	32,229	51,772	263
Portland, Maine	726	2,913	----------
Providence, R.I	----------	3,532	----------
St. Albans, Vt	18,498	35,223	24,680
San Diego, Calif	101	119	135
San Francisco, Calif	96	----------	2,554
Seattle, Wash	400	1,970	----------
Tampa, Fla	----------	----------	40
Total	50,181,361	49,302,390	49,510,381

r Revised.

Table 15.—Shipments of bituminous coal to possessions and other areas administered by the United States

(Short tons)

Territory	1965	1966	1967
American Samoa	-----	119	-------
Puerto Rico	1,044	552	1,052
Virgin Islands	64	40	-------

Table 16.—Bituminous coal[1] imported for consumption in the United States, by countries and customs districts

(Short tons)

Country and customs district	1965	1966	1967
Country:			
Brazil	55	----------	----------
Canada	184,328	177,672	175,070
Germany, West	-------	----------	51,548
Ireland	-------	----------	180
Japan	13	----------	----------
Norway	-------	----------	540
United Kingdom	3	----------	----------
Total	184,399	177,672	227,338
Customs district:			
Boston, Mass	-------	----------	51,548
Buffalo, N.Y	-------	2,195	3,089
Detroit, Mich	1,000	427	37
Duluth, Minn	368	7,584	1,265
El Paso, Tex	-------	----------	74
Galveston, Tex	-------	----------	540
Great Falls, Mont	14,907	13,219	19,983
Honolulu, Hawaii	13	----------	----------
Juneau, Alaska	5	----------	----------
Los Angeles, Calif	3	----------	----------
New York	55	----------	----------
Pembina, N. Dak	1,255	1,368	2,837
Portland, Maine	166,747	152,879	147,965
Seattle, Wash	46	----------	----------
Total	184,399	177,672	227,338

[1] Includes slack, culm, and lignite.

Table 17.—World production of bituminous coal, anthracite, and lignite, by countries [1] [2]

(Thousand short tons)

Country	1963	1964	1965	1966	1967 [p]
North America:					
Canada:					
Bituminous	8,702	9,325	9,525	9,313	9,387
Lignite	1,874	1,994	2,064	2,078	2,008
Greenland: Bituminous	44	26	22	37	35
Mexico: Bituminous	2,283	[r] 2,357	2,211	2,316	2,380
United States:					
Anthracite (Pennsylvania)	18,267	17,184	14,866	12,941	12,256
Bituminous	456,223	484,048	509,045	530,000	546,590
Lignite	2,705	2,950	3,043	3,881	4,410
South America: [1]					
Argentina: Bituminous (mined)	276	467	596	666	[e] 440
Brazil: Bituminous (including lignite)	2,834	3,578	3,729	4,041	4,782
Chile: Bituminous (mined)	1,895	1,972	1,904	[r] 1,821	1,649
Colombia: Bituminous	3,527	3,307	3,417	[r] 3,307	[e] 3,420
Peru: Bituminous and anthracite	144	[r] 162	[r] 142	[r] 171	193
Venezuela: Bituminous	46	42	34	37	37
Europe:					
Albania: Lignite	278	322	[e] 330	[e] 340	[e] 380
Austria:					
Bituminous	115	114	65	22	15
Lignite	6,672	6,350	6,008	5,824	5,075
Belgium: Bituminous and anthracite	[r] 23,607	23,485	21,810	19,289	18,116
Bulgaria:					
Bituminous and anthracite	725	671	608	540	[e] 515
Lignite	22,349	26,181	26,996	27,143	[e] 31,750
Czechoslovakia:					
Bituminous	31,191	31,211	30,568	[r] 29,463	[e] 28,440
Lignite	80,803	83,340	80,707	[r] 81,690	71,650
Denmark: Lignite	2,769	2,420	2,346	[r] 2,185	[e] 2,090
France:					
Bituminous and anthracite	52,649	58,469	56,601	55,488	52,498
Lignite	2,724	2,474	2,965	2,826	3,230
Germany:					
Bituminous and anthracite:					
East	2,737	2,579	2,438	[r] 2,190	[e] 1,980
West	156,656	156,750	148,897	[r] 138,858	123,506
Lignite:					
East	280,228	283,212	[r] 276,499	[r] 274,515	[e] 275,580
West	117,572	122,294	112,333	[r] 108,123	106,666
Pech coal: West	2,029	2,060	1,913	1,280	981
Greece: lignite	[r] 3,887	[r] 4,254	[r] 5,600	[e] [r] 5,500	[e] 5,500
Hungary:					
Bituminous	4,090	4,547	4,808	4,806	4,468
Lignite	29,508	30,229	29,845	28,647	25,327
Ireland: Bituminous and anthracite	257	255	204	193	201
Italy.					
Bituminous and anthracite	[r] 645	519	[r] 429	461	452
Lignite	[r] 1,505	1,326	[r] 1,114	1,175	2,426
Netherlands: Bituminous and anthracite	12,686	12,655	12,617	11,080	8,890
Poland:					
Bituminous	124,726	129,360	130,989	134,459	136,576
Lignite	16,914	22,355	24,941	27,015	[e] 26,350
Portugal:					
Anthracite	459	489	472	[r] 472	488
Lignite	157	111	99	56	43
Rumania:					
Bituminous and anthracite [3]	6,234	6,495	6,654	[r] 6,956	7,275
Lignite	5,084	5,766	6,679	7,872	8,422
Spain:					
Bituminous and anthracite	14,229	13,444	[r] 14,267	14,106	13,608
Lignite	2,856	2,870	[r] 3,057	2,901	2,961
Svalbard (Spitzbergen): Bituminous:					
Controlled by Norway	421	487	470	[r] 478	450
Controlled by U.S.S.R. (shipments)	408	[r] 422	[e] [r] 440	[e] 440	[e] 440
Sweden: Bituminous	109	93	65	[r] 44	[e] 22
U.S.S.R.: [4]					
Bituminous and anthracite	[r] 435,555	[illegible]50,701	471,658	[r] 484,095	[e] 490,000
Lignite	150,565	159,975	165,181	[r] 161,418	[e] 166,000
United Kingdom: Bituminous and anthracite	219,291	216,863	209,999	[r] 195,522	192,824
Yugoslavia:					
Bituminous	1,418	1,391	1,289	1,268	992
Lignite	28,810	31,139	31,733	31,040	28,173
Africa:					
Algeria: Bituminous and anthracite	42	51	50	[e] 55	[e] 55
Congo (Kinshasa): Bituminous	101	110	126	121	147
Malagasy Republic: Bituminous	2	4	2	---------	2

See footnotes at end of table.

Table 17.—World production of bituminous coal, anthracite, and lignite, by countries [1] [2] —Continued

(Thousand short tons)

Country	1963	1964	1965	1966	1967 p
Africa—Continued					
Morocco: Anthracite	445	441	462	497	531
Mozambique: Bituminous	312	270	262	r 325	311
Nigeria: Bituminous	636	771	816	705	e 220
Rhodesia, Southern: Bituminous	3,020	3,355	3,868	e 3,350	3,019
South Africa, Republic of: Bituminous and anthracite (marketable)	r 46,797	49,513	53,418	52,847	54,344
Swaziland: Anthracite and bituminous	---------	4	33	74	86
Tanzania: Bituminous	2	1	2	2	2
United Arab Republic: Bituminous	---------	---------	22	e 22	NA
Zambia: Bituminous	---------	---------	---------	126	433
Asia:					
Afghanistan: Bituminous [5]	108	125	r 146	155	e 160
Burma: Bituminous	3	11	11	e r 17	e 17
China, mainland: Bituminous, anthracite, and lignite e	300,000	320,000	330,000	360,000	250,000
India:					
Bituminous	72,704	68,828	76,611	77,753	77,714
Lignite	1,101	1,730	2,535	2,831	3,198
Indonesia: Bituminous	r 651	492	430	353	229
Iran: Bituminous [5]	213	302	303	e 330	e 330
Japan:					
Bituminous and anthracite	57,377	56,140	54,602	56,601	51,859
Lignite	1,008	762	632	498	403
Korea:					
North: Anthracite, bituminous, and lignite	15,476	15,983	e r 19,620	e 21,500	e 23,590
South: Anthracite	9,765	10,606	11,296	12,801	13,708
Mongolia: Lignite and bituminous	931	780	1,091	r 1,107	e 1,170
Pakistan: Bituminous and lignite	r 1,348	1,338	r 1,621	r 1,497	e 1,500
Philippines: Bituminous	173	127	105	r 83	72
Taiwan: Bituminous	5,302	5,542	5,571	5,528	5,598
Thailand: Lignite	151	115	138	188	369
Turkey (salable):					
Bituminous	r 4,570	r 4,903	r 4,851	r 5,394	5,546
Lignite	r 3,568	r 4,267	r 4,592	r 5,262	e 5,200
Viet-Nam:					
North: Anthracite	r 3,689	r 3,748	e 3,900	e 3,900	e 3,100
South: Anthracite	115	85	---------	---------	---------
Oceania:					
Australia:					
Bituminous	27,839	30,689	35,204	r 37,334	38,875
Lignite	20,672	21,319	r 23,137	24,400	26,193
New Zealand:					
Bituminous and anthracite	2,890	3,047	2,801	2,721	2,467
Lignite	181	175	176	185	186
Total lignite	r 783,941	r 819,930	r 812,750	r 807,593	803,590
Total bituminous and anthracite (by subtraction)	r 2,138,989	r 2,210,794	r 2,269,976	r 2,311,359	2,198,991
Total, all grades [6]	r 2,922,930	r 3,030,724	r 3,082,726	r 3,118,952	3,002,581

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Ecuador produces a negligible amount of coal.
[2] Compiled mostly from data available June 1968.
[3] Includes a preponderant share of low-grade bituminous.
[4] Output from U.S.S.R. in Asia (including Sakhalin) included with U.S.S.R. in Europe.
[5] Year ended March 20 of year following that stated.
[6] Totals are of listed figures only; no undisclosed data included.

Coal—Pennsylvania Anthracite

By Staff, Division of Environmental Activities

All of the reported production of anthracite in the United States originates in 13 counties located in northeast Pennsylvania. In 1967 this production, derived from underground mines, strip pits, culm and silt banks, and river dredges, totaled 12.3 million short tons, a decrease of 5.3 percent from the 1966 level.

The lower output in the United States in 1967 compared with that of 1966 parallels a similar trend in world anthracite production which registered a 9-million-ton decline during the same period.

Legislation and Government Programs.—Federal cooperation with the Commonwealth of Pennsylvania on the control of mine water continued in 1967 under the

Table 1.—Salient statistics of the Pennsylvania anthracite industry

	1963	1964	1965	1966	1967
Production:					
Preparation plants______short tons__	17,415,365	16,335,700	14,023,269	12,139,106	11,481,582
Dredges____________________do____	691,370	704,748	699,857	661,017	631,660
Used at collieries for power and heat short tons__	160,649	143,803	142,829	141,141	142,821
Total production__________do____	18,267,384	17,184,251	14,865,955	12,941,264	12,256,063
Value_______________thousands__	$153,503	$148,648	$122,021	$100,663	$96,160
Average sales realization per short ton on preparation plant shipments (excludes dredge coal):					
Pea and larger____________________	$11.65	$12.38	$11.70	$11.11	$11.53
Buckwheat No. 1 and smaller______	$6.43	$6.56	$6.48	$6.40	$6.35
All sizes_______________________	$8.64	$8.93	$8.51	$8.08	$8.15
Percentage of total preparation plant shipments (excludes dredge coal):					
Pea and larger____________________	42.4	40.8	39.0	35.6	34.8
Buckwheat No. 1 and smaller______	57.6	59.2	61.0	64.4	65.2
Exports [1]________________short tons__	3,357,340	1,575,097	850,630	766,025	594,797
Imports [1]_______________________do____	[2] 4,625	NA	NA	NA	NA
Consumption (apparent)[3]________do____	14,100,000	14,400,000	12,900,000	11,400,000	10,800,000
Average number of days worked________	216	214	204	203	219
Average number of men working daily__	13,498	13,144	11,132	9,292	7,750
Output per man per day____short tons__	6.27	6.11	6.55	6.87	7.21
Output per man per year__________do____	1,354	1,308	1,336	1,395	1,579
Quantity cut by machines________do____	240,427	417,080	329,328	246,658	146,908
Quantity mined by stripping______do____	7,467,842	7,177,188	5,938,982	5,253,408	4,740,187
Quantity loaded by machines underground_________________short tons__	3,665,962	3,455,034	3,246,034	2,590,547	1,997,806
Distribution:					
Receipts in New England [4]__do____	422,012	331,780	241,638	[5] 149,010	__________
Exports to Canada [1]________do____	794,585	636,867	642,657	624,280	448,744
Loaded into vessels at Lake Erie [6] short tons__	191,609	216,590	224,460	208,432	206,975
Receipts at Duluth-Superior [7] short tons__	32,615	47,649	11,560	__________	__________

NA Not available.

[1] U.S. Department of Commerce, 1963–67 export data does not include shipments to U.S. military forces. See NOTE, tables 2 and 34.

[2] Import data discontinued with August 1963.

[3] Beginning with 1961 exports to the U.S. military forces in West Germany were taken into consideration. See NOTE on summary and export tables.

[4] Commonwealth of Massachusetts, Division on the Necessaries of Life

[5] Data discontinued with September 1966.

[6] Ore and Coal Exchange, Cleveland, Ohio.

[7] Lake Superior area office, Corps of Engineers, U.S. Army, Duluth, Minn.

Act of July 15, 1955 (Public Law 162), as did cooperative activities related to surface subsidence resulting from underground mining operations.

Under the Appalachian Program, Federal agencies continued to participate in mine-void filling, mine fire control, and land reclamation projects in the anthracite region, as approved by the Appalachian Regional Commission.

The Federal Government policy of supplying Pennsylvania anthracite as a portion of the solid mineral fuel needs of the U.S. Armed Forces, West Germany, was continued in 1967. Shipments to West Germany and the Netherlands totaled 826,968 tons, an increase of slightly more than 8 percent over 1966 shipments.

DOMESTIC PRODUCTION

Production of Pennsylvania anthracite totaling 12.3 million short tons in 1967 was approximately 0.7 million tons, or 5.3 percent below the 1966 output.

A slight increase in output from the Lehigh region was not sufficient to offset the losses in production incurred in the Schuylkill and Wyoming regions. Similarly, the increased recovery of coal from culm banks did not counterbalance the lower output of the underground mines, strip pits, and river dredges.

Over the past several years (1962–67) the combined secondary recovery of fuel from culm banks and the dredging of silt from rivers has remained at a fairly constant level, fluctuating between 3.4 and 4.3 million tons annually. The contribution to total availability, represented by these sources, has increased from 20 to 35 percent.

A significant portion of the fuel obtained from culm banks and by dredging is used for the generation of electric power. Although the demands for electricity are expected to increase, the sources of secondary recoveries of anthracite fuel are diminishing. It is improbable that the increased need for electric power will result in expanded output of culm bank and dredge anthracite.

VALUES AND PRICES

The average value of all Pennsylvania anthracite, including colliery fuel and dredge coal, was $7.85 per short ton, 1 percent above the 1966 realization. Based on total production, the value of the year's output was $96.2 million.

Retail prices quoted for Pennsylvania anthracite during 1967, as reported in trade journals, fluctuated over the year, but were generally in line with 1966 quotations until the end of the period. Year-end quotations in 1967 were appreciably higher, however, than those of 1966. This may have been due primarily to the extended period of cold weather that enveloped the domestic market area during the final weeks of the year.

CONSUMPTION AND USES

The apparent domestic consumption of anthracite (production, minus shipments to U.S. Armed Forces, West Germany, and to export) during 1967 fell approximately 0.6 million tons below that of 1966. This deviation from the previous year's consumption pattern is represented almost entirely by the decline in the sales of anthracite for residential and commercial heating purposes.

During the winter of 1967–68, a protracted period of abnormally cold weather created an unusually heavy demand for certain anthracite sizes. Because of the inherent rigidity of production schedules, which require considerable time to appreciably alter, plus difficulty of transport, the industry was unable to meet all demands for specific sizes of prepared coal.

Over the past years, retail merchants, who are the final link in the chain of supply from the preparation plant to the ultimate space heating domestic consumer, have shown an increasing reluctance to procure sufficient stocks of prepared coal during the "off" season to guard against emergencies due to abnormal weather.

The combination of an unusually cold

winter, the inflexibility of production schedules at the mines, and insufficient stocks in the hands of anthracite merchants may account for the major portion of the decrease in domestic consumption in 1967.

FOREIGN TRADE

Increased shipments to the European Coal and Steel Community countries and to markets in Asia and Oceania were offset by smaller export tonnages to Canada and other destinations. The net result was a decrease in exports of anthracite in 1967 of 594,797 short tons, 22.4 percent below the 1966 level. This performance marks a continuation of a 5-year downtrend in the export demand for Pennsylvania anthracite.

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, West Germany, this offshore movement is not, technically, an export, and is not included in the export total. In 1967 shipments against the military requirements totaled 826,968 short tons, an increase of 61,994 tons over the 1966 level.

WORLD REVIEW

Precise data are not available from all anthracite producing countries. Some country figures are only estimates while certain other producers include in their official data some fuels which, by U.S. standards, are of no higher quality than semianthracite. Despite these discrepancies, information pertaining to the 1967 output, when compared with data from similar sources for previous years, is sufficiently accurate to indicate general trends. Based on such information, and in full recognition of the margin of error that could exist, it is indicated that total world production of anthracite in 1967 (some 205.9 million tons) was 4.1 percent below the 1966 output.

Anthracite production generally reflects the demand. The ready availability of alternative and more convenient fuels at competitive prices is considered to be the principle reason for the lessening demand for anthracite in world fuel markets.

TECHNOLOGY

While no significant advances were made in anthracite underground mining techniques, surface-mining (stripping) methods were improved. An 85-cubic-yard-dragline, largest in the anthracite region, began operations in the Eastern Middle field. The 300-foot boom has a depth capacity of 220 feet. The new machine is working in conjunction with a previously installed 65-cubic-yard-dragline to recover anthracite from pillars in two beds totaling up to 40 feet thick, in an area that has an estimated 10-year stripping life.

Investigations are in progress on a high-pressure gasifier utilizing a fixed-bed grate type producer at 100 pounds per square inch and standard anthracite fuel to determine equipment operating characteristics. The work is designed to produce new information on operations at higher pressures than presently available. Also under investigation in the use of No. 5 Buckwheat size anthracite in a fluidized-bed burner to develop a universal type combustor for power generation. The objectives are lower combustion temperatures, higher heat transfer rates, and reduced air pollution.

The Bureau of Mines conducted pressure-drop studies in a 4-foot-diameter simulated blast furnace shaft to compare anthracite metallurgical briquets with coke and formcoke.[1]

Laboratory tests were conducted to determine the feasibility of separating anthracite particles from a water-anthracite slurry by atomizing the water and removing the resultant mist in an air current.[2]

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[1] Baker, A. F., W. S. Sanner, R. F. Tenney, and J. W. Eckerd. Experimental Study of Pressure Drop Across Fixed Beds of Anthracite Briquets and Blast Furnace Materials. BuMines Rept. of Inv. 6945, 1967, 28 pp.

[2] Brady, G. A., Harold H. Griffiths, and J. W. Eckerd. Dewatering Anthracite Slurry. BuMines Rept. of Inv. 7012, 1967, 13 pp.

Tests were made on seven anthracite samples from the Ross Bottom bed to determine cleaning characteristics, proximate and ultimate analyses, specific gravity, grindability, content, and ash fusion point.[3]

Tests were conducted on hollow-core anthracite briquets as a blast furnace fuel in which metal production rates of 42 to 45 tons per day were obtained in an experimental blast furnace.[4]

Experiments in filling mine voids with pneumatically injected fly ash for controlling mine fires were conducted at the Bureau of Mines' Experimental Coal Mine, Bruceton, Pa. Impressive results were obtained, and the technique is now being utilized successfully in mine fire control project work.

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[3] Brady, G. A., and H. H. Griffiths. Properties of Anthracite From the Bottom Ross Bed. BuMines Rept. of Inv. 7086, 1968, 29 pp.

[4] Eckerd, J. W., R. E. McKeever, P. L. Woolf, and W. S. Sanner. Hollow-Core Anthracite Briquets as Blast Furnace Fuel. BuMines Rept. of Inv. 7157, 1968, 13 pp.

Table 2.—Summary of monthly developments in the Pennsylvania anthracite industry in 1967

(Thousand short tons, except as otherwise indicated)

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year 1967	Change from 1966 (percent)	Year 1966
Production (including mine fuel, local sales, and dredge coal)	1,101	939	979	952	1,102	995	899	1,132	1,071	1,073	1,017	996	12,256	−5.3	12,941
Shipments (breakers and washeries only, all sizes):															
By rail [1]	384	303	377	466	550	600	450	602	569	498	421	401	5,621	−8.8	6,166
By truck [2]	578	574	500	375	410	344	283	354	391	445	523	535	5,312	−11.8	6,021
Carloadings [3]	8	6	8	10	11	11	9	11	10	10	9	8	110	−9.0	121
Distribution:															
Lake Erie loadings [4]	----	----	----	20	31	30	16	34	23	32	13	7	207	−.7	208
Lake Ontario loadings [4]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Upper Lake dock trade: [5]															
Receipts:															
Lake Superior	----	----	----	----	11	6	----	15	----	13	----	----	45	(6)	(12)
Lake Michigan	(12)	(12)	1	1	4	1	(12)	(12)	1	(12)	(12)	1	9	−1.3	9
Deliveries (reloadings):															
Lake Superior	----	4	5	4	6	3	3	5	4	5	3	4	46	(6)	(12)
Lake Michigan	1	1	1	1	1	1	1	1	1	1	1	1	10	−12.7	12
New England receipts:															
By rail [7]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	[7] 149
Exports [8]	60	35	41	37	46	45	35	49	76	63	59	48	595	−22.4	766
Industrial consumption and stocks by:															
Electric utilities: [9]															
Consumption	186	174	180	168	189	158	172	203	191	185	198	182	2,186	−.3	2,192
Stocks	992	943	923	983	1,043	1,116	1,154	1,190	1,226	1,281	1,280	1,250	1,250	+25.3	998
Coke plants:															
Used for carbonizing	48	43	46	48	45	42	37	48	42	40	46	44	528	+2.6	515
Stocks	127	103	83	86	90	101	106	129	136	151	149	157	157	+16.8	135
Stocks on Upper Lake docks: [5]															
Lake Superior	18	13	9	5	10	13	10	20	16	24	22	17	17	(6)	(12)
Lake Michigan	4	2	2	2	5	6	5	5	5	4	4	3	3	−29.5	5
Stocks in retail dealer yards: [10]															
Chestnut and larger	217	163	135	149	178	229	245	279	265	252	240	219	219	−14.8	257
Pea	28	24	20	21	24	28	31	30	29	38	28	31	31	+19.2	26
Buckwheat No. 1 and rice	113	93	66	65	87	116	109	135	120	115	103	106	106	−17.8	129
Total	358	280	221	235	289	373	385	444	414	405	371	356	356	−13.6	412

See footnotes at end of table.

Table 2.—Summary of monthly developments in the Pennsylvania anthracite industry in 1967—Continued

(Thousand short tons, except as otherwise indicated)

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year 1967	Change from 1966 (percent)	Year 1966
Retail dealer deliveries: [10]															
Chestnut and larger	201	213	160	77	80	55	64	109	150	192	218	222	1,741	−1.3	1,764
Pea	33	36	30	17	17	66	58	93	87	38	27	26	528	+64.0	322
Buckwheat No. 1 and rice	59	60	56	31	44	57	68	54	71	65	50	61	676	+2.9	657
Total	293	309	246	125	141	178	190	256	308	295	295	309	2,945	+7.4	2,743
Wholesale price indexes (1957–59 = 100): [11]															
F.o.b. mines:															
Chestnut	93.4	93.4	93.4	83.2	83.2	83.2	86.6	86.6	90.0	90.0	93.4	95.8	89.4	+.2	89.2
Buckwheat No. 1	93.7	93.7	93.7	86.2	86.2	86.2	88.1	88.1	91.4	91.4	93.7	96.4	90.7	+.6	90.2

[1] Furnished by the 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] 1966 data believed to be incorrect.
[7] Commonwealth of Massachusetts, Division on the Necessaries of Life. These data discontinued with September 1966.
[8] U.S. Department of Commerce. Does not include shipments to the U.S. military forces.
[9] Federal Power Commission.
[10] Estimated from reports submitted by a selected list of retail dealers located outside the producing region.
[11] Bureau of Labor Statistics. Based on data obtained from authorized trade publications.
[12] Less than ½ unit.

NOTE: According to the Association of American Railroads, 879,849 short tons of anthracite was exported to Europe during 1967 compared with 830,216 tons for 1966. Of this total 826,968 tons was consigned to West Germany and Netherlands, including exports to the U.S. military forces, compared with 764,974 tons for 1966.

Table 3.—Trends in the Pennsylvania anthracite industry

Year	Production (thousand short tons)	Value of production (thousands)	Average value per short ton	Exports [1] (thousand short tons)	Imports [1] (thousand short tons)	Apparent consumption (thousand short tons)	Average number of employees
1963	18,267	$153,503	$8.40	3,357	[2] 5	14,100	13,498
1964	17,184	148,648	8.65	1,575	NA	14,400	13,144
1965	14,866	122,021	8.21	851	NA	12,900	11,132
1966	12,941	100,663	7.78	766	NA	11,400	9,292
1967	12,256	96,160	7.85	595	NA	10,800	7,750

Year	Average number of days worked	Average tons per man per day	Average tons per man per year	Quantity cut by machines (thousand short tons)	Quantity produced by stripping (thousand short tons)	Quantity loaded mechanically underground (thousand short tons)
1963	216	6.27	1,354	240	7,468	3,666
1964	214	6.11	1,308	417	7,177	3,455
1965	204	6.55	1,336	329	5,939	3,246
1966	203	6.87	1,395	247	5,253	2,591
1967	219	7.21	1,579	147	4,740	1,998

NA Not available.
[1] U.S. Department of Commerce. Export data does not include shipments to U.S. military forces. See NOTE, tables 2 and 34.
[2] For period January-August. Beginning with September, anthracite import data are included with bituminous coal.

Table 4.—Commercial production of Pennsylvania

Size	From preparation plants					
	Lehigh region			Schuylkill region		
	Rail	Truck	Total	Rail	Truck	Total
Quantity, thousand short tons:						
Lump [2] and broken	------	------	------	------	------	------
Egg	137	5	141	67	1	68
Stove	270	64	334	224	288	512
Chestnut	179	191	370	157	429	586
Pea	84	190	274	116	322	438
Total pea and larger	670	449	1,119	564	1,041	1,605
Buckwheat No. 1	135	187	322	217	387	603
Buckwheat No. 2 (rice)	49	222	271	105	396	501
Buckwheat No. 3 (barley)	137	139	277	141	468	609
Buckwheat No. 4	132	50	182	153	211	364
Buckwheat No. 5	471	14	485	516	182	699
Other [4]	60	336	395	609	480	1,090
Total buckwheat No. 1 and smaller	984	949	1,932	1,742	2,124	3,865
Grand total	1,654	1,397	3,051	2,306	3,165	5,470
Value, thousands:						
Lump [2] and broken	------	------	------	------	------	------
Egg	$1,739	$53	$1,792	$838	$14	$851
Stove	3,390	789	4,179	2,682	3,359	6,041
Chestnut	2,225	2,383	4,607	1,827	4,931	6,758
Pea	773	1,806	2,579	1,023	2,987	4,010
Total pea and larger	8,127	5,031	13,157	6,370	11,290	17,660
Buckwheat No. 1	1,206	1,695	2,901	1,989	3,455	5,444
Buckwheat No. 2 (rice)	427	2,178	2,605	891	3,452	4,343
Buckwheat No. 3 (barley)	1,064	1,086	2,150	1,049	3,474	4,523
Buckwheat No. 4	718	280	997	885	1,116	2,001
Buckwheat No. 5	2,578	74	2,652	2,547	739	3,286
Other [4]	190	1,045	1,235	2,537	1,769	4,306
Total buckwheat No. 1 and smaller	6,184	6,358	12,541	9,899	14,005	23,903
Grand total	14,310	11,388	25,698	16,269	25,295	41,564
Average value per ton:						
Lump [2] and broken	------	------	------	------	------	------
Egg	$12.69	$12.26	$12.68	$12.50	$12.30	$12.49
Stove	12.54	12.41	12.51	11.98	11.65	11.80
Chestnut	12.41	12.50	12.46	11.63	11.49	11.53
Pea	9.24	9.50	9.42	8.83	9.27	9.15
Total pea and larger	12.12	11.21	11.76	11.30	10.85	11.00
Buckwheat No. 1	8.94	9.06	9.01	9.17	8.94	9.02
Buckwheat No. 2 (rice)	8.78	9.80	9.62	8.48	8.72	8.67
Buckwheat No. 3 (barley)	7.75	7.80	7.78	7.44	7.43	7.43
Buckwheat No. 4	5.44	5.57	5.48	5.78	5.29	5.50
Buckwheat No. 5	5.47	5.23	5.46	4.93	4.05	4.70
Other [4]	3.20	3.11	3.13	4.16	3.68	3.95
Total buckwheat No. 1 and smaller	6.29	6.70	6.49	5.68	6.59	6.18
Grand total	8.65	8.15	8.42	7.06	7.99	7.60

[1] Includes Sullivan County.
[2] Quantity of lump included is insignificant.
[3] Less than ½ unit.
[4] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.

anthracite in 1967, by regions and sizes

From preparation plants						From river dredging			Total		
Wyoming region [1]			Total preparation plants								
Rail	Truck	Total	Rail	Truck	Total	Rail	Truck	Total	Rail	Truck	Total
-------	(3)	(3)	------	(3)	(3)	------	------	------	------	(3)	(3)
86	3	89	290	8	298	------	------	------	290	8	298
238	117	354	732	469	1,201	------	------	------	732	469	1,201
154	315	469	491	934	1,425	------	------	------	491	934	1,425
43	315	358	242	828	1,070	------	------	------	242	828	1,070
521	750	1,270	1,755	2,239	3,994	------	------	------	1,755	2,239	3,994
90	303	393	442	877	1,319	------	------	------	442	877	1,319
45	234	279	199	852	1,051	------	------	------	199	852	1,051
169	144	313	447	751	1,198	------	------	------	447	751	1,198
66	13	78	351	274	624	------	25	25	351	299	649
66	111	177	1,053	308	1,361	------	11	11	1,053	319	1,372
18	432	450	687	1,248	1,935	574	22	596	1,261	1,269	2,531
453	1,237	1,690	3,179	4,309	7,487	574	57	632	3,753	4,366	8,119
974	1,986	2,960	4,934	6,548	11,482	574	57	632	5,508	6,605	12,113
-------	$1	$1	------	$1	$1	------	------	------	------	$1	$1
$1,098	36	1,134	$3,674	103	3,777	------	------	------	$3,674	103	3,777
3,010	1,477	4,487	9,082	5,624	14,706	------	------	------	9,082	5,624	14,706
1,907	3,866	5,774	5,960	11,180	17,139	------	------	------	5,960	11,180	17,139
467	3,374	3,841	2,264	8,167	10,430	------	------	------	2,264	8,167	10,430
6,483	8,753	15,236	20,980	25,074	46,054	------	------	------	20,980	25,074	46,054
862	2,915	3,778	4,058	8,065	12,123	------	------	------	4,058	8,065	12,123
423	2,253	2,676	1,741	7,883	9,624	------	------	------	1,741	7,883	9,624
1,254	1,072	2,325	3,368	5,631	8,999	------	------	------	3,368	5,631	8,999
369	73	442	1,972	1,468	3,440	------	$120	$120	1,972	1,588	3,560
355	450	806	5,480	1,263	6,743	------	38	38	5,480	1,301	6,781
57	1,044	1,101	2,785	3,859	6,643	$2,034	65	2,099	4,819	3,924	8,743
3,321	7,807	11,128	19,403	28,169	47,573	2,034	223	2,257	21,437	28,392	49,829
9,804	16,560	26,364	40,383	53,244	93,626	2,034	223	2,257	42,417	53,466	95,883
-------	$14.96	$14.96	------	$14.96	$14.96	------	------	------	------	$14.96	$14.96
$12.74	12.73	12.74	$12.66	12.43	12.65	------	------	------	$12.66	12.43	12.65
12.67	12.64	12.66	12.41	12.00	12.25	------	------	------	12.41	12.00	12.25
12.36	12.29	12.31	12.14	11.96	12.03	------	------	------	12.14	11.96	12.03
10.98	10.70	10.73	9.35	9.87	9.75	------	------	------	9.35	9.87	9.75
12.45	11.68	11.99	11.95	11.20	11.53	------	------	------	11.95	11.20	11.53
9.54	9.62	9.60	9.18	9.20	9.19	------	------	------	9.18	9.20	9.19
9.42	9.62	9.59	8.77	9.25	9.16	------	------	------	8.77	9.25	9.16
7.43	7.45	7.44	7.53	7.50	7.51	------	------	------	7.53	7.50	7.51
5.63	5.75	5.65	5.62	5.36	5.51	------	$4.78	$4.78	5.62	5.32	5.48
5.41	4.04	4.55	5.20	4.10	4.95	------	3.62	3.62	5.20	4.09	4.94
3.19	2.42	2.45	4.05	3.09	3.43	$3.54	3.01	3.52	3.82	3.09	3.45
7.33	6.31	6.58	6.10	6.54	6.35	3.54	3.89	3.57	5.71	6.50	6.14
10.07	8.34	8.91	8.19	8.13	8.15	3.54	3.89	3.57	7.70	8.09	7.92

Table 5.—Sizes of Pennsylvania anthracite (excluding dredge coal) prepared at plants in 1967, by regions

(Percent)

Size	Lehigh region			Schuylkill region		
	Shipped by rail	Shipped by truck	Total	Shipped by rail	Shipped by truck	Total
Lump [1] and broken	----	-------	-------	-------	-------	------
Egg	8.3	0.3	4.6	2.9	(2)	1.2
Stove	16.3	4.6	11.0	9.7	9.1	9.4
Chestnut	10.8	13.6	12.1	6.8	13.6	10.7
Pea	5.1	13.6	9.0	5.1	10.2	8.0
Total pea and larger	40.5	32.1	36.7	24.5	32.9	29.3
Buckwheat No. 1	8.2	13.4	10.5	9.4	12.2	11.0
Buckwheat No. 2 (rice)	2.9	15.9	8.9	4.6	12.5	9.2
Buckwheat No. 3 (barley)	8.3	10.0	9.1	6.1	14.8	11.1
Buckwheat No. 4	8.0	3.6	6.0	6.6	6.6	6.7
Buckwheat No. 5	28.5	1.0	15.9	22.4	5.8	12.8
Other [3]	3.6	24.0	12.9	26.4	15.2	19.9
Total buckwheat No. 1 and smaller	59.5	67.9	63.3	75.5	67.1	7.07
	Wyoming region [4]			Total		
Lump [1] and broken	----	(2)	(2)	-------	(2)	(2)
Egg	8.8	0.1	3.0	5.9	0.1	2.6
Stove	24.4	5.9	12.0	14.8	7.2	10.5
Chestnut	15.9	15.8	15.8	10.0	14.3	12.4
Pea	4.4	15.9	12.1	4.9	12.6	9.3
Total pea and larger	53.5	37.7	42.9	35.6	34.2	34.8
Buckwheat No. 1	9.3	15.3	13.3	9.0	13.4	11.5
Buckwheat No. 2 (rice)	4.6	11.8	9.4	4.0	13.0	9.2
Buckwheat No. 3 (barley)	17.3	7.3	10.6	9.1	11.5	10.4
Buckwheat No. 4	6.7	.6	2.6	7.1	4.2	5.4
Buckwheat No. 5	6.8	5.6	6.0	21.3	4.7	11.9
Other [3]	1.8	21.7	15.2	13.9	19.0	16.8
Total buckwheat No. 1 and smaller	46.5	62.3	57.1	64.4	65.8	65.2

[1] Quantity of lump included is insignificant.
[2] Less than 0.05 percent.
[3] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.
[4] Includes Sullivan County.

Table 6.—Sizes of Pennsylvania anthracite (excluding dredge coal) prepared at plants, by regions

(Percent)

Size	Lehigh region					Schuylkill region				
	1963	1964	1965	1966	1967	1963	1964	1965	1966	1967
Lump [1] and broken	----	----	----	----	----	(2)	(2)	----	----	----
Egg	2.3	3.3	3.9	2.7	4.6	1.1	0.9	1.0	0.9	1.2
Stove	9.7	11.8	11.8	11.1	11.0	11.9	11.3	10.3	9.3	9.4
Chestnut	11.7	14.1	14.9	12.4	12.1	15.0	14.2	12.0	12.0	10.7
Pea	10.1	10.3	9.4	7.4	9.0	10.3	9.1	8.4	8.3	8.0
Total pea and larger	33.8	39.5	40.0	33.6	36.7	38.3	35.5	31.7	30.5	29.3
Buckwheat No. 1	9.3	10.4	10.5	11.3	10.5	12.3	11.3	11.9	12.1	11.0
Buckwheat No. 2 (rice)	8.7	10.5	9.5	9.9	8.9	9.7	9.3	10.1	10.2	9.2
Buckwheat No. 3 (barley)	9.8	11.0	10.2	9.1	9.1	11.2	11.7	13.5	13.3	11.1
Buckwheat No. 4	7.8	6.8	5.5	6.2	6.0	6.8	6.6	6.5	7.0	6.7
Buckwheat No. 5	16.8	12.1	12.5	14.8	15.9	12.8	13.3	14.7	14.1	12.8
Other [3]	13.8	9.7	11.8	15.1	12.9	8.9	12.3	11.6	12.8	19.9
Total buckwheat No. 1 and smaller	66.2	60.5	60.0	66.4	63.3	61.7	64.5	68.3	69.5	70.7
	Wyoming region [4]					Total				
Lump [1] and broken	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Egg	4.9	4.6	4.7	3.4	3.0	2.6	2.5	2.8	2.0	2.6
Stove	16.7	15.2	15.0	13.1	12.0	13.0	12.6	12.1	10.8	10.5
Chestnut	18.5	17.3	16.6	17.2	15.8	15.4	15.2	14.1	13.5	12.4
Pea	13.9	12.9	12.9	12.6	12.1	11.4	10.5	10.0	9.3	9.3
Total pea and larger	54.0	50.0	49.2	46.3	42.9	42.4	40.8	39.0	35.6	34.8
Buckwheat No. 1	15.1	13.9	13.8	15.0	13.3	12.6	11.9	12.2	12.7	11.5
Buckwheat No. 2 (rice)	9.3	9.2	9.2	9.7	9.4	9.3	9.5	9.7	9.9	9.2
Buckwheat No. 3 (barley)	10.9	10.3	10.7	10.8	10.6	10.8	11.1	11.9	11.6	10.4
Buckwheat No. 4	2.4	2.2	3.8	4.7	2.6	5.6	5.3	5.4	6.2	5.4
Buckwheat No. 5	4.0	3.1	2.9	4.3	6.0	10.8	9.9	10.5	11.6	11.9
Other [3]	4.3	11.3	10.4	9.2	15.2	8.5	11.5	11.3	12.4	16.8
Total buckwheat No. 1 and smaller	46.0	50.0	50.8	53.7	57.1	57.6	59.2	61.0	64.4	65.2

[1] Quantity of lump included is insignificant.
[2] Less than 0.05 percent.
[3] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.
[4] Includes Sullivan County.

Table 7.—Production of Pennsylvania anthracite in 1967, by regions

(Thousand short tons and thousand dollars)

Region	Production							
	Rail shipments		Truck shipments		Colliery fuel		Total [1]	
	Quantity	Value [2]	Quantity	Value [2]	Quantity	Value	Quantity	Value [2]
Lehigh:								
Preparation plants	1,654	$14,310	1,397	$11,388	8	$74	3,059	$25,773
Schuylkill:								
Preparation plants	2,306	16,269	3,165	25,295	6	54	5,477	41,618
Dredges	574	2,034	57	223	-----	-----	632	2,257
Total Schuylkill	2,880	18,303	3,222	25,518	6	54	6,108	43,875
Wyoming:								
Preparation plants [3]	974	9,804	1,986	16,560	128	148	3,088	26,512
Total: [1]								
Preparation plants	4,934	40,383	6,548	53,244	143	277	11,624	93,903
Dredges	574	2,034	57	223	-----	-----	632	2,257
Grand total [1]	5,508	42,417	6,605	53,466	143	277	12,256	96,160

[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	1963	1964	1965	1966	1967
Eastern Middle: Breakers and washeries	2,657	2,189	2,027	2,009	2,039
Western Middle:					
Breakers and washeries	4,270	4,492	3,428	3,025	2,893
Dredges	36	34	36	26	27
Total [1]	4,307	4,526	3,464	3,051	2,920
Southern:					
Breakers and washeries	4,858	4,592	4,160	3,781	3,604
Dredges	656	672	664	635	605
Total [1]	5,514	5,264	4,824	4,416	4,209
Northern: Breakers and washeries [2]	5,790	5,206	4,551	3,465	3,088
Total:[1]					
Breakers and washeries	17,576	16,479	14,165	12,280	11,624
Dredges	692	705	700	662	632
Grand total [1]	18,267	17,184	14,866	12,941	12,256

[1] Data may not add to totals shown because of independent rounding.
[2] Includes Sullivan County.

Table 9.—Production of Pennsylvania anthracite in 1967, by counties

(Thousand short tons and thousand dollars)

County	Rail shipments		Truck shipments		Colliery fuel		Total production [1]	
	Quantity	Value [2]	Quantity	Value [2]	Quantity	Value	Quantity	Value [2]
Berks, Lancaster, and Snyder	574	$2,034	40	$141	-----	-----	614	$2,175
Carbon	424	3,496	200	877	-----	-----	624	4,373
Columbia	276	2,768	141	1,021	-----	-----	418	3,788
Dauphin	50	209	105	459	-----	-----	155	668
Lackawanna	208	1,899	245	1,662	(3)	$3	453	3,564
Lebanon	-----	--------	3	12	-----	-----	3	12
Luzerne	1,671	15,841	2,458	20,920	135	214	4,264	36,975
Northumberland	676	3,426	778	6,047	(3)	4	1,455	9,476
Schuylkill	1,628	12,742	2,600	22,140	7	57	4,235	34,939
Sullivan	-----	--------	35	184	-----	-----	35	184
Susquehanna	(3)	2	(3)	3	-----	-----	(3)	6
Total [1]	5,508	42,417	6,605	53,466	143	277	12,256	96,160

[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] Less than ½ unit.

Table 10.—Pennsylvania anthracite produced in 1967, classified as fresh-mined, culm-bank, and river coal, by fields

(Thousand short tons)

Field	Fresh-mined coal				From culm banks	From river dredging	Total [1]
	Underground mines			Strip pits			
	Mechanically loaded	Hand loaded	Total [1]				
Eastern Middle	15	10	25	1,259	755	------	2,039
Western Middle	167	368	535	1,123	1,235	27	2,920
Southern	376	881	1,257	1,492	855	605	4,209
Northern [2]	1,440	--------	1,440	866	782	------	3,088
Total [1]	1,998	1,260	3,258	4,740	3,627	632	12,256

[1] Data may not add to totals shown because of independent rounding.
[2] Includes Sullivan County.

Table 11.—Pennsylvania anthracite produced in 1967, classified as fresh-mined, culm-bank, and river coal, by regions

(Thousand short tons)

Region	Fresh-mined coal: Underground mines: Mechanically loaded	Hand loaded	Total [1]	Strip pits	From culm banks	From river dredging	Total [1]
Lehigh	15	33	48	1,878	1,134	------	3,059
Schuylkill	543	1,226	1,769	1,997	1,710	632	6,108
Wyoming [2]	1,440	--------	1,440	866	782	------	3,088
Total [1]	1,998	1,260	3,258	4,740	3,627	632	12,256

[1] Data may not add to totals shown because of independent rounding.
[2] Includes Sullivan County.

Table 12.—Production of Pennsylvania anthracite from strip pits

	Mined by stripping (thousand short tons)	Percent of fresh-mined total	Number of men employed	Average number of days worked
1963	7,468	52.7	3,025	224
1964	7,177	54.9	3,075	217
1965	5,939	52.9	2,349	217
1966	5,253	56.2	2,085	225
1967:				
Lehigh region	1,878	97.5	674	257
Schuylkill region	1,997	53.0	828	217
Wyoming region [1]	866	37.5	381	244
Total [2] or average	4,740	59.3	1,883	237

[1] Includes Sullivan County.
[2] Data may not add to totals shown because of independent rounding.

Table 13.—Power shovels and draglines used in recovering coal from culm banks and stripping Pennsylvania anthracite, by type of power

Type of power	1965: Number of power shovels	Number of draglines	Total	1966: Number of power shovels	Number of draglines	Total	1967: Number of power shovels	Number of draglines	Total
Gasoline	29	6	35	20	1	21	4	6	10
Electric	32	59	91	28	53	81	27	43	70
Diesel	84	175	259	72	149	221	93	140	233
Diesel-electric	4	1	5	3	2	5	1	1	2
Total	149	241	390	123	205	328	125	190	315

Table 14.—Production of Pennsylvania anthracite from culm banks, by regions

(Thousand short tons)

Year	Lehigh region	Schuylkill region	Wyoming region	Total [1]
1963	1,298	1,389	706	3,393
1964	936	1,580	897	3,413
1965	833	1,380	716	2,930
1966	971	1,390	578	2,938
1967	1,134	1,710	782	3,627

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

Table 15.—Pennsylvania anthracite produced by dredges in 1967, by rivers, including tributaries

(Thousand short tons and thousand dollars)

River	Production	Value	
		Total	Average
Schuylkill	39	$116	$3.00
Susquehanna	593	2,140	3.61
Total [1]	632	2,257	3.57

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

Table 16.—Pennsylvania anthracite produced by dredges, by rivers, including tributaries

(Thousand short tons and thousand dollars)

Year	Schuylkill River	Susquehanna River	Total	Total value	Average value (per ton)
1963	84	608	692	$2,469	$3.57
1964	98	607	705	2,359	3.35
1965	86	614	700	2,337	3.34
1966	57	606	662	2,287	3.46
1967	39	593	632	2,257	3.57

Table 17.—Estimated production of Pennsylvania anthracite, by weeks, in 1967 [1]

Week ended—	Thousand short tons	Week ended—	Thousand short tons	Week ended—	Thousand short tons
Jan. 7	206	May 13	228	Sept. 16	267
14	293	20	256	23	278
21	281	27	254	30	261
28	246	June 3	221	Oct. 7	273
Feb. 4	193	10	223	14	263
11	208	17	239	21	235
18	217	24	257	28	241
25	294	July 1	179	Nov. 4	216
Mar. 4	206	8	90	11	241
11	225	15	241	18	221
18	220	22	248	25	203
25	194	29	255	Dec. 2	279
Apr. 1	241	Aug. 5	266	9	241
8	218	12	248	16	256
15	246	19	266	23	217
22	232	26	231	30	200
29	251	Sept. 2	235		
May 6	245	9	211	Total	12,256

[1] Estimated from weekly carloadings as reported by the Association of American Railroads and other factors; adjusted to annual production from Bureau of Mines canvass.

Table 18.—Estimated monthly production of Pennsylvania anthracite [1]

(Thousand short tons)

Month	1965	1966	1967
January	1,215	1,108	1,101
February	1,006	1,091	939
March	1,256	1,033	979
April	1,127	1,058	952
May	1,264	1,103	1,102
June	1,565	998	995
July	1,209	745	899
August	1,244	1,191	1,132
September	1,313	1,145	1,071
October	1,221	1,221	1,073
November	1,208	1,145	1,017
December	1,238	1,103	996
Total	14,866	12,941	12,256

[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 19.—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]	
	1966	1967	1966	1967	1966	1967	1966	1967
Northern	916	700	23	32	1,041	709	1,979	1,440
Eastern Middle	7	7	(4)	----	18	8	25	15
Western Middle	19	12	----	----	151	155	170	167
Southern	174	189	7	2	235	185	416	376
Total [3]	1,116	908	30	34	1,444	1,056	2,591	1,998

1 Includes mobile loaders.
2 Shaker chutes, including those equipped with duckbills.
3 Data may not add to totals shown because of independent rounding.
4 Less than ½ unit.

Table 20.—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
1963	147	862	30	305	512	2,499	689	3,666
1964	139	750	31	493	495	2,212	665	3,455
1965	155	907	25	393	403	1,946	583	3,246
1966	151	788	30	328	383	1,474	564	2,591
1967	119	707	21	201	228	1,090	368	1,998

1 Includes duckbills and other self-loading conveyors.
2 Data may not add to totals shown because of independent rounding.

Table 21.—Trends in mechanical loading [1], hand loading, and stripping of Pennsylvania anthracite

(Thousand short tons)

Year	Fresh-mined coal							
	Underground					Strip pits		
	Mechanical loading	Percent of total underground	Hand loading	Percent of total underground	Total [2]	Quantity	Percent of total fresh-mined	Total [2]
1963	3,666	54.6	3,049	45.4	6,715	7,468	52.7	14,183
1964	3,455	58.7	2,434	41.3	5,889	7,177	54.9	13,066
1965	3,246	61.3	2,051	38.7	5,297	5,939	52.9	11,236
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

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 22.—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 4⅜ Over 3¼ to 3	----	15	7½	1½	2	11
Egg	Through 3¼ to 3 Over 2 7/16	5	15	7½	1½	2	11
Stove	Through 2 7/16 Over 1⅝	7½	15	7½	2	3	11
Chestnut	Through 1⅝ Over 13/16	7½	15	7½	3	4	11
Pea	Through 13/16 Over 9/16	10	15	7½	4	5	12
Buckwheat No. 1	Through 9/16 Over 5/16	10	15	7½	------	----	13
Buckwheat No. 2 (rice)	Through 5/16 Over 3/16	10	17	7½	------	----	13
Buckwheat No. 3 (barley)	Through 3/16 Over 3/32	10	20	10	------	----	15
Buckwheat No. 4	Through 3/32 Over 3/64	20	30	10	------	----	15
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 23.—Average sales realization of Pennsylvania anthracite (excluding dredge coal) at preparation plants, by regions and sizes

(Per short ton)

Size	Lehigh region					Schuylkill region				
	1963	1964	1965	1966	1967	1963	1964	1965	1966	1967
Lump [1] and broken	-----	-----	-----	-----	-----	$12.62	$13.76	-----	-----	-----
Egg	$11.75	$13.04	$12.95	$12.46	$12.68	11.81	12.92	$12.65	$12.42	$12.49
Stove	12.28	13.41	12.62	12.03	12.51	11.92	12.59	11.73	11.30	11.80
Chestnut	12.39	13.44	12.50	11.95	12.46	11.86	12.52	11.68	11.04	11.53
Pea	9.89	11.06	10.09	9.00	9.42	9.63	10.18	9.37	8.66	9.15
Total pea and larger	11.57	12.78	12.01	11.37	11.76	11.28	11.95	11.11	10.51	11.00
Buckwheat No. 1	8.76	9.68	9.28	8.45	9.01	8.78	9.42	8.69	8.68	9.02
Buckwheat No. 2 (rice)	9.25	10.00	9.66	9.32	9.62	8.63	8.99	8.53	8.28	8.67
Buckwheat No. 3 (barley)	6.74	7.21	7.57	7.53	7.78	6.67	6.87	7.12	7.19	7.43
Buckwheat No. 4	4.97	5.33	5.57	5.59	5.48	4.70	4.98	5.26	5.32	5.50
Buckwheat No. 5	4.86	5.17	5.36	5.38	5.46	4.12	4.43	4.31	4.61	4.70
Other [2]	3.00	3.16	2.98	2.99	3.13	3.25	3.37	3.44	3.57	3.95
Total buckwheat No. 1 and smaller	5.89	6.85	6.66	6.26	6.49	6.16	6.25	6.19	6.23	6.18
Total all sizes	7.81	9.19	8.80	7.98	8.42	8.12	8.28	7.75	7.53	7.60
	Wyoming region [3]					Total				
Lump [1] and broken	$11.72	$12.42	$12.39	$12.50	$14.96	$12.10	$12.84	$12.39	$12.50	$14.96
Egg	12.19	12.90	13.12	12.51	12.74	12.03	12.94	12.99	12.48	12.65
Stove	12.42	13.06	12.58	12.17	12.66	12.19	12.32	12.25	11.77	12.25
Chestnut	12.62	13.18	12.51	12.04	12.31	12.24	12.92	12.17	11.59	12.03
Pea	10.83	11.42	10.62	10.34	10.73	10.15	10.82	10.02	9.35	9.75
Total pea and larger	12.06	12.67	12.09	11.65	11.99	11.65	12.38	11.70	11.11	11.53
Buckwheat No. 1	9.51	10.04	9.34	9.01	9.60	9.06	9.69	9.03	8.74	9.19
Buckwheat No. 2 (rice)	9.41	9.73	9.42	9.18	9.59	9.00	9.43	9.03	8.77	9.16
Buckwheat No. 3 (barley)	6.53	6.93	7.42	7.30	7.44	6.64	6.95	7.28	7.28	7.51
Buckwheat No. 4	5.60	5.22	5.82	6.16	5.65	4.90	5.10	5.45	5.56	5.51
Buckwheat No. 5	4.77	4.95	5.08	5.43	4.55	4.44	4.66	4.64	4.93	4.95
Other [2]	1.92	1.87	1.80	2.04	2.45	2.94	2.88	2.86	3.09	3.43
Total buckwheat No. 1 and smaller	7.46	6.97	6.91	6.96	6.58	6.43	6.56	6.48	6.40	6.35
Total all sizes	9.94	9.82	9.46	9.13	8.91	8.64	8.93	8.51	8.08	8.15

[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 24.—Average value of Pennsylvania anthracite from all sources, by regions [1]

(Per short ton)

Region	1966				1967			
	Shipped by rail	Shipped by truck	Colliery fuel	Total	Shipped by rail	Shipped by truck	Colliery fuel	Total
Lehigh	$7.94	$8.02	$8.61	$7.98	$8.65	$8.15	$8.82	$8.42
Schuylkill	6.29	7.84	7.83	7.12	6.35	7.92	8.75	7.18
Wyoming [2]	9.81	8.69	1.52	8.85	10.07	8.34	1.16	8.58
Total	7.51	8.12	2.22	7.78	7.70	8.09	1.94	7.85

[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 25.—Wholesale prices of Pennsylvania anthracite, in 1967, by sizes [1]

(Per short ton)

Size	Winter	Spring discount	Summer-fall	End of year
Egg and stove	$13.50–$14.00	$12.50	$13.00–$13.50	$14.00–$14.75
Chestnut	13.25– 13.75	12.25	12.75– 13.25	13.75– 14.25
Pea	10.25– 11.00	10.00	10.25– 10.75	10.75– 11.25
Buckwheat No. 1	9.35– 10.10	9.25	9.50– 9.85	10.10– 10.50
Buckwheat No. 2 (rice)	9.25– 9.85	9.25	9.50– 9.85	10.10– 10.50
Buckwheat No. 3 (barley)	8.70– 8.75	8.50–8.70	8.50– 8.70	8.70– 9.00

[1] As quoted in The Black Diamond Magazine. All prices are per short ton f.o.b. at mines.

Table 26.—Employment at operations producing Pennsylvania anthracite (including strip contractors) in 1967

	Lehigh region	Schuylkill region	Wyoming region [1]	Total	
				1967	1966
Average number of men working daily:					
Underground	42	1,038	1,207	2,287	3,332
In strip pits	674	828	381	1,883	2,085
At culm banks	161	257	152	570	502
At preparation plants	519	979	395	1,893	1,956
Other surface	40	327	685	1,052	1,339
Total excluding dredge operations	1,436	3,429	2,820	7,685	9,214
Dredge operations	-------	65	-------	65	78
Total	1,436	3,494	2,820	7,750	9,292
Average number of days active:					
All operations except dredges	225	214	222	219	202
Dredge operations	-------	284	-------	284	271
Average, all operations	225	215	222	219	203
Man-days of labor:					
All operations except dredges	323,181	733,960	625,069	1,682,210	1,861,848
Dredge operations	-------	18,490	-------	18,490	21,125
Total, all operations	323,181	752,450	625,069	1,700,700	1,882,973
Average tons per man-day:					
All operations except dredges	9.47	7.46	4.94	6.91	6.60
Dredge operations	-------	34.16	-------	34.16	31.32
Average, all operations	9.47	8.12	4.94	7.21	6.87

[1] Includes Sullivan County.

Table 27.—Employment at operations producing Pennsylvania anthracite (including strip contractors) by counties

County	1966	1967	County	1966	1967
Berks, Lancaster, Lebanon, and Snyder	71	57	Northumberland	1,093	846
Carbon	234	214	Schuylkill	3,123	2,735
Columbia	238	227	Sullivan	14	14
Dauphin	124	107	Susquehanna and Wayne [1]	5	2
Lackawanna	840	480	Total	9,292	7,750
Luzerne	3,550	3,068			

[1] None employed in Wayne in 1967.

Table 28.—Distribution of Pennsylvania anthracite, April 1, 1966, to March 31, 1967, by 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	381	10,655	13,592	502	25,130	1,485	3,525	7,563	72	12,645	37,775	0.3
Maine	143	11,414	11,241	458	23,256	1,781	6,849	--------	9	8,639	31,895	.3
Massachusetts	2,972	37,434	23,492	3,599	67,497	10,935	15,284	6	57	26,282	93,779	.9
New Hampshire	75	6,956	5,045	611	12,687	2,038	4,256	--------	168	6,462	19,149	.2
Rhode Island	--------	2,816	2,958	59	5,833	1,993	611	--------	2	2,606	8,439	.1
Vermont	260	12,605	7,765	2,053	22,683	7,097	12,079	--------	--------	19,176	41,859	.4
Total	3,831	81,880	64,093	7,282	157,086	25,329	42,604	7,569	308	75,810	232,896	2.2
Middle Atlantic States:												
New Jersey	2,880	69,383	159,328	52,869	284,460	82,474	54,755	176,180	234,156	547,565	832,025	7.6
New York	13,083	219,206	183,425	326,460	742,174	266,587	101,593	125,264	233,569	727,013	1,469,187	13.4
Pennsylvania [1]	13,859	431,230	899,000	706,431	2,050,520	902,656	868,837	1,026,103	1,197,288	3,994,884	6,045,404	55.2
Total	29,822	719,819	1,241,753	1,085,760	3,077,154	1,251,717	1,025,185	1,327,547	1,665,013	5,269,462	8,346,616	76.2
South Atlantic States: [2]												
Delaware	1,204	8,924	13,120	2,509	25,757	663	272	3,078	9	4,022	29,779	.3
District of Columbia	49	5,057	3,501	522	9,129	3,270	649	531	--------	4,450	13,579	.1
Maryland	159	24,522	17,526	2,425	44,632	39,915	3,568	2,768	240,268	286,519	331,151	3.0
Virginia	23	3,458	1,554	15,643	20,678	831	190	1	199	1,221	21,899	.2
Total	1,435	41,961	35,701	21,099	100,196	44,679	4,679	6,378	240,476	296,212	396,408	3.6
Lake States:												
Illinois	--------	929	1,947	2,728	5,604	63,705	12,607	1,125	21,196	98,633	104,237	1.0
Indiana	--------	--------	1,824	14,709	16,533	1,169	291	418	37,964	39,842	56,375	.5
Michigan	--------	1,949	9,572	6,416	17,937	8,492	2,518	17	107,806	118,833	136,770	1.2
Minnesota	--------	36	48	52	136	8	1	8	23,571	23,588	23,724	.2
Ohio	34	1,785	1,837	6,719	10,375	28,996	9,467	88	64,558	103,109	113,484	1.0
Wisconsin	--------	3,268	4,274	314	7,856	1,374	868	61	6,925	9,228	17,084	.2
Total	34	7,967	19,502	30,938	58,441	103,744	25,752	1,717	262,020	393,233	451,674	4.1
Other States	1,343	51	2,305	7,946	11,645	70,758	6,741	22,172	184,603	284,274	295,919	2.7
Total United States	36,465	851,678	1,363,354	1,153,025	3,404,522	1,496,227	1,104,961	1,365,383	2,352,420	6,318,991	9,723,513	88.8
Canada:												
Ontario	450	96,740	69,852	23,627	190,669	67,160	16,022	7,390	3,015	93,587	284,256	2.6
Quebec	98	13,368	8,463	1,215	23,144	9,962	55,495	57,585	218	123,255	146,399	1.3
Other Provinces	400	2,245	1,629	19	4,293	14	889	24	143	1,070	5,363	.1
Total Canada	948	112,353	79,944	24,861	218,106	77,136	72,406	64,999	3,371	217,912	436,018	4.0
Other countries	211,771	385,090	110,392	33,885	741,138	21,709	19	6,739	25,201	53,668	794,806	7.2
Grand total	249,184	1,349,121	1,553,690	1,211,771	4,363,766	1,595,072	1,177,386	1,437,121	2,380,992	6,590,571	10,954,337	100.0

[1] Includes "Local Sales."

[2] Shipments to other States in the South Atlantic area are included in "Other States."

Table 29.—Truck shipments of Pennsylvania anthracite in 1967, by months, and by State of destination [1]

(Thousand short tons)

Destination	January	February	March	April	May	June	July
Pennsylvania:							
Within region	208	231	201	151	147	104	100
Outside region	268	254	222	173	205	174	140
New York	51	41	43	28	34	34	19
New Jersey	34	28	23	16	20	26	19
Delaware	3	2	1	(2)	(2)	1	2
Maryland	10	15	6	5	3	3	3
District of Columbia	1	1	(2)	(2)	(2)	------	(2)
Other States	3	2	2	1	(2)	(2)	(2)
Total [3]: 1967	578	574	500	375	410	344	283
1966	652	662	514	463	455	419	306

Destination	August	September	October	November	December	Total [3]	Percent of total trucked
Pennsylvania:							
Within region	113	153	162	206	209	1,986	37.4
Outside region	186	177	208	234	244	2,485	46.8
New York	23	28	36	42	39	418	7.8
New Jersey	22	23	25	26	25	286	5.4
Delaware	2	1	3	3	3	23	.4
Maryland	6	7	9	8	12	89	1.7
District of Columbia	(2)	(2)	(2)	2	(2)	6	.1
Other States	1	1	2	2	3	20	.4
Total [3]: 1967	354	391	445	523	535	5,312	100.0
1966	416	436	533	537	628	6,021	100.0

[1] Compiled from reports of Pennsylvania Department of Mines and Mineral Industries; does not include dredge coal.
[2] Less than ½ unit.
[3] Data may not add to totals shown because of independent rounding.

Table 30.—Truck shipments of Pennsylvania anthracite, by destinations [1]

(Thousand short tons)

Destination	1963	1964	1965	1966	1967
Pennsylvania:					
Within region	3,228	3,231	2,712	2,343	1,986
Outside region	3,156	3,284	3,015	2,685	2,485
New York	870	692	521	477	418
New Jersey	547	501	440	392	286
Delaware	37	34	30	26	23
Maryland	90	78	63	69	89
District of Columbia	4	5	7	8	6
Other States	37	36	24	21	20
Total [2]	7,970	7,862	6,812	6,021	5,312

[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.

Table 31.—Rail shipments of Pennsylvania anthracite, by destinations [1]

(Thousand short tons)

Destination	1963	1964	1965	1966	1967
New England States	407	381	298	221	174
New York	1,516	1,317	1,056	957	703
New Jersey	675	641	654	399	323
Pennsylvania	2,002	2,209	1,780	1,247	1,052
Delaware	17	12	6	4	5
Maryland	208	230	184	210	83
District of Columbia	15	19	12	9	10
Virginia	11	12	39	29	13
Ohio	139	162	142	121	85
Indiana	26	72	80	67	51
Illinois	78	102	121	103	114
Wisconsin	25	29	21	19	16
Minnesota	8	21	39	25	22
Michigan	35	51	84	54	41
Other States	217	232	272	305	244
Total United States [2]	5,378	5,493	4,788	3,768	2,936
Canada	647	513	464	434	306
Other foreign countries	1,954	1,444	1,170	741	894
Grand total [2]	7,979	7,450	6,422	4,943	4,136

[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.

Table 32.—Consumption of Pennsylvania anthracite in the United States, by consumer categories

(Thousand short tons)

Year	Residential and commercial heating [1]	Colliery fuel	Railroads	Electric utilities [2]	Briquet plants	Cement plants	Iron and steel industry: Coke making	Iron and steel industry: Sintering and pelletizing [3]	Iron and steel industry: Other [4]	Other industrial [1]	Unaccounted for [1]
1963	7,890	161	NA	2,155	W	184	451	766	670	1,664	159
1964	7,550	144	NA	2,239	W	153	492	1,014	NA	2,713	95
1965	6,628	143	NA	2,158	W	269	507	966	NA	2,071	158
1966	5,622	141	NA	2,192	W	187	515	897	NA	1,715	131
1967	5,035	143	NA	2,186	W	NA	528	819	NA	2,039	50

NA Not available.
W Withheld to avoid disclosing of individual company confidential data.
[1] Calculated.
[2] Federal Power Commission.
[3] Annual Statistical Report, American Iron and Steel Institute.
[4] Contains a small but not exactly determined amount of anthracite used for sintering.

Table 33.—Apparent consumption of anthracite, heating and range oil, and natural gas, in the principal anthracite markets

(Thousand short tons)

Fuel	New England	New York	New Jersey	Pennsylvania	Delaware	Maryland	District of Columbia	Total	Percent of total fuels
Anthracite (all users): [1]									
1964	381	[2] 2,009	[2] 1,142	8,725	46	309	24	12,636	8.5
1965	298	[2] 1,577	[2] 1,094	7,507	36	247	19	10,778	6.7
1966	221	[2] 1,434	[2] 790	6,275	30	279	18	9,047	5.5
1967	174	[2] 1,121	[2] 609	5,523	28	171	16	7,642	4.4
Oil (heating and range): [3]									
1964	31,432	30,988	12,851	12,484	934	4,692	1,498	94,879	63.7
1965	34,950	36,670	13,469	13,123	975	4,534	2,173	105,894	66.2
1966	34,202	37,015	14,247	13,155	1,037	4,882	2,217	106,755	65.1
1967	37,586	40,156	16,967	15,512	965	5,080	2,762	119,028	67.5
Natural gas: [4]									
1964	4,850	14,499	5,303	13,080	262	3,397	(5)	41,391	27.8
1965	5,129	15,465	5,565	13,359	289	3,568	(5)	43,375	27.1
1966	5,520	18,280	6,003	14,404	320	3,616	(5)	48,143	29.4
1967	6,121	17,427	6,681	14,750	364	4,255	(5)	49,598	28.1
Total:									
1964	36,663	47,496	19,296	34,289	1,242	8,398	[6] 1,522	148,906	100.0
1965	40,377	53,712	20,128	33,989	1,300	8,349	[6] 2,192	160,047	100.0
1966	39,943	56,729	21,040	33,834	1,387	8,777	[6] 2,235	163,945	100.0
1967	43,881	58,704	24,257	35,785	1,357	9,506	[6] 2,778	176,268	100.0

[1] Pennsylvania Department of Mines and Mineral Industries.
[2] Part of the anthracite shown as shipped to New Jersey is reshipped to New York.
[3] Converted to coal equivalent upon the basis of 4 barrels of fuel oil equaling 1 ton of coal.
[4] Converted to coal equivalent upon the basis of 24,190 cubic feet of natural gas equaling 1 ton of coal.
[5] District of Columbia included with Maryland.
[6] Natural gas for the District of Columbia included with Maryland.

Table 34.—U.S. exports of anthracite by countries and customs districts

(Thousand short tons)

Country	1966	1967
North America:		
Canada	624	449
Haiti	-----	2
Mexico	23	11
Panama	1	8
Trinidad and Tobago	(1)	1
Other	1	1
Total	649	472
South America:		
Argentina	4	2
Brazil	6	2
Chile	1	1
Surinam	1	2
Venezuela	9	8
Other	(1)	(1)
Total	21	15
Europe:		
Belgium-Luxembourg	(1)	(1)
France	9	1
Italy	32	45
Norway	2	-----
Rumania	10	11
Spain	10	(1)
United Kingdom	1	-----
Other	1	1
Total	65	58
Africa	(1)	1
Asia:		
India	3	5
Japan	2	8
Thailand	6	5
Viet-Nam, South	17	26
Other	1	1
Total	29	45
Oceania	2	4
Grand total	766	595

Customs district	1966	1967
North Atlantic:		
Portland, Maine	3	---
New York City	4	4
Philadelphia	290	277
South Atlantic:		
Baltimore	(1)	14
Norfolk	7	2
Gulf Coast:		
Houston	7	4
New Orleans	2	9
Mexican border: Laredo	23	11
Northern border:		
Buffalo	345	220
Chicago	2	-----
Detroit	7	2
Ogdensburg	75	50
Pembina	1	-----
St. Albans	-----	1
Pacific Coast: Seattle	-----	1
Other	-----	(1)
Total	766	595

[1] Less than ½ unit.

NOTE: According to the Association of American Railroads, 879, 849 short tons of anthracite was exported to Europe during 1967 compared with 830,216 tons for 1966. Of this total 826,968 tons was consigned to West Germany and Netherlands, including exports to the U.S. military forces, compared with 764,974 tons for 1966.

Table 35.—World production of anthracite, by countries [1]

(Thousand short tons)

Country	1963	1964	1965	1966	1967 p
Belgium	8,562	8,710	7,934	7,336	5,503
Bulgaria	239	244	209	e 185	NA
China, mainland e	22,000	23,100	24,300	25,400	19,840
France	11,998	13,511	13,660	r 13,950	e 12,840
Germany, West	14,969	16,217	15,526	13,725	12,103
Ireland	164	169	130	133	e 136
Italy	15	10	7	(2)	-------
Japan	1,982	1,884	1,797	1,777	1,669
Korea:					
North e	10,700	12,300	16,000	17,100	18,700
South	9,764	10,606	11,296	12,801	13,708
Morocco	445	441	462	497	531
Netherlands [3]	r 4,200	r 4,639	r 4,884	r 4,845	e 4,275
New Zealand	(2)	(2)	(2)	(2)	NA
Peru	11	35	9	15	6
Portugal	459	489	472	r 463	488
Rumania e	17	17	17	17	17
South Africa, Republic of	1,270	1,450	1,375	1,187	1,411
Spain	3,057	2,954	3,059	3,028	3,058
Swaziland	-------	4	33	74	86
U.S.S.R	84,528	86,906	88,700	e r 90,400	e 91,500
United Kingdom	4,658	5,150	4,707	4,986	e 4,630
United States (Pennsylvania)	18,267	17,184	14,866	12,941	12,256
Viet-Nam:					
North	3,689	e 3,700	e 3,900	e 3,900	e 3,100
South	115	85	-------	-------	-------
Total [4]	r 201,109	r 209,805	r 213,343	r 214,760	205,857

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Compiled mostly from data available June 1968.
[2] Less than ½ unit.
[3] Revised to exclude coal with more than 10 percent volatile matter.
[4] Total is of listed figures only; no undisclosed data included.

NOTE: An undetermined amount of semi-anthracite is included in the figures for some countries.

Cobalt

By Horace T. Reno[1]

The world's supply of cobalt in 1967 was more than adequate to meet the demand. Mines produced more than 20,000 tons of cobalt, the U.S. Government sold 3,000 tons of cobalt from its stockpile, and world consumers used less cobalt than in 1966.

Legislation and Government Programs. The General Services Administration (GSA) sold cobalt from the Defense Production Act Inventory in the first half of 1967 for domestic consumption only, but relaxed this restriction July 3, 1967, to permit sales for export. On December 31, 1967, U.S. Government stockpiles contained 95,249,020 pounds of cobalt.

DOMESTIC PRODUCTION

Cobalt is produced in the United States as a by-product of iron ore mining and is recovered in processing zinc concentrate. The quantities are not significant.

CONSUMPTION AND USES

Domestic cobalt consumption decreased in 1967 compared with 1966 levels following the downward trend in the metal economy. The pattern of cobalt usage was not changed significantly from that of the last few years, although data reported to the Bureau of Mines indicate proportionately less cobalt used in high-temperature, high-strength alloys. In all probability the change was due more to imperfect canvassing and reporting rather than to any actual change in the pattern of usage.

[1] Mining engineer, Division of Mineral Studies.

Table 1.—Salient cobalt statistics

(Thousand pounds of contained cobalt)

	1963	1964	1965	1966	1967
United States:					
Consumption	10,529	10,650	13,595	14,205	13,976
Imports for consumption	10,522	12,443	15,408	18,823	8,215
Stocks, Dec. 31: Consumer	1,099	1,420	1,590	1,996	2,471
Price: Metal ... per pound	$1.50	$1.50	$1.65	$1.65	$1.85
World: Production	32,048	34,964	37,634	44,188	40,090

Table 2.—Cobalt materials consumed by refiners or processors in the United States

(Thousand pounds of contained cobalt)

Form [1]	1963	1964	1965	1966	1967
Alloy and concentrate	1,075	1,174	1,188	1,214	1,168
Metal	1,339	1,392	1,669	1,699	1,618
Hydrate	15	21	32	35	18
Other	6	9	3	6	2

[1] Total consumption is not shown because some metal, hydrate, and carbonate originated from alloy and concentrate.

Table 3.—Cobalt products [1] produced and shipped by refiners and processors in the United States

(Thousand pounds)

Product	1966				1967			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Oxide	478	334	499	349	485	336	476	334
Hydrate	584	325	538	303	579	290	614	298
Salts:								
Acetate	597	97	360	87	1,063	255	1,055	253
Carbonate	598	270	633	282	632	325	595	276
Sulfate	562	124	509	113	459	105	459	102
Other	445	100	397	90	328	73	316	65
Driers	11,806	761	11,820	755	9,751	671	9,496	598
Total	15,070	2,011	14,756	1,979	13,297	2,055	13,011	1,926

[1] Figure on metal withheld to avoid disclosing individual company confidential data.

Table 4.—Cobalt consumed in the United States, by uses

(Thousand pounds of contained cobalt)

Use	1963	1964	1965	1966	1967
Metallic:					
High-speed steel	404	305	304	411	374
Other tool steel	138	154	113	175	140
Other alloy steel	697	563	807	847	666
Permanent magnet alloys	2,352	2,210	2,736	2,698	2,486
Cutting and wear-resisting materials	275	337	414	360	324
High-temperature high-strength alloys	2,453	2,461	3,261	3,641	3,447
Alloy hard-facing rods and materials	607	801	1,055	r 953	864
Cemented carbides	409	431	530	r 581	486
Nonferrous alloys	158	326	330	356	177
Other [1]	426	427	892	1,342	2,241
Total	7,919	8,015	10,442	11,364	11,205
Nonmetallic (exclusive of salts and driers):					
Ground-coat frit	580	599	535	456	286
Pigments	222	209	259	185	204
Other	606	548	684	579	689
Total	1,408	1,356	1,478	1,220	1,179
Salts and driers: Lacquers, varnishes, paints, inks, pigments, enamels, glazes, feed, electroplating, etc. (estimate)	1,202	1,279	1,675	1,621	1,592
Grand total	10,529	10,650	13,595	14,205	13,976

r Revised.
[1] Includes unspecified end uses.

Table 5.—Cobalt consumed in the United States, by forms

(Thousand pounds of contained cobalt)

Form	1963	1964	1965	1966	1967
Metal	8,146	8,265	10,872	11,768	11,610
Oxide	935	958	961	768	654
Purchased scrap	246	148	87	48	120
Salts and driers	1,202	1,279	1,675	1,621	1,592
Total	10,529	10,650	13,595	14,205	13,976

PRICES

Cobalt prices, which were stable throughout 1966, were raised January 14, 1967 as follows:

Form	Old price per pound	New price per pound
Metal granules, 500 pound lots	$1.65	$1.85
Powder, 300 mesh, 100 pound lots	2.01	2.39
Briquets, 10-ton lots	1.83	2.03
Fines, 95–96 percent content	1.65	2.25

At the beginning of the year, the GSA offered cobalt briquets, rondelles, broken cathodes, pellets, and granules for sale restricted for domestic consumption at $1.65 per pound of contained cobalt. This price was revised effective February 6, 1967, to $1.70 per pound of contained cobalt in metal of 99.50 percent purity, ranging downward $0.01 for each 0.5 percent decrease in the percentage of cobalt content.

Throughout the remainder of the year commercial and GSA prices were unchanged.

FOREIGN TRADE

Exports of unwrought cobalt, metal, alloys, waste, and scrap totaled 1,355,395 pounds valued at $1,509,383, half again as much in weight and double the value of the 1966 exports of these items. Exports of wrought cobalt metal and alloys totaled 143,132 pounds valued at $857,847, slightly more in weight but 8 percent less in value than in 1966. Trade with the United Kingdom in 1967 was significantly less than normal, judged by past records. Variations in trade with other countries were not particularly unusual in view of the nature of the market fluctuations in scrap metal.

Table 6.—U.S. imports for consumption of cobalt metal and oxide, by countries

(Thousand pounds)

Country	Metal		Oxide (gross weight)	
	1966	1967	1966	1967
Australia	-------	60	-------	-------
Belgium-Luxembourg	4,263	1,826	1,233	1,028
Canada	879	783	46	16
Congo (Kinshasa)	9,710	3,186	-------	-------
France	905	889	-------	-------
Germany, West	684	188	-------	-------
Italy	18	-------	-------	-------
Japan	5	3	(1)	-------
Netherlands	58	27	-------	-------
Norway	1,159	605	-------	-------
Switzerland	-------	-------	-------	(1)
United Kingdom	190	379	-------	-------
Total	17,871	7,946	1,279	1,044

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 (estimated)
1965	14,846	$23,132	947	$1,011	186	$179	15,979	15,408
1966	17,871	27,734	1,279	1,411	150	81	19,300	18,823
1967	7,946	14,420	1,044	1,670	167	200	9,157	8,215

WORLD REVIEW

The supply of cobalt available on world markets was uncertain in the first quarter of 1967 as mines in the Republic of the Congo (Kinshasa), which in recent years produced more than 50 percent of the total, were taken over by the Government. Nevertheless, the surplus of supply over demand prevalent in 1966 continued in all industrialized countries. Demand declined throughout the world following the pattern of industrial activity.

Exploration crews were active in cobalt bearing deposits in North America, Africa, and Asia but reportedly did not discover any new ore deposits.

Table 8.—World production of cobalt by countries [1]

(Short tons of contained cobalt)

Country [1]	1963	1964	1965	1966	1967 p
Australia (content of zinc concentrate)	r 96	r 82	r 100	r 107	e 100
Canada [2]	1,512	1,592	1,824	r 1,756	1,652
Congo (Kinshasa)	8,131	8,461	9,246	12,453	10,709
Cuba (recoverable from sulfide) e	520	770	880	r 1,010	e 1,000
Finland [3]	2,176	1,856	1,646	e 1,500	e 1,350
Morocco (content of concentrate)	1,511	1,850	2,019	2,198	e 2,130
U.S.S.R. e	1,300	1,300	1,400	1,400	1,500
Zambia (cathode metal and other products)	778	1,571	1,702	1,670	1,604
Total [4]	r 16,024	r 17,482	r 18,817	r 22,094	20,045

e Estimate. p Preliminary. r Revised.

[1] Cobalt was produced in Bulgaria, East Germany, Poland, and Uganda but production data are not available. U.S. figure is withheld to avoid disclosing individual company confidential data. Estimates for these countries are not in the world total.

[2] Cobalt in all forms. Excludes the cobalt content of nickel-oxide sinter shipped to the United Kingdom by International Nickel, but includes the cobalt content of Falconbridge shipments of nickel-copper matte to Norway.

[3] Content of pyrites.

[4] Total is of listed figures only, no undisclosed data included.

Australia.—The method of reporting Australian cobalt production was changed to include all the cobalt content of zinc concentrate, whether it was recovered in Australia as oxide or exported. The figures for Australia in table 8 for 1963–66 were revised because of this change.

Canada.—Cobalt was produced as a byproduct in Canadian nickel and silver mines. Output in 1967 was adversely affected by the labor shortage in the nickel mines but benefited from increased activity in the silver mines. Total output however, was 344,000 pounds less than the record produced in 1965 and 208,000 pounds less than produced in 1966.

The International Nickel Company of Canada Ltd., Falconbridge Nickel Mines Ltd., and Sherritt Gordon Mines Ltd. produced cobalt at their nickel mining operations in the Sudbury district of Ontario. Falconbridge cobalt was recovered in its refinery at Kristiansand, Norway. That of the other two companies was recovered in Canadian refineries.

All cobalt produced as a byproduct of silver mining came from mines in the Cobalt and Gowganda districts of Ontario. It was recovered as cobalt oxide by the Refinery Division of Kam-Kotia Mines Ltd.

Congo (Kinshasa).—Cobalt production in the Congo (Kinshasa) was interrupted for about 2 months when the Government took over all assets and concessions of Union Minière du Haut-Katanga the first of the year. Union Minière asserted its right to ownership of all materials already produced or to be produced in the future from its mines and plants. The action effectively stopped sale of all cobalt and other metals produced by Union Minière from the Congo. The dispute was settled by a technical agreement whereby Société Genérale des Minerais de Belgique was given the right to manage the Union Minière properties and market the metals produced therefrom.

Société Genérale had marketed Union Minière produced metals in the past. It retained most of Union Miniéres' 1,600-man technical staff to operate the mines and refineries. Within a short time the Congo's cobalt operations were normal and continued so throughout the remainder of the year.

Prompt settlement of the Congo dispute apparently was brought about by the importance of copper sales income to that nation's economy. The Government faced bankruptcy with continued suspension. On the other hand, the Congo's cobalt is more important to the industrial nations of the world than is its copper. The world could ill afford to lose half of its cobalt supply, but loss of less than 10 percent of its copper although from one of the major producing countries, is not as critical.

Zambia.—Cobalt was produced in Zambia as a byproduct of copper mining operations. The copper mines were adversely affected by labor unrest and transportation problems through neighboring Rhodesia. By the end of 1967, alternative transportation routes other than through Rhodesia had been developed. However, a shortage of fuel for the smelters and refineries, which was caused by the transportation shortage, had not been overcome by the end of the year. Rhokana Corporation Ltd., the only producer of refined cobalt, produced more in its 1966–67 fiscal year than in 1965–66, as its cobalt operations were not affected by the fuel shortage.

Roan Selection Trust Ltd., Chibuluma Mine, produced cobalt-copper concentrate but stockpiled most of it for later processing.

The Luanshya Division of Roan Selection Trust continued detailed exploration of the Baluba deposit, which has a reported reserve of 102 million tons containing 0.16 percent cobalt. If the political and labor elements in Zambia stabilize, Baluba apparently could become a significant source of cobalt.

TECHNOLOGY

Researchers in 1967 continued the slow evolution of reliable data on the physical and chemical characteristics of cobalt. This work has been overshadowed since World War II by the more glamorous research in cobalt alloys, magnets, cemented carbides, and cobalt-bearing steels. However, it was equally significant and provided the basis for much of the advance in alloys in the last 20 years. A study of the kinetics of oxidation of ultra-high-purity cobalt at high temperatures published in 1967 was typical of the basic work.[2]

Studies of use of cobalt in high-strength steel alloys, in binary and ternary alloys, in cemented carbides, and in permanent magnets in 1967 were at the same high intensity of the last decade. Cobalt-rare-earth alloys for use in magnets, and cobalt-columbium alloys for use at high temperature showed promise of commercial application on the basis of laboratory investigations.

Development research to design better ways to recover cobalt from the nickeliferous laterite deposits was in progress in several industrial laboratories according to company reports to stockholders, but there were no significant new elements announced.

Metallurgists of Sherritt Gordon Mines Ltd. described that firms process for recovering cobalt from nickeliferous sulfide ores.[3] Sherritt uses a chemical process to separate nickel and cobalt based on the greater stability of cobaltic pentammine complex over that of nickel ammine forms in an acidic medium. The cobaltic complex is reduced to ammine which is reduced to cobalt with hydrogen by a process of nucleation, densification, and then leaching controlled by temperature and pressure. Sherritt metallurgists reported reduction time of 117 hours.

Bureau of Mines metallurgists studied the action of cobalt in steel. A report on their work will be published in 1968.

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[2] Snide, J. A., J. R. Myers, and R. K. Saxer. Oxidation of Ultra-High-Purity Cobalt at Selected Oxygen Pressures Over the Temperature Range 950° to 1250° C. Cobalt, No. 36, September 1967, pp 157–161.

[3] Stauffer, R., and S. Lindsay. Cobaltic Ammine Process. Trans. C.I.M. Conf. of Metallurgists, Toronto, Canada, v. 70, 1967, pp 161–166.

Coke and Coal Chemicals

By Joseph A. DeCarlo [1] and Barbara D. Watson [2]

Production of coke totaled 64.6 million short tons in 1967, a decrease of 4 percent from 1966. Both oven- and beehive-coke plants shared in the reduced output, although beehive production dropped 44 percent as compared with less than 4 percent for oven-coke plants. The production decline started in the second quarter of the year as cumulative production through the first quarter was actually higher than it was for the comparable period of 1966. In the second quarter, however, operating rates of oven plants, the major source of coke, began to decline, and by July were well below those of the previous year. Oven-plant production began to rise slowly in the third quarter and in December was the highest in 14 months. "Furnace" oven-coke plants supplied 89 percent of the total coke output, "merchant" oven-coke plants 10 percent, and beehive plants about 1 percent.

Production of coke exceeded demand during most of 1967, with stocks of oven coke at producing plants increasing steadily each month and reaching an alltime peak of more than 5.5 million tons on November 30, 1967, before declining slightly in December. The quantity of oven and beehive coke on hand at the end of the year was equivalent to 30 days' production at the December rate of operation.

Table 1.—Salient coke statistics [1]

	1957–59 (average)	1965	1966	1967
United States				
Production:				
Oven coke......thousand short tons..	60,552	65,198	65,959	63,775
Beehive coke......do....	1,254	1,657	1,442	806
Total......do....	61,806	66,854	67,402	64,580
Imports......do....	121	90	96	92
Exports......do....	558	834	1,102	710
Producers' stocks, Dec. 31......do....	[2] 4,682	2,703	3,079	5,468
Consumption, apparent......do....	60,586	65,379	66,019	61,572
Value of coal-chemical materials used or sold thousands..	$330,902	$311,407	$309,143	$292,579
Value of coke and breeze produced......do....	1,143,590	1,153,730	1,193,533	1,152,251
Total value of all products......do....	1,474,492	1,465,137	1,502,676	1,444,830
World production:				
Hard coke......thousand short tons..	287,855	r 341,799	r 341,166	316,270
Gashouse and low-temperature coke......do....	51,130	r 38,413	r 36,382	30,489

r Revised.
[1] Data may not add exactly to totals shown due to independent rounding.
[2] 1959.

The disposal patterns of coke and breeze closely paralleled those of the preceding year. Although all consumer groups used less coke, it was distributed in roughly the same proportions. Blast-furnace plants continued to receive the bulk of the shipments, or 92 percent. Foundries were the next largest single-purpose users, receiving 5 percent. Coke used in miscellaneous industrial applica-

[1] Supervisory chemical engineer.
[2] Commodity research assistant.

tions, classified as "other industrial," comprised nearly 3 percent of the market. An insignificant quantity of coke was used for residential and commercial heating, and the remainder was exported.

Breeze production declined less than 0.1 percent, due to the slightly higher yield reported by oven-coke producers. Unsuitable for most metallurgical applications because of its small size and high ash content, the bulk of this material is used by producers for sintering iron ore and for raising steam. However, nearly one-third of the 1967 output was sold for use mainly as a reductant in electric furnaces that smelt phosphate rock to produce elemental phosphorus. The increased demand for breeze influenced prices, and average value, f.o.b. plant, of breeze sold in 1967 was 16 percent higher than in 1966.

Coal costs to coke producers increased 3 percent over those of 1966 with costs to oven-coke producers rising 2.5 percent and to beehive-coke makers 8.7 percent. The delivered costs of bituminous coking coals vary among plants largely because of the transportation charges and ranged from $5.53 per ton to $12.39. In some cases the freight rate exceeded the f.o.b. mine costs in plants located long distances from their coal supply.

Production of coal chemicals normally parallels oven-coke output, and this was true of all the primary coal chemicals. The output of crude tar, ammonia, and gas dropped 3 percent each, and crude light oil dropped 4 percent. Yields of the basic chemical raw materials showed only minor changes from 1966 with yields of ammonia, gas, and light oil declining slightly and tar remaining virtually the same. Processing of crude tar and crude light oil for the production of various tar and light-oil products is an integral part of coke-oven operations at many plants. There was no change in the number of producers processing crude tar, and about the some percentage of tar was processed in 1967 as in 1966. With crude light oil, however, the greatest proportion of the output on record was sold for processing outside the producing plants. This marked change in the processing or refining of crude light oil started in the early 1960's, when a few of the producing companies started to sell their output because their processing equipment was not able to produce the high-purity products required by some of the large markets.

Price quotations on oven and beehive foundry coke published in various trade journals showed no changes in 1967. The average values or realization on commercial sales of oven and beehive coke reported to the Bureau of Mines showed minor changes in several instances. Prices on oven coke sold to foundries (foundry coke) and other industrial plants increased $0.65 and $0.26 per ton, respectively, f.o.b. plant, whereas prices received on oven coke sold to blast-furnace plants and for residential heating were lower. Beehive producers received slightly higher prices on sales to blast-furnace plants, but lower prices on sales to all other consumers. Prices on coal-chemical materials changed only slightly during the year. Ammonium sulfate dropped $1 per ton in the first half of the year, but naphthalene prices increased about 25 percent. Prices on the principal light-oil derivatives–benzene, toluene, and xylene– did no change.

The total value of coal carbonized in 1967 decreased 2 percent from the 1966 total and amounted to $925 million. The value of all coke-oven products used and sold amounted to $1,445 million, or 56 percent more than the value of the coal. The value of coke and breeze represented 80 percent of the value of all coke-oven products.

OVEN AND BEEHIVE COKE AND BREEZE

DOMESTIC PRODUCTION

Fluctuations in industrial activity were reflected generally in the pattern of coke output. The slight rally at the beginning of the year tapered steadily into the low in July, a traditionally slow period, in the bituminous coal and coke industries when personnel normally take their vacations. Only 166,000 tons of coke per day were produced in July, less than in any month since April 1964. Production pulled out of its slump in the last 6 months and finished the year with the year's highest average daily output in December. December's daily average of 185,000 tons per day, however, was still not quite up to the yearly average of 1966, lacking just 300 tons per day.

Table 5 summarizes monthly and average daily production of oven and beehive coke in 1967 and shows comparable data for the 2 preceding years.

Merchant and Furnace Plants.—The terms "merchant" and "furnace" in this report apply only to oven-coke plants. Furnace plants are owned by, or are financially affiliated with, iron and steel companies that produce coke mainly for use in their own blast furnaces. Merchant plants include those that manufacture metallurgical, industrial, and residential-heating grades of coke for sale on the open market; those associated with chemical companies or gas utilities; and those affiliated with local iron works that consume only a small part of their output in affiliated blast furnaces. Both merchant and furnace plants shared in the reduced output primarily because of lessened demands from all markets. Oven-coke output supplied by merchant plants continued to decline in 1967, their share of the output amounting to less than 10 percent.

Tables 6 and 7 show production of oven coke by merchant and furnace plants in 1967.

By States.—Coke was produced in 21 States from coast to coast in 1967, with 93 percent manufactured in 15 States east of the Mississippi River. This was the same number of States producing in 1966. Since the nationwide pattern of supply has not changed to any marked degree in the past decade, the relative proportions supplied by the individual States have remained relatively static. The bulk of coke output in 1967, as always, was centered in the highly industrialized States which use coke as blast-furnace fuel for ironmaking.

Pennsylvania continued to be the largest producer, with oven- and beehive-coke output comprising nearly 30 percent of the U.S. total. As in most other States, oven-coke production decreased slightly in Pennsylvania in 1967, but the State's relative contribution to total output was virtually the same as in 1966. Still the leader in beehive production, the 42-percent portion supplied by Pennsylvania in 1966 was virtually the same as in 1967. Indiana, Ohio, Alabama, West Virginia, and Michigan followed Pennsylvania in output in the order named. The combined production of these 5 States and Pennsylvania exceeded 47 million tons and was 73 percent of the total. Increases in production were recorded in Alabama, whose output rose 1 percent, and in Kentucky and Missouri, each of which gained over 10 percent. All other States shared in the general decline in output. Statistics on production of oven and beehive coke, by States, are shown in table 8.

Screenings or Breeze.—One phase of coke-oven operations that is practiced by all oven-coke and some beehive-coke producers is the screening of run-of-oven coke. In this process, the smaller sizes of coke, called screenings or breeze, usually are separated from the industrial-size coke by passing them through a ½-inch, or sometimes a ⅝-inch, screen. There is, however, no established screen size and sizes vary with local conditions.

In the past, breeze, which is unsuitable for most metallurgical applications, was used chiefly by producers for steam raising. In recent years, however, new uses have been developed for breeze, and currently only about 15 percent of the production is used for boiler fuel. Producers continue to consume the bulk of the breeze output, but more than three-fifths of the breeze now consumed by producing companies is used for sintering iron ore.

Approximately 31 percent of the breeze produced in 1967 was sold on the commercial market. Data on the exact end uses were not available, but most of the shipments probably went to plants that manufactured elemental phosphorus. Approximately 1.5 tons of coke breeze is required to produce 1 ton of elemental phosphorus, and on this basis, it is estimated that approximately 875,000 tons of coke breeze was charged in electric furnaces to smelt phosphate rock. Breeze was sold also for mineral-wool manufacture and for several other industrial applications. An average yield of 4.40 percent per ton of coal was attained by oven-coke plants. The highest yield, 7.11 percent, was reported for Alabama, and the lowest, 2.94 percent, for Pennsylvania. Most beehive plants do not recover breeze, but the average yield for the plants that did report production was 7.01 percent.

Table 9 shows the production and disposal of breeze in 1967, by State, and table 10 shows the quantities of breeze used by producers according to major end use and the quantities and values of breeze sold.

CONSUMPTION AND SALES

The United States consumed 61.6 million short tons of coke in 1967, allowing for imports, exports, and changes in producers' stocks. This was the lowest consumption figure since 1963 and was nearly 7 percent less than in 1966 and 21 percent less than the record high of 1951.

The largest single factor in the general decline in coke consumption from 1966 was the decreased tonnage used in blast furnaces. Not only did this consumer group manufacture less pig iron and ferroalloys than in the preceding year, but the effect was compounded by the further decline in the coke rate, which is the amount of coke required to produce 1 ton of pig iron and ferroalloys. This can be illustrated by the fact that while pig iron and ferroalloys production dropped 4.9 percent from 1966, consumption of coke in iron furnaces, as reported by the American Iron and Steel Institute, dropped 5.8 percent, due to the 1-percent reduction in the coke rate. The continuing downward trend in coke rates is attributed mainly to improved burdens (coke and iron ore) and advanced operating techniques, such as higher blast temperatures, fuel injection, and oxygen enrichment of the blast. The ultimate effect on the coke industry may best be illustrated by citing a hypothetical case of blast furnaces operating at 1951 rates; the 87.6 million tons of pig iron and ferroalloys produced in 1967 would have required 81.9 million tons of coke rather than the 56.2 million tons actually consumed.

All other consumer groups also used less coke in 1967. The most severe percentage reduction occurred in the dwindling residential-heating market. Fuel oil and natural gas have virtually replaced coke for this purpose, and the quantity of coke so used will probably soon be negligible. Less than 100,000 tons was used for residential heating in 1967.

Data on total coke consumption are shown in table 11; data on coke rates are shown in table 12.

Tables 13 and 14 summarize, by major end use, the disposal of oven and beehive coke in 1967. Furnace oven-coke plants supplied 89 percent of the 62.2 million tons of oven and beehive coke distributed. Ninety-six percent of the coke distributed by furnace plants was consumed in integrated and affiliated blast furnaces, an additional 1 percent was used for other purposes, and the remaining 3 percent was marketed, chiefly to blast furnaces and other industrial plants but with small quantities going also to foundries and for residential heating.

Merchant coke plants distributed nearly 6 million tons of coke in 1967, 95 percent of which was placed on the commercial market. Principal markets were blast-furnace operations without coke facilities, independent gray-iron foundries, nonferrous smelters, and chemical plants. Of the 5.7 million tons of oven coke sold by merchant plants in 1967, 43 percent was shipped to blast furnaces, 45 percent to foundries, and 11 to other industrial plants; the remaining 1 percent was sold for residential heating. Only 5 percent of the total coke distributed by merchant plants was retained for use by the producers.

Less than 1.3 percent of the coke distributed in 1967 came from beehive plants. Seventy percent of the beehive shipments were destined for use in blast furnaces. Most of the remainder went to other industrial plants. These were mainly chemical plants that used the coke to produce calcium carbide and elemental phosphorus. Minor quantities were used also in foundries and for residential heating. Coke was produced in or received by all States except Alaska, Hawaii, and Nevada and the District of Columbia in 1967. A total of 61.7 million tons of coke was distributed domestically. This was 7 percent less than the 1966 total, chiefly because of the decreased quantity received by blast furnaces. However, the foundry, other-industrial, and residential-heating markets also received smaller shipments than in the preceding year.

Eighteen States consumed 56.9 millon tons of blast-furnace coke. Pennsylvania, Ohio, Indiana, Illinois, Michigan, New York, Maryland, Alabama, and West Virginia together received 91 percent of the total. Most blast-furnace installations are integrated with coke ovens, and blast-furnace coke generally moves only short distances, usually by conveyor belt or company railroad within the producing establishment. Coke so restricted in its movement accounted for 89 percent of the blast-furnace distribution. The remaining 6.3 million tons, or 11 percent, was shipped out of the producing State, mainly to affiliated blast furnaces in adjoining or nearby States.

The chief recipients of foundry-coke shipments 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. To reach these markets, foundry coke generally must be shipped long distances by rail. In 1967, the combined consumption of Michigan, Ohio, Alabama, Pennsylvania, Illinois, Indiana, Wisconsin, and New York accounted for 77 percent of the foundry-coke shipments. Lesser quantities were sent to 37 other States. Eighty-nine percent of the total foundry coke was sold commercially.

Less than 3 percent of the total coke distributed was utilized for miscellaneous industrial applications by, among others, nonferrous smelters, alkali plants, and chemical plants that manufacture calcium carbide and elemental phosphorus. Leading consumers of this classification of coke were, in the order named, Ohio, Pennsylvania, Idaho, Michigan, Illinois, Indiana, Tennessee, Kentucky, Louisiana, New York, Virginia, and Alabama. Together, these 12 States consumed more than two-thirds of the total other-industrial coke.

The quantity of coke used for residential heating in 1967 declined 29 percent from the 1966 level. Although 26 States used coke for this purpose, the quantity sent to each was so small that the total distributed was only 85,000 tons. Seven States consumed less than 500 tons each, and only 3 States, New Jersey, New York, and Massachusetts, used more than 10,000 tons each. Distribution of oven and beehive coke and breeze, by major end use and final destination, are shown in table 15.

STOCKS OF COKE AND BREEZE

Coke stockpiled at producers' plants increased in quantity each month of 1967 except December. Stocks on hand at the close of the year exceeded those of December 31, 1966, by 78 percent. Although production lagged behind 1966 levels, consumption was still further curtailed, and stocks attained record levels from September through December. The principal factor in this development was the decreased demand from blast-furnace plants. Of the overall 4.8-million-ton reduction in consumption, 4.1 million tons, or 85 percent, was accounted for by the decline in blast-furnace consumption.

Only 9 percent of the reserve coke supply was retained by merchant coke plants. However, this quantity was equivalent to the production of 29.8 days. Although furnace plants kept much larger quantities on hand, they equaled only 31.6 days of furnace-plant production thus exceeding the relative stock at merchant plants by a very small margin. Almost all of the stocks at furnace plants was blast-furnace coke. Stocks at merchant plants were composed of 14 percent blast-furnace coke; 34 percent foundry coke; and 52 percent other grades.

Beehive-coke stocks were nearly the same as in 1966 and amounted to about 1,000 tons. Stocks of coke breeze also increased, and the 1 million tons on hand on December 31, 1967, was 10 percent more than that of 1966. Tables 16 and 17 show data on producers' stocks of coke.

VALUE AND PRICE

The average values of oven and beehive coke production, and average receipts for commercial sales, f.o.b. plant, of the different grades of coke are shown in tables 18 and 19. Production values were based upon the prevailing market value as assigned by producers for the coke they consumed; sales prices for the different grades of coke sold were based upon commercial sales, as reported by producers.

There was a 1-percent increase in the average value assigned to all coke produced in 1967. The average value of $17.42 per ton recorded for oven-coke production in 1967 was higher than the value per ton of oven coke in the 2 preceding years. Beehive-coke production averaged $15.03 per ton in value, $0.13 per ton lower than in 1966.

The average value per ton, f.o.b. plant, of all coke sold commercially was $21.92. Receipts for sales of oven coke averaged $22.67 per ton, an increase of $0.45 over 1966, and the beehive coke value increased $0.43 per ton to $15.03. Average receipts per ton of oven coke sold to blast-furnace plants and for residential heating declined $0.04 each, but this was more than offset by the increased prices brought by foundry and other-industrial coke, which increased $0.65 and $0.26 per ton, respectively. The overall increase in receipts for beehive coke was due solely to the 10-percent rise in the average price per ton of coke sold to blast furnaces.

The large variance in price for blast-furnace and foundry oven coke was attributed principally to the lower yields obtained in producing foundry coke, and to larger minimum sizes required to meet foundry-coke specifications. The differences in f.o.b. prices of oven and beehive foundry coke were due largely to transportation costs for coal and/or coke.

FOREIGN TRADE

U.S. exports of coke decreased 35 percent from those of the preceding year. Nearly all of this decrease was the result of the more than 400,000-ton drop in Canadian shipments, which were nearly halved in 1967. Canada, nevertheless, remained the leading export market, absorbing 62 percent of the foreign consumption of U.S. coke. In addition, nearly 38 percent was shipped to Mexico, Venezuela, Japan, and Brazil, and less than 1 percent went to various other countries.

More than three-fourths of the coke exports were through the Buffalo, N.Y., Detroit, Mich., and Laredo, Tex., customs districts. Each of these ports handled well in excess of 100,000 tons. Table 21 shows exports of coke by country and by customs district for 1965, 1966, and 1967. The quantity shown is substantially larger than that reported by producers and shown in table 15 because there were additional shipments to foreign countries by export firms.

The United States imported 92,000 tons of coke in 1967. Almost twice this tonnage was produced domestically in a single day. This imported coke had a negligible bearing on the general nationwide market and was significant only in certain local areas, such as the Northwest, which are far removed from sources of coke production.

Ninety-five percent of the coke imported for consumption in 1967 originated in Canada and was produced in the Province of British Columbia. This coke is used mainly in nonferrous smelters and enters the United States through the Great Falls, Mont., customs district. Four percent of the imported coke came from West Germany, and the remaining 1 percent, from France, Mexico, and the Netherlands.

Table 20 shows imports of coke for 1967 and the 2 immediately preceding years, by country and by customs district.

WORLD PRODUCTION

World production of metallurgical coke in 1967 was estimated at 316 million tons, a decrease of 7 percent from the estimated output for 1966. This decrease was attributed princpally to the smaller outputs of the United States West Germany, and Mainland China. Also, the 1967 estimate does not include the production of 12 countries for which data were not available, but whose combined outputs totaled 18.5 million tons in 1966.

Europe maintained the lead in world production with 61 percent of the output. Although the European output apparently decreased 8 percent, it must be noted that data were not available for Czechoslovakia, which has consistently produced more than 10 million tons annually for the past 4 years.

Output of coke and breeze in the Soviet Union, currently the world's largest producer, was estimated at 76 million tons, about two-fifths of the European total and nearly one-fourth of the world total. This was an increase of 2 percent over the 1966 production and a record output for the U.S.S.R. Although Soviet production exceeds that of the United States, the actual difference in outputs of the two countries was 7.5 million tons rather than 11.5 million tons as reflected in table 22, because the U.S. production figure does not include 4 million tons of breeze produced in 1967.

The United States, with 20 percent of the world output ranked second, and West Germany, with 12 percent, ranked third. The United States had a 4-percent production decrease, and West Germany's output was 12 percent below that of 1966.

Other leading coke-producing countries in order of output were Japan, the United Kingdom, Poland, France, Mainland China, and India. Except for Japan, where production increased 25 percent (4.7 million tons), and China, where production decreased 29 percent (5.5 million tons), output in these countries did not differ essentially from that of 1966.

In addition to the high-temperature metallurgical coke produced in conventional slot- and beehive-coke ovens, over 30 million tons of other coke was produced at high, medium, and low temperatures in vertical and horizontal retorts and other types of carbonizing equipment. Commonly referred to as "soft," this coke, which is not suitable for most metallurgical applications, was used principally for domestic heating, chemical processing, and the production of producer and water gas. When produced as char, the material generally was briquetted and then used for domestic fuel.

Europe produced nearly three-fourths of the world's soft coke, and Asia supplied most of the remainder. The leading European producers were East Germany and the United Kingdom, with a combined output equal to 49 percent of the world total and 66 percent of Europe's production. The major part of East Germany's output of soft coke was principally carbonized lignite briquets. Production in the United Kingdom consisted mainly of carbonized briquets or semicoke produced in retorts from bituminous coal. Both countries used these fuels principally for domestic heating. Other countries with relatively large outputs were West Germany, Japan, India, and Poland. The United States produced 163,000 tons of soft coke in 1967.

Table 23 shows production of gashouse, low-, and medium-temperature coke in the various countries.

COKING COALS

QUANTITY AND VALUE OF COAL CARBONIZED

The carbonization of bituminous coal for coke production is currently the second largest end use of this fuel. Only the electric utilities, whose annual consumption of bituminous coal generally absorbs about half of the production, ranks higher in usage. In 1967 coke producers charged 92 million tons of bituminous coal, one-sixth of the total bituminous coal produced, into coke ovens. An additional 528,000 tons of anthracite was blended with bituminous coal at oven-coke plants and carbonized, chiefly to produce foundry coke.

The average value per ton for all coals carbonized at oven-coke plants was $10.02 compared with an average value of $5.98 per ton for the coal carbonized at beehive ovens. The difference in value was attributed mainly to transportation charges for coal shipped to oven plants, as virtually all beehive plants are located at the mines where they obtain their coal. In some instances, transportation charges exceed the value of the coal at the mine, and this partially accounts for the high values of coals used at plants in the Western States, most of which receive shipments of low-volatile coals from the East.

The overall average values of the coals carbonized at both oven- and beehive-coke plants were somewhat higher than in 1966. The $0.24-per-ton increase in coal costs to oven-coke plants was the result of higher prices paid by virtually all States for their coking coals. The cost of coal to beehive-coke plants rose $0.48 per ton, largely because of the $0.86-per-ton increase in the average value of coals carbonized in Pennsylvania.

An overall average of 1.43 tons of coal, valued at $14.37, was required for each ton of oven coke produced in 1967. Beehive ovens required an average of 1.66 tons of coal per ton of coke production, but coal costs averaged only $10.18 per ton of coke because of the lower value of the coal delivered to beehive ovens.

Tables 24–28 present data on the coals carbonized at oven and beehive plants.

PREPARATION

Washed and Unwashed.—The cleaning of coals prior to carbonization has become an almost universal practice. It is done to lower the ash and sulfur contents of the coals carbonized, thus ensuring a higher quality coke. Wet processes usually are employed; hence, the term "washed" coal is used, as opposed to "unwashed" coal.

Ninety-six percent of the coal charged into slot ovens and 94 percent of that carbonized in beehive ovens in 1967 was washed. Although less coal was carbonized at oven-coke plants than in 1966, approximately the same percentage of the total was cleaned because oven-coke plants obtained their coal requirements from the same sources. Beehive plants carbonized less coal also, and likewise consumed virtually the same percentage of cleaned coal as in 1966.

The production of increased quantities of coal by modern mining methods has resulted in the cleaning of larger percentages of the coal shipped to coke plants and, in 1967, 96.2 percent of all coals carbonized was washed. The bulk of the unwashed coals, which were produced mainly in Pennsylvania and West Virginia, had low ash and sulfur contents and did not require cleaning. Detailed data on the use of washed and unwashed coals in the various States are shown in table 29; trends in the use of washed and unwashed coals are presented in table 30.

Blending.—The production of high-quality coke requires the use of coal with certain special characteristics. Since all of the desired properties are not inherent in an individual coal, it becomes necessary to blend coals, exploiting the most favorable traits of each in a carefully balanced mixture. Thus, coals are selected and combined in order to improve the chemical and physical properties of the coke, control the pressure developed in slot ovens during carbonization, regulate the yield of products, and broaden the use of inferior coals. The usual procedure followed is to blend relatively small proportions of low-volatile coal with high-volatile coal. The exclusive use of high-volatile coals would result in a weaker coke and lower yields. The addition of low-volatile coals improves the yield and the physical structure of the coke. However, restrictions on the proportions of low-volatile coals used are necessary because they are highly expanding and, if used alone or in large proportions in the coal mix, would damage the oven walls when coke was discharged from the ovens. Some plants add medium-volatile coals or other materials, such as anthracite or coal-tar pitch, to their high- and low-volatile coals. The addition of medium-volatile coals can regulate the volatile matter in a mix to the desired content, while anthracite and coal-tar pitch are used to impart special properties to the resulting coke.

Some coals are unsuitable for the production of coke because they contain excessive amounts of sulfur. These coals still may be utilized to some extent if they are blended with low-sulfur coals. This is permissible if the low-sulfur coals compensate for the excess in the high-sulfur coals, maintaining the total sulfur at a level no higher than normally used for the production of coke of high quality.

The relative quantities of high-, medium-, and low-volatile coals blended by coke producers are fairly constant, with little variation from year to year at individual plants. From plant to plant, however, a wide range of blends is employed. In 1967, high-volatile coals were carbonized most extensively in West Virginia and the Far West, while Minnesota and Wisconsin used fairly large percentages of low-volatile coals. The largest proportions of low-volatile coals were used at merchant plants to improve the strength of the foundry coke which makes up the bulk of their output. Table 31 shows the average volatile-matter content of the coals carbonized at oven-coke plants, and table 32 shows the volatile-matter content of the coals received by oven-coke plants in the various States.

SOURCES

Although 22 States produced bituminous coal (excluding lignite) in 1965, only 10 shipped coal to coke plants. Of this number, five States (Alabama, Kentucky, Pennsylvania, Virginia, and West Virginia) supplied 92 percent of the total. The remainder was supplied by Colorado, Illinois, New Mexico, Oklahoma, and Utah.

Of the coals received by oven-coke plants, 37 percent was produced in West Virginia and 31 percent in Pennsylvania. West Virginia shipments were principally low-volatile coals from McDowell County, and high-volatile coals from Logan, Marion, and Fayette Counties. Pennsylvania shipments were principally high-volatile coals from Washington, Greene, and Allegheny Counties, and low-volatile coals from Cambria County.

Illinois supplied more than 1.5 million tons of high-volatile coal to coke plants in

Illinois and Indiana. This coal was blended with larger proportions of high-rank Eastern coals that were shipped principally from Kentucky, Virginia, and West Virginia.

Most of the coals carbonized in California, Colorado, and Utah were produced in the latter two Western States. In most instances, plants in the Western States also received shipments of West Virginia low-volatile coals that were used for blending. Tables 33 and 34 show the origin of the coals received by oven-coke plants in 1967.

Captive Coal.—The coke industry receives more than 60 percent of its coal from company owned or affiliated mines. This is known as "captive" coal and ordinarily does not move in commercial channels but is mined as needed by the coke-producing companies.

Most of the captive mines are owned by iron- and steel-producing companies. In 1967, 61.9 percent of the total coal received by furnace plants was captive. Merchant plants received 36.4 percent of their coal from company owned or affiliated sources. Table 35 shows the quantities and percentages of captive coal received by oven-coke plants for 1967 and several prior years.

STOCKS

Producer's month-end stocks of bituminous coal at oven-coke plants rose steadily from January through June, then dropped abruptly in July, when a lull is to be expected because of the curtailed production at most bituminous-coal mines. Thereafter, stocks again maintained a steady ascent, and on December 31, 1967, were 19 percent higher than at the end of 1966. The quantity retained by merchant plants was sufficient for an 86-day supply at the December rate of production; furnace plants retained a 57-day supply.

Stocks of anthracite amounted to 157,000 tons at the end of 1967, an increase of 16 over those of 1966.

Tables 36 and 37 show month-end stocks of bituminous coal and anthracite at oven coke-plants.

COAL CHEMICALS

The term "coal chemicals" refers to the chemical materials recovered from the volatile matter released 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, creosote oil, pitch, and pyridine. 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 a number of other factors.

Yields of the basic, as well as the primary, chemicals vary somewhat 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 1967 are shown in table 38.

Table 39 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 1967 were roughly equivalent to the heating value of about one-fourth of the coal carbonized in slot ovens. Table 40 shows average values for the chemicals and surplus gas used and sold, compared with the unit values of the coke and breeze produced, from each ton of coal carbonized.

COKE-OVEN GAS

Coke-oven gas is one of the primary coproducts recovered in the carbonization of coal in slot ovens. After tar, ammonia, and light oil have been removed from the gaseous streams, coke-oven gas remains as the final product. Because it has a high calorific value producers use most of it as fuel for heating coke ovens and other steel- and allied-plant furnaces. Small quantities are also sold for distribution through city mains and other industrial uses.

Generally, between 9,300 and 11,000 cubic feet of gas is produced for each ton of coal carbonized at high temperatures in slot ovens. This equals from 14 to 16 percent of the weight of the coals. In 1967, the yield of gas was 10,490 cubic feet per ton of coal, a decrease of 4 percent from the 1966 yield, due largely to lower yields in the far Western States and Indiana.

About 36 percent of the output was used at the plants to heat coke ovens. Gas used otherwise is called surplus gas and was used by producers to fire boilers, transferred to steel or allied plants to heat open-hearth and other metallurgical furnaces, and 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.

Furnace plants consumed almost all of their own surplus gas, mostly in steel and allied plants. Only 30 percent of the surplus gas at merchant plants was used by the producers. The rest, except for the small amount wasted, was sold commercially for distribution through city mains and for industrial use. The bulk of the furnace-plant gas sales were to industrial plants. Table 44 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 blast-furnace gas, a mixture of coke-oven and blast-furnace gases, and natural gas were also used. Over 400 billion cubic feet of coke-oven gas equivalent was so consumed, of which 84 percent was coke-oven gas; 15 percent was blast-furnace gas; and the remainder was natural gas and producer gas.

Surplus coke-oven gas used and sold in 1967 was valued at $138 million. This 3-percent decrease from the 1966 value was due to the overall lower quantity, as the average value per thousand cubic feet actually increased slightly. No value is reported by producers for coke-oven gas used to heat coke ovens, but applying the average value of $0.228 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 1967 would be $216 million. This value is equivalent to nearly one-fourth of the total value of the coal carbonized.

COKE-OVEN AMMONIA

Coal carbonized at high temperatures releases nitrogen, which oven-coke operators recover as either ammonia liquor, a weak solution of ammonia (about 7 grams per liter of solution), or as a crystallized solid (ammonium sulfate and diammonium and monoammonium 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 allowed to be released as a waste material would create stream pollution problems.

Most of the coke-oven ammonia is reacted with sulfuric acid to form ammonium sulfate. In 1967, 48 plants used 88 percent of the total ammonia recovered to produce 738,000 tons of ammonium sulfate, and another 5 percent was treated with phosphoric acid to produce 41,000 tons of diammonium phosphate at three plants. Ten plants recovered ammonia liquor, and eight recovered no ammonia products at all.

Table 45 shows production and sales of ammonia products and yields in 1967 in terms of sulfate equivalent. Compared with 1966, the yield of ammonia declined less than 1 percent, but overall output dropped 3 percent because of the smaller quantity of coal carbonized.

Sales of ammonium sulfate decreased 16 percent and, since this amounted to only 93 percent of the production, stocks of this material rose 52 percent. Ammonia liquor sales were about the same as in 1966 but were not equal to production, and stocks of liquor also increased. The average value per ton, f.o.b. plant, of ammonium sulfate increased $1.23 per ton to $26.87, and the average plant values of diammonium phosphate and ammonia liquor, decreased $3.62 per ton and $6.32 per ton, respectively. The total value of all ammonia products sold was $23 million, equivalent to 8 percent of the total value of all coal-chemical materials used or sold.

Although the sale of ammonia products returned coke-oven operators $23 million in 1967, coke-oven ammonia represented only about 2 percent of the estimated 12.1 million tons of ammonia output from all sources. More than 90 percent of the output was synthetic anhydrous ammonia, produced from natural gas. The remainder, except for the sulfate and liquor produced at coke plants, was synthetic ammonium sulfate, produced as a byproduct of the chemical industry.

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 is 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 1967 they ranged from 3.62 to 11.48 gallons per ton of coal carbonized, and averaged 8.53 gallons. 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 1967 decreased 3 percent from 1966 principally because less coal was carbonized. The average yield of tar, however, remained at 8.53 gallons per ton of coal, the same as in 1967. Table 46 shows the quantities of tar produced, used by producers, sold, and in stock in the various States at the end of 1967.

Coke-plant operators used 54 percent of the tar produced in 1967. Of this quantity, 69 percent was processed (refined or "topped"), 30 percent underwent no processing and was burned for fuel, and 1 percent was used for miscellaneous purposes, such as tarring ingots, road materials, and tar paints. The remaining 46 percent of the production was sold, principally to tar-distilling plants which refined it to produce many tar derivatives.

Ten coke plants processed tar in 1967 of which 7 plants 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 because 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 1967 recovered only crude chemical oil and a residual tar or soft pitch. However, some of the larger plants recovered a number of other 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.

The total value of crude coal tar and derivatives used and sold in 1967 was $90.8 million, a decrease of 4 percent from the value of 1966, and nearly 10 percent of the total value of the coal carbonized.

CRUDE LIGHT OIL AND DERIVATIVES

Light oil is a light-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 kinds of coals carbonized and with operating conditions, but an average of 2.84 gallons of light oil was recovered at the plants that extracted light oil in 1967. 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.

Of the 66 active oven-coke plants, 56 recovered light oil. Yields per ton of coal decreased slightly at both furnace and merchant plants and total production decreased 4 percent from that of 1966 because a smaller amount of coal was carbonized. Yearend stocks increased approximately 700,000 gallons, but the amount on hand on December 31 was equivalent to only a little less than 2 weeks' production. Producers continued to sell an increasingly larger part of their output, and only 61 percent of the light oil produced was refined on the premises, or in affiliated plants, compared with 68 percent in 1966. 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 47.

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 benzene and toluene decreased slightly in 1967, while the average xylene and solvent-naphtha yields increased. Average yields for 1967 and prior years are shown in table 48.

Table 49 shows the quantities of the various grades of benzene and toluene produced at coke plants, while table 50 shows the principal light-oil derivatives produced and sold and yields of the various products by State. Roughly, 96 percent of the benzene and most of the toluene was specification grade. In past years large amounts of motor-grade benzene were produced for use in gasolines to increase their antiknock properties, but new petroleum-refining techniques have virtually eliminated this use for benzene, and only a small quantity of motor-grade benzene was produced in 1967. Although coke-oven light oil was the principal source of benzene until 1950 and the source of virtually all toluene and xylene until World War II, it now supplies only a small part of the total output of these products. According to preliminary data published by the U.S. Tariff Commission, only 10 percent of the benzene, 3 percent of the toluene, and 1 percent of the xylene was produced by coke-oven operators in 1967. These products now are derived principally from petroleum, although a part of the production credited to tar distillers and petroleum processors was derived from coke-oven light oil that was sold by producers to petroleum processors for refining.

TECHNOLOGY

Research and development work on coal carbonization throughout the world in recent years has centered on reducing carbonizing costs, improving coke quality, providing better working conditions, and increasing oven productivity. Progress has been made in all of the major coke-producing countries in automating certain aspects of coke-oven operations, particularly in connection with coke and coal-handling facilities. More attention has been given to the development of equipment to reduce atmospheric and stream pollution. Much work has been done on developing methods or processes of producing metallurgical coke from noncoking coals. As an indication of the worldwide interest in the various unconventional processes for producing metallurgical fuel, at the International Congress on Coke held in Charleroi, Belgium, September 19–22, 1966,[3] there were 10 papers from eight countries discussing experimental and pilot-plant work that was underway on this subject in the various countries.

Although there are some differences in the approaches used in the various unconventional processes, they all have one major objective which is to manufacture satisfactory solid products from coals deficient in coking power and therefore unsuitable for the production of metallurgical fuel. Such processes, therefore, are attractive to countries lacking adequate supplies of coking coals, and research and development work can be expected to be continued in these countries. All of the research efforts on coal carbonization, however, have not been devoted to unconventional processes, as there have been some significant accomplishments in the construction and operation of conventional coke ovens. Probably the most outstanding development of the past several years has been the construction of high-capacity or large coke ovens. In the United States the construction and operation of five high or tall ovens (18 feet 9 inches) at an eastern coke plant in 1966 was followed by the beginning of construction of a number of full-size batteries of high or tall ovens ranging from 45 to 78 in number. These ovens range in height from about 16.5 feet to 19 feet and on the average have about 60 percent greater volume than the usual 13-foot high ovens. More important, however, is that the new high ovens are capable of increasing coal throughput about 75 percent because of faster coking rates that are easily attainable. This substantial increase in volume in coking rate is due to improved refractories that permit higher oven temperatures. In addition to the improvement in coke-oven refractories, the new ovens have incorporated better heating designs for uniform heating from bottom to top, and many other new operating techniques. Because of the great interest in larger ovens, the 25th Ironmaking Conference sponsored by the Metallurgical Society of the American Institute of Mining, Metallurgical and Petroleum Engineers devoted an entire session to prepared papers and discussions on high coke ovens.[4] This conference was held December 5–9, 1966, in Philadelphia, Pa., and papers on all sessions including the one on high ovens are given in the proceedings for that year.

One aspect of coke-plant operations on which there is much concern throughout the world is in the area of air and stream pollution. In order to obtain information on what measures are being taken in the various countries to reduce air pollution from coke plants, the Coal Committee of the Economic Commission for Europe (ECE) appointed an ad hoc group of experts on coking in 1965 to obtain the above information. A compilation of the data submitted was made by this group and the results summarized in a report issued early in 1968 by the United Nations.[5] This study covered only air pollution caused by coke-oven operations. Air pollution resulting from the operation of the chemical departments of coke plants is being considered for the next study.

Bureau of Mines research during 1967 was devoted principally to fundamental studies on both high-temperature (1,800° F) and low-temperature carbonization of coals and lignite, including process development and the identification and classification of chemicals in low-temperature tar, and a variety of other investigations involving the use of coals and coke for the production of coke. A brief summary of the work is contained in the review of Bureau of Mines and program for 1967 which also cites references to the individual studies and reports.[6]

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[3] Coke in Iron and Steel Industry. First Technical Session, Proc. Internat. Coke Congress. Charleroi, Belgium, September 19–22, 1966, pp. 42–153.

[4] AIME. Ironmaking Proceedings, V. 25, 1967, pp. 25–57.

[5] Economic Commission for Europe, Coal Committee. Air Pollution by Coke Plants. United Nations, New York, ST/ECE/Coal/26, 1968, 65 pp.

[6] Spencer, John D. Review of Bureau of Mines Coal Program, 1967. BuMines Inf. Circ. 8385, 1968, pp. 59–65.

Table 2.—Statistical summary of the coke industry in the United States in 1967 [1]

	Slot ovens	Beehive ovens	Total
Coke produced:			
At merchant plants:			
Thousand short tons	6,220	(2)	(2)
Value (thousands)	$147,931	(2)	(2)
At furnace plants:[3]			
Thousand short tons	57,555	(2)	(2)
Value (thousands)	$963,131	(2)	(2)
Total:			
Thousand short tons	63,775	806	64,580
Value (thousands)	$1,111,062	$12,111	$1,123,173
Breeze produced:			
Thousand short tons	4,025	21	4,046
Value (thousands)	$29,034	$44	$29,079
Coal carbonized:			
Bituminous:			
Thousand short tons	90,900	1,372	92,272
Value (thousands)	$910,897	$8,201	$919,098
Average per ton	$10.02	$5.98	$9.96
Anthracite:			
Thousand short tons	528	----------	528
Value (thousands)	$5,624	----------	$5,624
Average per ton	$10.65	----------	$10.65
Total:			
Thousand short tons	91,428	1,372	92,800
Value (thousands)	$916,520	$8,201	$924,722
Average per ton	$10.02	$5.98	$9.96
Average yield in percent of total coal carbonized:			
Coke	69.75	58.72	69.59
Breeze (at plants actually recovering)	4.40	7.01	4.41
Coke used by producing companies:			
In blast furnaces:			
Thousand short tons	53,304	----------	53,304
Value (thousands)	$892,205	----------	$892,205
In foundries:			
Thousand short tons	349	----------	349
Value (thousands)	$11,640	----------	$11,640
For other industrial uses:			
Thousand short tons	363	----------	363
Value (thousands)	$6,857	----------	$6,857
Breeze used by producing companies:			
In steam plants:			
Thousand short tons	594	----------	594
Value (thousands)	$3,999	----------	$3,999
In agglomerating plants:			
Thousand short tons	1,695	----------	1,695
Value (thousands)	$11,594	----------	$11,594
For other industrial uses:			
Thousand short tons	517	----------	517
Value (thousands)	$3,393	----------	$3,393
Coke sold (commercial sales):			
To blast furnaces:			
Thousand short tons	3,244	565	3,809
Value (thousands)	$52,856	$8,458	$61,314
Average per ton	$16.29	$14.97	$16.10
To foundries:			
Thousand short tons	2,845	17	2,862
Value (thousands)	$92,176	$215	$92,391
Average per ton	$32.40	$12.34	$32.28
To other industrial plants:			
Thousand short tons	1,189	222	1,412
Value (thousands)	$20,415	$3,427	$23,842
Average per ton	$17.16	$15.41	$16.89
For residential heating:			
Thousand short tons	85	(4)	85
Value (thousands)	$1,477	(4)	$1,477
Average per ton	$17.35	(4)	$17.35
Breeze sold (commercial sales):			
Thousand short tons	1,229	21	1,250
Value (thousands)	$10,532	$44	$10,576
Average per ton	$8.57	$2.10	$8.46

See footnotes at end of table.

Table 2.—Statistical summary of the coke industry in the United States in 1967[1]—Continued

	Slot ovens	Beehive ovens	Total
Coal-chemical materials produced:			
Crude tar:			
Thousand gallons	780,334	----------	780,334
Gallons per ton of coal	8.53	----------	8.53
Ammonia:[5]			
Thousand short tons	834	----------	834
Pounds per ton of coal	18.68	----------	18.68
Crude light oil:			
Thousand gallons	252,138	----------	252,138
Gallons per ton of coal	2.84	----------	2.84
Gas:			
Million cubic feet	959,359	----------	959,359
Thousand cubic feet per ton of coal	10.49	----------	10.49
Percent burned in coking process	35.62	----------	35.62
Percent surplus used or sold	63.17	----------	63.17
Percent wasted	1.21	----------	1.21
Value of coal-chemical materials used or sold:			
Crude tar and derivatives:			
Used ... thousands	$29,045	----------	$29,045
Sold ... do	$61,707	----------	$61,707
Ammonia products [6] ... do	$23,262	----------	$23,262
Crude light oil and derivatives [7] ... do	$40,286	----------	$40,286
Surplus gas ... do	$138,279	----------	$138,279

[1] Data may not add exactly to totals shown due to independent rounding.
[2] Not separately recorded.
[3] Plants associated with iron-blast furnaces.
[4] Combined with coke sold "To foundries" to avoid disclosing individual company data.
[5] In terms of sulfate equivalent.
[6] Includes ammonium sulfate, ammonia liquor (NH_3 content), and diammonium phosphate.
[7] Includes intermediate light oil.

Table 3.—Summary of oven-coke operations in the United States in 1967, by States [1]

State	Plants in existence Dec. 31 [2]	Coal carbonized (thousand short tons)	Yield of coke from coal (percent)	Coke produced (thousand short tons)	Value of coke at ovens	
					Total (thousands)	Per ton
Alabama	7	7,782	70.23	5,465	$92,200	$16.87
California, Colorado, Utah	3	5,112	60.18	3,076	80,607	26.20
Connecticut, Maryland, New Jersey, New York	6	12,164	69.76	8,486	145,989	17.20
Illinois	6	3,422	68.99	2,361	47,708	20.21
Indiana	5	11,871	69.85	8,293	134,803	16.26
Kentucky, Missouri, Tennessee, Texas	5	2,764	72.52	2,004	34,240	17.08
Michigan	3	4,496	73.59	3,309	60,165	18.18
Minnesota and Wisconsin	3	1,269	75.53	958	22,512	23.49
Ohio	13	11,520	70.15	8,081	138,962	17.20
Pennsylvania	12	26,248	70.22	18,433	295,882	16.05
West Virginia	3	4,781	69.21	3,309	57,995	17.53
Total 1967	66	91,428	69.75	63,775	1,111,062	17.42
At merchant plants	16	8,649	71.92	6,220	147,931	23.78
At furnace plants	50	82,780	69.53	57,555	963,131	16.73
Total 1966	66	94,037	70.14	65,959	1,144,181	17.35

[1] Data may not add exactly to totals shown due to independent rounding.
[2] Excludes plants retired permanently during year.

Table 4.—Summary of beehive-coke operations in the United States in 1967, by States[1]

State	Plants in existence Dec. 31 [2]	Coal carbonized (thousand short tons)	Yield of coke from coal (percent)	Coke produced (thousand short tons)	Value of coke at ovens: Total (thousands)	Value of coke at ovens: per ton
Pennsylvania	8	574	60.19	346	$4,913	$14.21
Kentucky, Virginia, West Virginia	8	797	57.65	460	7,197	15.65
Total:						
1967	16	1,372	58.72	806	12,111	15.03
1966	15	2,369	60.89	1,442	21,867	15.16

[1] Data may not add exactly to totals shown due to independent rounding.
[2] Excludes plants retired permanently during year.

Table 5.—Production of oven and beehive coke in the United States, by months [1] [2]

(Thousand short tons)

Month	1965 Total	1965 Daily average	1966 Total	1966 Daily average	1967 Total	1967 Daily average
Oven coke:						
January	5,626	182	5,205	168	5,457	176
February	5,149	184	4,915	176	5,000	172
March	5,755	186	5,621	181	5,557	179
April	5,593	186	5,422	181	5,316	177
May	5,806	187	5,696	184	5,398	174
June	5,590	186	5,550	185	5,102	170
July	5,623	181	5,704	184	5,108	165
August	5,573	180	5,736	185	5,209	168
September	5,230	174	5,534	185	5,155	172
October	5,179	167	5,626	182	5,413	175
November	4,949	165	5,447	182	5,413	180
December	5,124	165	5,504	178	5,647	182
Total	65,198	179	65,960	181	63,775	174
Beehive coke:						
January	179	6	99	3	116	4
February	163	6	99	4	89	3
March	197	6	115	4	60	2
April	163	6	108	4	57	2
May	149	5	113	4	56	2
June	177	6	121	4	53	2
July	159	5	102	3	46	1
August	165	5	140	5	58	2
September	90	3	142	5	54	2
October	74	2	141	5	72	2
November	65	2	135	5	72	2
December	78	3	126	4	73	2
Total	1,657	5	1,442	4	806	2
Total:						
January	5,805	187	5,304	171	5,573	180
February	5,313	190	5,014	179	5,089	175
March	5,953	192	5,736	185	5,616	181
April	5,756	192	5,530	184	5,374	179
May	5,955	192	5,809	187	5,455	176
June	5,766	192	5,671	189	5,154	172
July	5,782	187	5,806	187	5,153	166
August	5,738	185	5,876	190	5,267	170
September	5,320	177	5,676	189	5,209	174
October	5,253	169	5,767	186	5,485	177
November	5,014	167	5,582	186	5,486	183
December	5,202	168	5,631	182	5,720	185
Total	66,855	183	67,402	185	64,580	176

[1] Data may not add exactly to totals shown due to 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 [1]

(Thousand short tons)

Month	1965 Merchant plants	1965 Furnace plants	1966 Merchant plants	1966 Furnace plants	1967 Merchant plants	1967 Furnace plants
Production:						
January	571	5,055	542	4,663	558	4,899
February	522	4,628	496	4,419	495	4,505
March	598	5,157	565	5,056	545	5,011
April	564	5,029	540	4,882	517	4,799
May	577	5,229	547	5,149	528	4,870
June	549	5,041	520	5,029	511	4,591
July	559	5,064	540	5,165	499	4,608
August	553	5,020	544	5,193	511	4,697
September	528	4,702	524	5,010	490	4,665
October	551	4,628	512	5,114	521	4,892
November	544	4,405	505	4,942	515	4,898
December	557	4,567	544	4,961	528	5,119
Total	6,673	58,524	6,377	59,583	6,220	57,555
Daily average:						
January	18	163	18	150	18	158
February	19	165	18	158	17	155
March	19	166	18	163	18	162
April	19	168	18	163	17	160
May	19	169	18	166	17	157
June	18	168	17	168	17	153
July	18	163	17	167	16	149
August	18	162	18	168	16	152
September	18	157	18	167	16	156
October	18	149	17	165	17	158
November	18	147	17	165	17	163
December	18	147	18	160	17	165
Average for year	18	160	18	163	17	157

[1] Data may not add exactly to totals shown due to independent rounding.

Table 7.—Production of oven coke and number of plants in the United States, by type of plant

Year	Number of active plants [1]		Coke produced (thousand short tons)		Percent of production	
	Merchant plants	Furnace plants	Merchant plants	Furnace plants	Merchant plants	Furnace plants
1964	17	47	6,336	54,573	10.4	89.6
1965	17	48	6,673	58,524	10.2	89.8
1966	16	50	6,377	59,583	9.7	90.3
1967	16	50	6,220	57,555	9.8	90.2

[1] Includes plants operating any part of year.

Table 8.—Production of coke in the United States, by States [1]

(Thousand short tons)

State	1964	1965	1966	1967
Oven coke:				
Alabama	4,689	5,491	5,409	5,465
California, Colorado, Utah	2,936	3,187	3,218	3,076
Connecticut, Maryland, New Jersey, New York	7,687	8,428	8,640	8,486
Illinois	2,299	2,504	2,577	2,361
Indiana	8,170	8,315	8,421	8,293
Kentucky, Missouri, Tennessee, Texas	2,059	2,074	1,966	2,004
Michigan	3,908	3,979	3,755	3,309
Minnesota and Wisconsin	933	1,118	1,205	958
Ohio	7,244	7,669	8,515	8,081
Pennsylvania	17,594	18,912	18,691	18,433
West Virginia	3,390	3,521	3,562	3,309
Total	60,908	65,198	65,959	63,775
Beehive coke:				
Pennsylvania	562	880	610	346
Kentucky, Virginia, West Virginia	675	777	833	460
Total	1,236	1,657	1,442	806
Grand total	62,145	66,854	67,402	64,580

[1] Data may not add exactly to totals shown due to independent rounding.

Table 9.—Breeze recovered at coke plants in the United States in 1967, by States [1]

State	Yield per ton of coal [2] (percent)	Produced		Used by producers						Sold		On hand Dec. 31 (thousand short tons)
		Thousand short tons	Value (thousands)	In steam plants: Thousand short tons	In steam plants: Value (thousands)	In agglomerating plants: Thousand short tons	In agglomerating plants: Value (thousands)	For other industrial use: Thousand short tons	For other industrial use: Value (thousands)	Thousand short tons	Value (thousands)	
Oven coke:												
Alabama	7.11	553	$5,352	(3)	(3)	186	$1,153	29	$195	361	$4,286	64
California, Colorado, Utah	5.30	271	2,513	-----	--------	176	1,566	21	169	56	576	43
Connecticut, Maryland, New Jersey, New York	4.74	577	3,657	314	$2,126	(3)	(3)	90	556	56	400	342
Illinois	5.17	177	1,353	(3)	(3)	(3)	(3)	17	99	(3)	(3)	24
Indiana	4.40	523	3,020	(3)	(3)	424	2,475	43	317	113	573	43
Kentucky, Missouri, Tennessee, Texas	5.72	158	1,429	(3)	(3)	--------	--------	(3)	(3)	108	936	23
Michigan	4.54	204	1,599	(3)	(3)	(3)	(3)	(3)	(3)	58	433	55
Minnesota and Wisconsin	6.09	77	411	(3)	(3)	(3)	(3)	38	175	(3)	(3)	53
Ohio	4.14	476	3,303	70	633	37	266	93	623	235	1,695	140
Pennsylvania	2.94	773	4,994	81	436	549	3,735	94	528	120	879	210
West Virginia	4.94	236	1,403	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)	2
Undistributed	------	--------	--------	129	805	323	2,398	92	729	123	754	-------
Total 1967	4.40	4,025	29,034	594	3,999	1,695	11,594	517	3,393	1,229	10,532	[4] 1,000
At merchant plants	5.95	516	4,384	120	1,214	--------	--------	84	583	278	2,417	161
At furnace plants	4.24	3,509	24,651	474	2,785	1,695	11,594	433	2,809	950	8,115	838
Total 1966	4.27	4,012	27,417	644	4,139	1,873	12,618	505	3,147	1,136	8,453	[4] 905
Beehive coke:												
Pennsylvania and Virginia, 1967	7.01	21	44	-----	--------	--------	--------	-----	--------	21	44	(5)
Total 1966 [6]	6.38	36	67	-----	--------	--------	--------	-----	--------	36	67	1

[1] Data may not add exactly to totals shown due to independent rounding.
[2] Calculated by dividing production by coal carbonized at plants actually recovering breeze.
[3] Included with "Undistributed" to avoid disclosing individual company confidential data.
[4] Includes some breeze resulting from the screening of coke at blast furnaces.
[5] Less than ½ unit.
[6] Includes Kentucky and West Virginia.

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
1964	632	1,764	434	1,116	$7.44
1965	642	1,744	427	1,312	7.56
1966	644	1,873	505	1,172	7.27
1967	594	1,695	517	1,250	8.46

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
1964	62,145	103	524	−913	62,637	57,063	91.1	5,574	8.9
1965	66,854	90	834	+731	65,379	59,072	90.4	6,307	9.6
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

[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)
1964	1,323.6	69.6	1,901.7
1965	1,329.5	70.1	1,896.6
1966	1,300.6	69.9	1,860.7
1967	1,287.8	69.6	1,850.2

[1] American Iron and Steel Institute; consumption of pig iron only, excluding furnaces making ferroalloys, was 1,310 pounds in 1964, 1,312 in 1965, 1,282 in 1966, and 1,262 in 1967.

Table 13.—Oven coke produced in the United States, used by producers, and sold in 1967, by States [1]

(Thousand short tons and thousand dollars)

State	Produced		Used by producing companies				Commercial sales	
			In blast furnaces		For other purposes [2]		To blast-furnace plants	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	5,465	$92,200	3,565	$52,637	169	$4,514	315	$5,080
California, Colorado, Utah	3,076	80,607	2,845	76,497	24	515	------	------
Connecticut, Maryland, New Jersey, New York	8,486	145,989	6,767	110,060	47	986	881	15,509
Illinois	2,361	47,708	2,309	45,854	79	2,525	------	------
Indiana	8,293	134,803	7,556	116,159	11	162	(3)	(3)
Kentucky, Missouri, Tennessee, Texas	2,004	34,240	(3)	(3)	(3)	(3)	(3)	(3)
Michigan	3,309	60,165	(3)	(3)	129	3,980	(3)	(3)
Minnesota and Wisconsin	958	22,512	(3)	(3)	(3)	(3)	(3)	(3)
Ohio	8,081	138,962	6,855	113,012	167	3,315	383	6,517
Pennsylvania	18,433	295,882	16,731	263,812	22	361	354	5,753
West Virginia	3,309	57,995	2,986	53,117	(3)	(3)	(3)	(3)
Undistributed	------	------	3,691	61,059	62	2,137	1,311	19,997
Total 1967	63,775	1,111,062	53,304	892,205	712	18,497	3,244	52,856
At merchant plants	6,220	147,931	------	------	267	6,632	2,405	39,138
At furnace plants	57,555	963,131	53,304	892,205	445	11,864	839	13,718
Total 1966	65,959	1,144,181	56,752	940,037	781	20,188	3,492	57,016

State	Commercial sales—Continued							
	To foundries		To other industrial plants		For residential heating		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quzntity	Value
Alabama	529	$16,426	230	$3,922	10	129	1,084	$25,557
California, Colorado, Utah	(3)	(3)	(3)	(3)	------	------	219	3,789
Connecticut, Maryland, New Jersey, New York	366	11,795	87	1,595	49	902	1,384	29,802
Illinois	------	------	(3)	(3)	(3)	(3)	4	60
Indiana	(3)	(3)	(3)	(3)	8	116	549	15,865
Kentucky, Missouri, Tennessee, Texas	(3)	(3)	104	1,947	(3)	(3)	1,275	22,955
Michigan	(3)	(3)	(3)	(3)	(3)	(3)	385	11,615
Minnesota and Wisconsin	(3)	(3)	(3)	(3)	(3)	(3)	502	15,441
Ohio	(3)	(3)	124	1,988	(3)	(3)	869	20,084
Pennsylvania	(3)	(3)	95	1,564	(3)	(3)	732	16,282
West Virginia	------	------	(3)	(3)	------	------	363	5,477
Undistributed	1,950	63,956	549	9,399	19	330	------	------
Total 1967	2,845	92,176	1,189	20,415	85	1,477	7,364	166,924
At merchant plants	2,552	82,807	622	11,598	82	1,431	5,661	134,974
At furnace plants	293	9,369	568	8,817	3	46	1,703	31,950
Total 1966	8,002	95,822	1,408	28,798	112	1,950	8,014	178,081

[1] Data may not add exactly to totals shown due to independent rounding.
[2] Comprises 349,000 tons valued at $11,640,000 used in foundries; 363,000 tons valued at $6,857,000 for other purposes.
[3] Included with "Undistributed" to avoid disclosing individual company confidential data.

Table 14.—Beehive coke produced in the United States, used by producers, and sold in 1967, by States [1]

(Thousand short tons and thousand dollars)

State	Produced		Commercial sales			
			To blast-furnace plants		To foundries	
	Quantity	Value	Quantity	Value	Quantity	Value
Pennsylvania	346	$4,913	278	$4,085	16	$186
Kentucky, Virginia, West Virginia	460	7,197	[2] 287	[2] 4,374	[3] 2	[3] 29
Total:						
1967	806	12,111	565	8,458	17	215
1966	1,442	21,867	[4] 971	13,269	12	189

State	Commercial sales—Continued					
	To other industrial plants		For residential heating		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
Pennsylvania	52	$643	(5)	(5)	346	$4,913
Kentucky, Virginia, West Virginia	170	2,784	(5)	(5)	459	7,188
Total:						
1967	222	3,427	(5)	(5)	805	12,100
1966	436	7,310	8	97	1,427	20,864

[1] Data may not add exactly to totals shown due to independent rounding.
[2] Excludes Kentucky.
[3] Virginia only.
[4] Includes small quantity used by producers.
[5] Combined with coke sold "To foundries" to avoid disclosing individual company confidential data.

Table 15.—Distribution of oven and beehive coke and breeze in 1967 [1]

(Thousand short tons)

Consuming State	Coke					Breeze
	To blast-furnace plants	To foundries	To other industrial plants	For residential heating	Total	
Alabama	3,586	285	51	6	3,928	366
Arizona	------	1	2	--------	3	--------
Arkansas	------	2	2	--------	4	(3)
California	1,229	55	30	--------	1,313	69
Colorado	621	11	30	--------	662	69
Connecticut	------	25	43	5	73	35
Delaware	------	--------	(3)	--------	(3)	(3)
Florida	------	2	32	(3)	35	31
Georgia	------	14	3	1	17	(3)
Idaho	------	(3)	166	--------	167	20
Illinois	4,242	227	98	4	4,570	297
Indiana	7,426	170	78	8	7,683	525
Iowa	------	87	2	(3)	89	(3)
Kansas	------	12	1	--------	13	1
Kentucky	998	20	70	9	1,098	116
Louisiana	9	1	52	--------	62	1
Maine	------	2	10	1	13	--------
Maryland	3,594	22	6	--------	3,622	117
Massachusetts	------	34	1	10	45	--------
Michigan	3,905	721	135	1	4,762	131
Minnesota	354	24	16	1	396	25
Mississippi	------	(3)	(3)	--------	1	(3)
Missouri	------	21	49	(3)	70	2
Montana	------	1	46	--------	47	8
Nebraska	------	6	5	--------	11	--------
Nevada	------	--------	--------	--------	--------	(3)
New Hampshire	------	2	--------	1	3	--------
New Jersey	------	75	38	19	132	36
New Mexico	------	--------	(3)	--------	(3)	(3)
New York	3,595	142	52	12	3,802	288
North Carolina	------	14	16	1	31	30
North Dakota	------	20	3	--------	23	(3)
Ohio	8,762	394	203	1	9,360	454
Oklahoma	------	5	--------	--------	5	1
Oregon	------	5	20	--------	25	5
Pennsylvania	14,054	239	175	(3)	14,467	772
Rhode Island	------	12	(3)	1	13	--------
South Carolina	------	10	23	(3)	33	12
South Dakota	------	1	--------	--------	1	--------
Tennessee	1	62	78	1	143	121
Texas	747	78	17	(3)	842	66
Utah	997	7	17	--------	1,021	67
Vermont	------	2	1	1	4	--------
Virginia	14	71	52	(3)	138	3
Washington	------	4	4	--------	7	4
West Virginia	2,776	11	27	--------	2,814	278
Wisconsin	------	163	1	4	168	45
Wyoming	------	(3)	4	--------	4	(3)
Total	56,911	3,060	1,661	85	61,717	3,995
Exported	202	152	114	(3)	468	61
Grand total	57,114	3,212	1,774	85	62,185	4,056

[1] Based upon reports from producers showing destination and principal end use of coke used and sold. Does not include imported coke which totaled 92,000 tons in 1967.
[2] Data may not add exactly to totals shown due to independent rounding.
[3] Less than ½ unit.

Table 16.—Producers' stocks of coke and breeze in the United States on Dec. 31, 1967, by States [1]

(Thousand short tons)

State	Coke: Blast furnace	Coke: Foundry	Coke: Residential heating and other	Coke: Total	Breeze
Oven coke:					
Alabama	1,092	13	21	1,126	64
California, Colorado, Utah	259	-------	-------	259	43
Connecticut, Maryland, New Jersey, New York	619	30	154	803	342
Illinois	68	-------	(2)	68	24
Indiana	381	20	10	411	43
Kentucky, Missouri, Tennessee, Texas	81	30	21	132	23
Michigan	129	6	(2)	135	55
Minnesota and Wisconsin	106	45	32	184	53
Ohio	424	5	23	452	140
Pennsylvania	1,783	46	30	1,860	210
West Virginia	38	-------	-------	38	2
Total 1967	4,980	197	290	5,467	1,000
At merchant plants	72	173	261	506	161
At furnace plants	4,908	24	29	4,961	838
Total 1966	2,841	128	110	3,078	905
Beehive coke:					
Pennsylvania	-----	-------	-------	-------	-------
Kentucky, Virginia, West Virginia	1	1	(2)	1	(2)
Total:					
1967	1	1	(2)	1	(2)
1966	(2)	(2)	1	1	1

[1] Data may not add exactly to totals shown due to independent rounding.
[2] Less than ½ unit.

Table 17.—Producers' month-end stocks of oven coke in the United States

(Thousand short tons)

Month	At merchant plants: 1966	At merchant plants: 1967	At furnace plants: 1966	At furnace plants: 1967	Total [1]: 1966	Total [1]: 1967
January	242	231	2,548	3,018	2,789	3,249
February	192	232	2,504	3,156	2,696	3,388
March	185	254	2,442	3,273	2,627	3,527
April	173	267	2,172	3,465	2,345	3,732
May	157	277	2,009	3,687	2,166	3,963
June	141	299	1,939	4,051	2,080	4,350
July	197	396	2,061	4,371	2,258	4,766
August	210	421	2,228	4,595	2,438	5,016
September	220	453	2,356	4,824	2,575	5,277
October	207	467	2,428	4,972	2,635	5,439
November	200	477	2,621	5,022	2,821	5,499
December	215	506	2,863	4,961	3,078	5,467

[1] Data may not add exactly to totals shown due to independent rounding.

Table 18.—Average value per short ton of coke produced in the United States and average receipts per short ton from coke sold (commercial sales)

Year	Value per ton produced			Receipts per ton sold		
	Oven coke	Beehive coke	Total	Oven coke	Beehive coke	Total
1964	$17.80	$15.04	$17.74	$20.73	$15.00	$20.04
1965	16.89	14.97	16.84	21.68	14.96	20.63
1966	17.35	15.16	17.30	22.22	14.60	21.11
1967	17.42	15.03	17.39	22.67	15.03	21.92

Table 19.—Average receipts per short ton of coke sold (commercial sales) in the United States, by use

Year	Oven coke				Beehive coke			
	To blast-furnace plants	To foundries	To other industrial plants [1]	For residential heating	To blast-furnace plants	To foundries	To other industrial plants [1]	For residential heating
1964	$15.54	$30.43	$15.79	$16.28	$14.34	$17.54	$15.68	$7.83
1965	16.46	30.94	16.41	17.12	14.45	15.40	16.12	10.72
1966	16.33	31.75	16.90	17.39	13.58	15.30	16.77	11.97
1967	16.29	32.40	17.16	17.35	14.97	12.34	15.41	(2)

[1] Includes water-gas plants.
[2] Combined with value of coke sold "To foundries" to avoid disclosing individual company confidential data.

Table 20.—Coke exported from the United States, by country and by customs district

	1965		1966		1967	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Country:						
Argentina	12,420	$222	----------	--------	---------	--------
Australia	350	8	193	$3	152	$3
Bolivia	89	2	134	2	34	2
Brazil	6,053	162	12,913	417	7,144	248
Canada	603,248	12,452	854,637	18,165	439,853	10,562
Chile	637	28	220	10	147	7
Ecuador	75	2	242	4	---------	--------
India	733	16	1,420	33	---------	--------
Japan	581	10	275	15	21,312	392
Libya	120	3	176	43	---------	--------
Mexico	58,006	1,436	124,146	3,154	162,022	4,142
Netherlands	75	7	35,996	307	627	9
Nigeria	114	12	607	10	---------	--------
Panama	103	2	106	2	55	1
Peru	7,733	127	36	2	49	2
Philippines	980	31	----------	--------	148	2
Rumania	59,627	596	----------	--------	---------	--------
Tunisia	-------	--------	18,510	423	---------	--------
United Kingdom	-------	--------	673	13	40	1
Venezuela	81,816	1,137	51,448	798	77,807	1,103
Other	908	54	434	14	990	18
Total	833,668	16,307	1,102,166	23,415	710,380	16,492
Customs district:						
Baltimore	1,311	30	766	18	544	13
Buffalo	403,120	8,305	499,695	10,784	238,578	5,751
Chicago	27,541	365	76,210	1,088	---------	--------
Detroit	127,932	2,715	186,505	4,087	144,771	3,282
Duluth	1,178	32	3,043	63	3,190	108
Galveston	1,289	45	----------	--------	114	2
Great Falls	1,169	43	710	20	360	12
Houston	-------	--------	7,070	224	3,746	136
Laredo	57,301	1,416	123,378	3,127	161,102	4,120
Los Angeles	-------	--------	----------	--------	21,151	390
Mobile	17,792	290	909	54	47,048	672
New Orleans	525	29	603	42	784	16
New York City	2,269	67	4,765	167	2,931	81
Ogdensburg	19,850	357	50,420	975	16,413	316
Pembina	15,350	438	23,290	689	26,191	737
Philadelphia	145,255	1,863	70,952	1,255	30,483	427
Port Arthur	3,306	85	2,204	71	1,653	53
Portland, Oregon	550	9	----------	--------	---------	--------
St. Albans	-------	--------	700	24	2,220	93
San Diego	494	14	629	20	458	10
San Francisco	-------	--------	35,694	259	---------	--------
Seattle	6,628	187	14,016	430	8,130	262
Other	808	17	607	18	503	11
Total	833,668	16,307	1,102,166	23,415	710,380	16,492

Table 21.—Coke imported for consumption in the United States, by country and by customs district

	1965		1966		1967	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Country:						
Canada	87,724	$1,193	92,281	$1,464	87,549	$1,295
France	------	--------	--------	--------	80	9
Germany, West	1,733	176	3,099	286	3,650	326
Mexico	49	1	--------	--------	84	2
Netherlands	114	9	70	9	638	72
Switzerland	------	--------	311	31	--------	--------
Total	89,620	1,379	95,761	1,790	92,001	1,704
Customs district:						
Buffalo	12,250	57	9,967	51	8,115	38
Detroit	108	3	57	1	30	1
Galveston	------	--------	--------	--------	152	15
Great Falls	59,158	873	64,762	1,113	64,795	1,138
Honolulu	330	11	495	16	330	10
Houston	------	--------	--------	--------	16	3
New Orleans	1,403	165	2,985	309	3,388	361
New York City	114	9	--------	--------	--------	--------
Ogdensburg	472	16	139	5	10,000	40
Pembina	------	--------	79	2	--------	--------
Portland, Maine	57	1	76	2	35	1
St. Albans	51	1	32	(1)	44	1
San Juan	------	--------	--------	--------	482	18
Seattle	15,677	243	17,169	291	4,614	78
Total	89,620	1,379	95,761	1,790	92,001	1,704

1 Less than ½ unit.

Table 22.—World production of oven and beehive coke (excluding breeze), by countries[1]

(Thousand short tons)

Country	1963	1964	1965	1966	1967 p
North America:					
Canada [2]	4,281	4,343	4,369	4,426	4,430
Mexico	843	866	908	1,247	NA
United States	54,278	62,145	66,854	67,402	64,580
South America:					
Argentina	347	497	508	e 507	NA
Brazil	r 946	1,005	r 1,002	r 1,367	1,444
Chile	274	271	235	e 220	NA
Colombia	441	463	480	356	NA
Peru	42	29	30	39	45
Europe:					
Austria	1,801	1,773	1,706	1,625	1,551
Belgium	7,941	7,969	8,084	7,673	7,559
Bulgaria	141	519	808	e 827	NA
Czechoslovakia	10,250	10,385	10,468	r 10,433	NA
Finland	e r 33	e r 33	35	42	44
France [3]	14,842	15,439	14,781	r 14,244	13,922
Germany:					
East	r 3,596	r 3,746	r 3,537	r 3,517	e 3,585
West [4]	r 46,180	r 47,785	r 47,723	r 43,971	38,851
Hungary	728	733	708	712	708
Italy	5,065	5,162	6,324	r 6,908	6,885
Netherlands [3]	4,707	4,976	4,723	4,219	3,653
Norway	-------	119	r 222	r 254	e 265
Poland	r 14,025	r 14,358	r 14,544	r 14,855	e 15,100
Rumania	1,258	1,263	1,251	1,216	1,323
Spain [4]	3,034	2,832	r 3,052	3,082	3,180
Sweden	378	413	413	r 551	e 595
U.S.S.R.[3]	70,408	73,063	74,364	e 74,800	e 76,100
United Kingdom	17,408	18,982	19,159	18,051	17,180
Yugoslavia	1,112	1,200	1,271	1,353	1,344
Africa:					
Rhodesia, Southern	101	143	e 110	[3] 204	NA
South Africa, Republic of	2,520	2,636	3,521	3,174	NA
United Arab Republic	e 39	e 39	266	e 276	NA
Asia:					
China, mainland e	16,500	16,500	17,600	18,700	13,200
India	8,098	8,667	9,457	9,370	e 11,000
Iran e [5]	22	22	28	28	NA
Japan	13,300	15,098	16,536	18,775	23,473
Korea, North e	1,300	1,500	r 1,700	r 1,700	2,000
Taiwan	r 219	r 224	r 232	r 234	e 228
Turkey	907	947	1,370	1,235	NA
Oceania:[6]					
Australia	3,192	3,408	3,413	3,566	4,025
New Zealand	7	7	7	7	NA
Total [7]	r 310,564	r 329,560	r 341,799	r 341,166	316,270

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Compiled mostly from data available June 1968.
[2] Includes breeze and a small amount of gashouse coke.
[3] Including breeze.
[4] Includes a small amount of low-temperature coke.
[5] Year ended March 20 following that stated.
[6] Quantity of coke made from imported coal for use in nickel smelter in New Caledonia is not reported.
[7] Total is of listed figures only; no undisclosed data included.

Table 23.—World production of gashouse, low- and medium-temperature coke (excluding breeze), by countries [1] [2]

(Thousand short tons)

Country [3]	1963	1964	1965	1966	1967 p
North America:					
United States, retort, low- and medium-temperature	160	203	149	168	163
South America:					
Brazil	e 314	e 309	241	247	226
Chile	109	91	e 89	NA	NA
Uruguay	23	23	22	23	23
Europe:					
Austria	r 364	r 358	r 317	r 247	235
Czechoslovakia:					
Gashouse	497	337	r 351	r 228	NA
Lignite	2,330	2,126	1,866	r 1,954	NA
Denmark	r 557	r 467	r 363	r 349	295
Finland	e r 149	e r 127	121	127	106
France:					
Gashouse	152	67	22	15	10
Low-temperature	299	326	266	274	217
Germany:					
East: Lignite [4]	r 8,342	r 8,386	r 8,093	r 8,072	e 8,102
West:					
Gashouse	5,390	5,415	4,578	3,942	3,163
Lignite	661	657	637	599	434
Greece	23	18	19	NA	NA
Hungary	535	517	565	r 659	NA
Ireland [5]	r 141	r 144	r 141	r 116	e 88
Italy	799	597	425	r 375	349
Luxembourg	40	31	14	e 11	---------
Netherlands [5]	195	120	108	66	20
Norway	r 54	25	r 25	r 11	e 11
Poland:					
Gashouse	1,274	r 1,318	r 1,393	r 1,421	e 1,433
Low-temperature	280	276	287	e 276	e 276
Portugal	28	11	---------	---------	---------
Spain [5]	219	198	97	78	57
Sweden	628	606	584	r 601	e 562
Switzerland	582	517	498	342	303
United Kingdom	10,938	9,900	8,691	r 8,066	6,821
Yugoslavia	19	19	15	r 12	e 11
Africa:					
Algeria e	66	44	39	28	28
South Africa, Republic of	139	148	178	194	NA
United Arab Republic e	39	39	44	55	NA
Asia:					
Hong Kong [5]	17	14	14	11	10
India:					
Gashouse	119	76	71	e 73	e 77
Low-temperature	2,525	2,436	2,811	e 2,425	e 2,756
Japan:					
Gashouse	3,719	4,102	4,045	4,093	4,591
Low-temperature e	83	77	77	72	72
Taiwan	r 37	r 51	r 50	r 50	e 50
Turkey:					
Gashouse	186	191	128	196	NA
Low-temperature	87	87	79	79	NA
Oceania:					
Australia [5]	r 892	r 859	r 826	e r 827	NA
New Zealand [6]	r 88	r 76	r 74	NA	NA
Total [7]	r 43,099	r 41,389	r 38,413	r 36,382	30,489

e Estimate. p Preliminary. r Revised. NA Not available.
1 Gashouse coke unless otherwise specified.
2 Compiled mostly from data available June 1968.
3 Production data for Ceylon, China, Malaysia, Mexico, Rumania, and U.S.S.R. are not available.
4 Includes high-temperature coke.
5 Includes breeze.
6 Year ended March 31 of year following that stated.
7 Total is of listed figures only; no undisclosed data included.

Table 24.—Quantity and value at ovens of coal carbonized in the United States in 1967, by States [1]

State	Coal carbonized			Coal per ton of coke	
	Thousand short tons	Value		Short tons	Value
		Total (thousands)	Average		
Oven coke:					
Alabama	7,782	$77,453	$9.95	1.42	$14.17
California, Colorado, Utah	5,112	63,333	12.39	1.66	20.59
Connecticut, Maryland, New Jersey, New York	12,164	143,356	11.79	1.43	16.89
Illinois	3,422	32,056	9.37	1.45	13.58
Indiana	11,871	127,385	10.73	1.43	15.36
Kentucky, Missouri, Tennessee, Texas	2,764	26,499	9.59	1.38	13.22
Michigan	4,496	46,358	10.31	1.36	14.01
Minnesota and Wisconsin	1,269	14,666	11.56	1.32	15.30
Ohio	11,520	106,595	9.25	1.43	13.19
Pennsylvania	26,248	241,540	9.20	1.42	13.10
West Virginia	4,781	37,280	7.80	1.44	11.27
Total 1967	91,428	916,520	10.02	1.43	14.37
At merchant plants	8,649	89,410	10.34	1.39	14.41
At furnace plants	82,780	827,111	9.99	1.44	14.37
Total 1966	94,037	919,271	9.78	1.43	13.94
Beehive coke:					
Pennsylvania	574	3,794	6.60	1.66	10.97
Kentucky, Virginia, West Virginia	797	4,408	5.53	1.73	9.59
Total:					
1967	1,372	8,201	5.98	1.70	10.18
1966	2,369	13,040	5.50	1.64	9.03

[1] Data may not add exactly to totals shown due to independent rounding.

Table 25.—Bituminous coal carbonized in coke ovens in the United States, by months [1]

(Thousand short tons)

Month	1966			1967		
	Slot	Beehive	Total	Slot	Beehive	Total
January	7,377	161	7,539	7,760	199	7,959
February	7,041	160	7,201	7,109	152	7,261
March	7,988	188	8,176	7,890	103	7,993
April	7,645	175	7,820	7,520	99	7,619
May	8,080	185	8,265	7,754	96	7,850
June	7,951	200	8,151	7,251	90	7,341
July	8,049	169	8,217	7,303	78	7,381
August	8,084	238	8,321	7,444	98	7,543
September	7,833	233	8,066	7,358	93	7,452
October	7,975	231	8,205	7,723	120	7,843
November	7,718	222	7,940	7,731	122	7,853
December	7,783	208	7,991	8,056	122	8,179
Total	93,523	2,369	95,892	90,900	1,372	92,272

[1] Data may not add exactly to totals shown due to independent rounding.

Table 26.—Anthracite carbonized at oven-coke plants in the United States, by months

(Thousand short tons)

Month	1964	1965	1966	1967
January	42	41	45	48
February	39	37	41	43
March	42	46	46	46
April	41	43	43	46
May	41	42	42	45
June	40	40	45	42
July	43	36	39	37
August	35	41	40	48
September	42	41	41	42
October	43	46	44	40
November	42	46	45	46
December	42	47	45	44
Total	492	507	515	528

[1] Data may not add exactly to totals shown due to independent rounding.

Table 27.—Value of coal and products per short ton of coal carbonized in the United States

Year	Oven coke: Value of coal per ton	Oven coke: Value per ton of coal: Coke produced	Oven coke: Value per ton of coal: Breeze produced	Oven coke: Value per ton of coal: Coal-chemical materials used or sold [1]	Oven coke: Total	Beehive coke: Value of coal per ton	Beehive coke: Value per ton of coal
1964	$9.28	$12.43	$0.30	$3.34	$16.07	$5.32	$9.18
1965	9.51	11.89	.30	3.36	15.55	5.41	9.21
1966	9.78	12.17	.29	3.29	15.75	5.50	9.23
1967	10.02	12.15	.32	3.20	15.67	5.98	8.83

[1] Includes value of surplus gas used and tar and pitch-of-tar burned.

Table 28.—Average value per short ton of coal carbonized at oven-coke plants in the United States, by States

State	1964	1965	1966	1967
Alabama	$7.75	$9.74	$9.84	$9.95
California, Colorado, Utah	12.59	12.46	12.68	12.39
Connecticut, Maryland, New Jersey, New York	11.24	11.10	11.51	11.79
Illinois	9.23	9.04	9.28	9.37
Indiana	10.02	10.08	10.36	10.73
Kentucky, Missouri, Tennessee, Texas	9.35	8.97	9.10	9.59
Michigan	9.86	9.85	10.14	10.31
Minnesota and Wisconsin	10.73	10.67	11.37	11.56
Ohio	9.00	8.86	8.93	9.25
Pennsylvania	8.09	8.54	8.91	9.20
West Virginia	7.66	7.74	7.72	7.80
Average	9.28	9.51	9.78	10.02
Value of coal per ton of coke	13.29	13.51	13.94	14.37

Table 29.—Washed and unwashed coal carbonized in the United States in 1967, by States in which used [1]

(Thousand short tons)

State	Bituminous coal			Anthracite	Grand total
	Washed	Unwashed	Total		
Oven coke:					
Alabama	7,742	--------	7,742	40	7,782
California, Colorado, Utah	4,903	209	5,112	--------	5,112
Connecticut, Maryland, New Jersey, New York	10,419	1,671	12,090	74	12,164
Illinois	2,914	499	3,413	10	3,422
Indiana	11,807	18	11,825	47	11,871
Kentucky, Missouri, Tennessee, Texas	2,325	384	2,709	54	2,764
Michigan	4,404	--------	4,404	93	4,496
Minnesota and Wisconsin	1,226	--------	1,226	43	1,269
Ohio	11,052	372	11,424	95	11,520
Pennsylvania	25,897	278	26,175	73	26,248
West Virginia	4,781	--------	4,781	--------	4,781
Total 1967	87,470	3,431	90,900	528	91,428
At merchant plants	8,101	116	8,217	431	8,649
At furnace plants	79,368	3,314	82,683	97	82,780
Total 1966	90,434	3,089	93,523	515	94,037
Beehive coke:					
Pennsylvania	520	55	574	--------	574
Kentucky, Virginia, West Virginia	767	30	797	--------	797
Total:					
1967	1,287	85	1,372	--------	1,372
1966	2,220	148	2,369	--------	2,369

[1] Data may not add exactly to totals shown due to independent rounding.

Table 30.—Washed and unwashed bituminous coal carbonized in the United States [1]

(Thousand short tons)

Year	Washed coal			Unwashed coal			Total coal carbonized	Percent of total washed
	In slot ovens	In beehive ovens	Total	In slot ovens	In beehive ovens	Total		
1964	82,443	1,813	84,255	4,289	213	4,502	88,758	94.9
1965	88,890	2,179	91,068	3,196	514	3,710	94,779	96.1
1966	90,434	2,220	92,654	3,089	148	3,238	95,892	96.6
1967	87,470	1,287	88,756	3,431	85	3,516	92,272	96.2

[1] Data may not add exactly to totals shown due to independent rounding.

Table 31.—Average volatile content of bituminous coal carbonized by oven-coke plants in the United States [1]

Year	High		Medium		Low		Total	
	Thousand short tons	Volatile content (percent)	Thousand short tons	Volatile content (percent)	Thousand short tons	Volatile content (percent)	Thousand short tons	Volatile content (percent)
1964	58,012	35.2	11,152	25.9	17,569	17.5	86,732	30.4
1965	61,725	35.2	11,791	25.9	18,570	17.8	92,086	30.5
1966	63,061	34.6	10,395	26.2	20,067	17.8	93,523	30.1
1967	59,787	35.1	12,470	26.4	18,644	18.2	90,900	30.4

[1] Data may not add exactly to totals shown due to independent rounding.

Table 32.—Coal received by oven-coke plants in the United States in 1967, by consuming States and volatile content [1] [2]

(Thousand short tons)

Consuming State	High-volatile		Medium-volatile		Low-volatile		Total coal receipts
	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total	
Alabama	1,131	14.2	6,144	77.2	681	8.6	7,956
California, Colorado, Utah	4,159	82.9	788	15.7	70	1.4	5,018
Connecticut, Maryland, New Jersey, New York	9,576	74.7	546	4.3	2,699	21.0	12,821
Illinois	2,359	68.7	325	9.5	750	21.8	3,434
Indiana	7,185	59.1	2,131	17.5	2,848	23.4	12,164
Kentucky, Missouri, Tennessee, Texas	1,478	53.8	461	16.8	810	29.4	2,749
Michigan	3,119	66.1	128	2.7	1,469	31.2	4,716
Minnesota and Wisconsin	676	45.8	136	9.2	663	45.0	1,475
Ohio	8,749	75.9	223	1.9	2,551	22.2	11,524
Pennsylvania	18,178	66.2	1,558	5.7	7,719	28.1	27,455
West Virginia	3,873	81.9	120	2.5	735	15.6	4,728
Total 1967	60,484	64.3	12,559	13.4	20,997	22.3	94,040
At merchant plants	4,056	47.5	1,259	14.7	3,229	37.8	8,545
At furnace plants	56,428	66.0	11,299	13.2	17,768	20.8	85,495
Total 1966	61,745	65.5	10,319	10.9	22,300	23.6	94,364

[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 exactly to totals shown due to independent rounding.

Table 33.—Origin of coal received by oven-coke plants in the United States in 1967, by producing county and volatile content [1]

(Thousand short tons)

State and county where coal was produced	Volatile content [2]			Total
	High	Medium	Low	
Alabama:				
Bibb	162	-------	-------	162
Jefferson	310	5,420	-------	5,730
Walker	30	-------	-------	30
Colorado:				
Gunnison	668	-------	-------	668
Las Animas	1,062	-------	-------	1,062
Moffat	(3)	-------	-------	(3)
Pitkin	-----	[4] 615	-------	[4] 615
Illinois:				
Franklin	1,032	-------	-------	1,032
Jefferson	645	-------	-------	645
Saline	263	-------	-------	263
Williamson	21	-------	-------	21
Kentucky:				
Floyd	2,162	-------	-------	2,162
Harlan	2,852	-------	-------	2,852
Knott	3	-------	-------	3
Letcher	547	-------	-------	547
Pike	5,386	-------	-------	5,386
New Mexico: Colfax	607	-------	-------	607
Oklahoma:				
Haskell	-----	207	-------	207
Le Flore	-----	-------	108	108
Rogers	135	-------	-------	135
Pennsylvania:				
Anthracite	-----	-------	421	421
Bituminous:				
Allegheny	2,908	-------	-------	2,908
Cambria	-----	315	3,099	3,414
Fayette	162	-------	-------	162
Greene	6,078	-------	-------	6,078
Somerset	1	-------	678	678
Washington	13,564	-------	-------	13,564
Westmoreland	1,917	-------	-------	1,917
Utah: Carbon	1,823	-------	-------	1,823
Virginia:				
Buchanan	199	442	643	1,284
Dickenson	447	-------	-------	447
Russell	911	1,422	-------	2,333
Tazewell	-----	1,734	-------	1,734
Wise	713	-------	-------	713
West Virginia:				
Boone	1,496	-------	-------	1,496
Fayette	2,444	39	647	3,131
Greenbrier	-----	112	-------	112
Kanawha	1,068	-------	-------	1,068
Logan	4,885	-------	-------	4,885
McDowell	-----	342	10,316	10,658
Marion	2,954	-------	-------	2,954
Mercer	-----	-------	713	713
Mingo	1,612	-------	-------	1,612
Nicholas	853	1,121	-------	1,974
Raleigh	-----	44	1,559	1,604
Wayne	-----	267	-------	267
Webster	-----	40	-------	40
Wyoming	563	439	2,813	3,816
Total	60,484	12,559	20,997	94,040

[1] Data may not add exactly to totals shown due to independent rounding.
[2] Volatile matter on moisture-free basis: High-volatile—over 31 percent; medium-volatile—22 to 31 percent; and low-volatile—14 to 22 percent.
[3] Less than ½ unit.
[4] Includes small quantity imported from Canada.

Table 34.—Origin of coal received by oven-coke plants in the United States in 1967, by States [1]

(Thousand short tons)

Consuming State	Coal produced in—										Total
	Alabama	Colorado	Illinois	Kentucky	New Mexico	Okla-homa	Pennsyl-vania	Utah	Virginia	West Virginia	
Alabama	5,834	-------	-------	--------	-------	-------	42	-------	1,113	967	7,956
California, Colorado, Utah	-----	2,345	-------	--------	607	-------	--------	1,823	-------	244	5,018
Connecticut, Maryland, New Jersey, New York	-----	-------	-------	3,759	-------	-------	4,802	-------	542	3,718	12,821
Illinois	-----	-------	1,325	1,008	-------	-------	9	-------	57	1,036	3,434
Indiana	-----	-------	637	3,912	-------	-------	51	-------	2,275	5,290	12,164
Kentucky, Missouri, Tennessee, Texas	88	-------	-------	--------	-------	449	58	-------	130	2,024	2,749
Michigan	-----	-------	-------	1,416	-------	-------	92	-------	146	3,062	4,716
Minnesota and Wisconsin	-----	-------	-------	183	-------	-------	52	-------	472	768	1,475
Ohio	-----	-------	-------	497	-------	-------	4,749	-------	508	5,769	11,524
Pennsylvania	-----	-------	-------	69	-------	-------	15,898	-------	1,141	10,347	27,455
West Virginia	-----	-------	-------	108	-------	-------	3,389	-------	125	1,106	4,728
Total 1967	5,922	2,345	1,961	10,951	607	449	29,143	1,823	6,510	34,330	94,040
At merchant plants	674	-------	-------	102	-------	-------	468	-------	792	6,510	8,545
At furnace plants	5,248	2,345	1,961	10,849	607	449	28,675	1,823	5,719	27,820	85,495
Total 1966	5,855	2,401	1,863	10,267	353	542	27,547	2,129	4,659	38,748	94,364

[1] Data may not add exactly to totals shown due to independent rounding.

Table 35.—Quantity and percentage of captive coal received by oven-coke plants in the United States [1]

(Thousand short tons)

Year	At merchant plants			At furnace plants			Total		
	Total coal received	Captive coal		Total coal received	Captive coal		Total coal received	Captive coal	
		Quantity	Percent		Quantity	Percent		Quantity	Percent
1964	9,208	3,172	34.5	81,129	53,265	65.7	90,336	56,437	62.5
1965	9,167	3,229	35.2	84,654	55,228	65.2	93,820	58,457	62.3
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

[1] Data may not add exactly to totals shown due to independent rounding.

Table 36.—Month-end stocks of bituminous coal at oven-coke plants in the United States

(Thousand short tons)

Month	1963	1964	1965	1966	1967
January	7,339	7,780	9,517	10,137	9,244
February	7,233	7,900	9,225	9,970	9,364
March	6,595	8,299	9,424	11,318	9,491
April	6,883	8,411	9,576	8,640	9,829
May	7,648	8,841	9,749	8,624	10,596
June	8,202	9,375	9,970	9,078	11,019
July	6,386	7,467	7,744	6,645	8,774
August	6,919	7,969	8,501	7,265	9,465
September	7,290	8,643	8,253	7,621	9,726
October	7,912	9,346	9,107	8,180	10,611
November	8,054	9,873	9,743	8,568	10,914
December	8,014	10,081	10,506	9,206	10,940

Table 37.—Month-end stocks of anthracite at oven-coke plants in the United States

(Thousand short tons)

Month	1963	1964	1965	1966	1967
January	99	82	104	121	127
February	73	67	82	95	103
March	51	42	69	79	83
April	45	37	59	79	86
May	40	43	68	82	90
June	56	59	87	85	101
July	58	60	96	72	106
August	72	68	97	73	129
September	87	83	105	77	136
October	110	103	114	108	151
November	121	133	125	128	149
December	114	129	134	135	157

Table 38.—Coal-chemical materials, exclusive of breeze, produced at oven-coke plants in the United States in 1967 [1] [2]

Product	Produced	Sold: Quantity	Sold: Value: Total (thousands)	Sold: Value: Average per unit	On hand Dec. 31
Tar, crude thousand gallons	780,334	[3] 354,674	$33,686	$0.095	48,564
Tar derivatives:					
Sodium phenolate or carbolate do	3,241	3,192	323	.101	174
Crude chemical oil (tar acid oil) do	28,089	27,566	4,514	.164	1,072
Pitch-of-tar:[4]					
Soft thousand short tons	660	183	4,891	26.666	16
Hard do	340	105	3,971	37.717	60
Other tar derivatives:[5]	--------	-------	14,322	------	------
Ammonia products:					
Sulfate thousand short tons	738	687	18,469	26.867	152
Liquor (NH_3 content) do	14	12	683	56.685	2
Diammonium phosphate do	41	42	4,110	98.864	3
Total	--------	-------	23,262	------	------
Sulfate equivalent of all forms thousand short tons	834	776	-------	------	165
NH_3 equivalent of all forms do	215	200	-------	------	43
Gas:					
Used under boilers, etc. million cubic feet	[6] 959,359	100,069	19,330	.193	------
Used in steel or allied plants do		399,662	94,657	.237	------
Distributed through city mains do		20,039	8,559	.427	------
Sold for industrial use do		86,274	15,732	.182	------
Total do	959,359	606,044	138,279	.228	------
Crude light oil thousand gallons	[7] 252,138	94,504	13,229	.140	8,496
Light-oil derivatives:					
Benzene:					
Specification grades (1°, 2°, 90%) do	86,683	84,231	20,293	.241	7,120
Other industrial grades do	3,959	3,938	648	.165	92
Toluene (all grades) do	19,358	18,620	3,694	.198	1,646
Xylene (all grades) do	5,488	5,763	1,646	.286	482
Solvent naphtha (all grades) do	3,633	2,558	411	.161	591
Other light-oil derivatives do	8,397	2,068	239	.115	386
Total do	127,517	117,178	26,930	.230	10,317
Intermediate light oil do	5,558	1,566	127	.081	298
Grand total	--------	-------	263,534	------	------

[1] Data may not add exactly to totals shown due to independent rounding.
[2] Includes products of tar distillation conducted by oven-coke operators under the same corporate name.
[3] Includes 29,018,000 gallons sold to affiliated companies for refining and a small amount exported.
[4] 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.
[5] Creosote oil, cresols, cresylic acid, naphthalene, phenol, pyridine, refined tar, tar paint.
[6] Includes gas used for heating ovens and gas wasted.
[7] 153,871,000 gallons refined by coke-oven operators to make derived products shown.

Table 39.—Coal equivalent of the thermal materials, except coke, produced at oven-coke plants in the United States

Year	Materials produced: Coke breeze (thousand short tons)	Materials produced: Surplus gas (billion cubic feet)	Materials produced: Tar (thousand gallons)	Materials produced: Light oil (thousand gallons)	Estimated equivalent in heating value [1] (billion Btu): Coke breeze	Surplus gas	Tar	Light oil	Total	Coke equivalent (thousand short tons)
1964	3,902	582	762,918	248,669	78,040	320,100	114,438	32,327	544,905	20,798
1965	4,037	630	802,738	262,701	80,740	346,500	120,411	34,151	581,802	22,206
1966	4,012	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

[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 40.—Average value of coal-chemical materials used or sold and of coke and breeze produced per short ton of coal carbonized in the United States

	1964	1965	1966	1967
Ammonia products	$0.275	$0.268	$0.280	$0.254
Light oil and its derivatives	.459	.505	.481	.441
Surplus gas used or sold	1.516	1.556	1.522	1.512
Tar and its derivatives (including naphthalene):				
Tar burned by producers [1]	.381	.362	.328	.318
Sold	.705	.672	.677	.675
Total	3.336	3.363	3.288	3.200
Coke produced	12.426	11.890	12.167	12.152
Breeze produced	.303	.301	.292	.318
Grand total	16.065	15.554	15.747	15.670

[1] Includes pitch-of-tar.

Table 41.—Percentage of coal costs recovered from the recovery of coal-chemical materials in the United States

	1964	1965	1966	1967
Product:				
Ammonia products	3.0	2.8	2.9	2.5
Light oil and its derivatives	4.9	5.3	4.9	4.4
Surplus gas used or sold	16.3	16.4	15.6	15.1
Tar and its derivatives used or sold (including naphthalene)	11.7	11.0	10.3	11.4
Total	35.9	35.5	33.7	33.4
Value of coal per short ton	$9.28	$9.51	$9.78	$10.02

Table 42.—Production and disposal of coke-oven gas in the United States in 1967, by States[1]

(Million cubic feet)

State	Produced		Used in heating ovens	Surplus used or sold			Wasted
	Total	Thousand cubic feet per ton of coal coked		Quantity	Value		
					Thousand dollars	Average per thousand cubic feet	
Alabama	75,392	9,69	34,317	39,541	$5,792	$0.146	1,534
California, Colorado, Utah	54,607	10.68	17,999	36,305	5,906	.163	304
Connecticut, Maryland, New Jersey, New York	131,844	10.84	41,058	89,276	35,130	.393	1,510
Illinois	34,781	10.16	10,770	22,349	3,824	.171	1,662
Indiana	125,265	10.55	36,858	88,172	16,322	.185	235
Kentucky, Missouri, Tennessee, Texas	24,921	9.02	12,574	11,701	1,502	.128	646
Michigan	44,951	10.00	9,354	35,508	8,010	.226	89
Minnesota and Wisconsin	11,974	9.44	6,350	5,492	829	.151	132
Ohio	116,757	10.14	43,545	72,046	17,255	.240	1,166
Pennsylvania	284,680	10.85	114,004	167,471	34,337	.205	3,206
West Virginia	54,186	11.33	14,925	38,184	9,370	.245	1,077
Total 1967	959,359	10.49	341,753	606,044	138,279	.228	11,561
At merchant plants	74,273	8.59	35,714	37,595	10,395	.277	964
At furnace plants	885,086	10.69	306,039	568,449	127,883	.225	10,597
Total 1966	989,805	10.53	347,041	629,565	143,140	.227	13,199

[1] Data may not add exactly to totals shown due to independent rounding.

Table 43.—Surplus coke-oven gas used by producers in the United States and sold in 1967, by States [1]

(Million cubic feet)

State	Used by producers					
	Under boilers, etc.			In steel or allied plants		
	Quantity	Value		Quantity	Value	
		Thousand dollars	Average per thousand cubic feet		Thousand dollars	Average per thousand cubic feet
Alabama	15,776	$2,320	$0.147	19,715	$3,000	$0.152
California, Colorado, Utah	(2)	(2)	(2)	(2)	(2)	(2)
Connecticut, Maryland, New Jersey, New York	3,182	682	.214	71,177	27,097	.381
Illinois	4,121	594	.144	13,225	2,451	.185
Indiana	6,922	1,316	.190	78,540	13,912	.177
Kentucky, Missouri, Tennessee, Texas	4,947	542	.110	(2)	(2)	(2)
Michigan	(2)	(2)	(2)	(2)	(2)	(2)
Minnesota and Wisconsin	(2)	(2)	(2)	(2)	(2)	(2)
Ohio	12,897	3,424	.265	52,363	12,705	.243
Pennsylvania	24,019	4,760	.198	78,193	17,225	.220
West Virginia	(2)	(2)	(2)	(2)	(2)	(2)
Undistributed	28,205	5,693	.202	86,449	18,268	.211
Total 1967	100,069	19,330	.193	399,662	94,657	.237
At merchant plants	10,315	1,778	.172	1,103	274	.248
At furnace plants	89,753	17,552	.196	398,559	94,383	.237
Total 1966	102,975	19,631	.191	480,452	110,393	.230

State	Sold					
	Distributed through city mains			For industrial use		
	Quantity	Value		Quantity	Value	
		Thousand dollars	Average per thousand cubic feet		Thousand dollars	Average per thousand cubic feet
Alabama	(2)	(2)	(2)	2,422	$362	$0.150
California, Colorado, Utah	-------	-------	-------	-------	-------	-------
Connecticut, Maryland, New Jersey, New York	14,848	7,336	$0.494	(2)	(2)	(2)
Illinois	-------	-------	-------	(2)	(2)	(2)
Indiana	(2)	(2)	(2)	(2)	(2)	(2)
Kentucky, Missouri, Tennessee, Texas	-------	-------	-------	(2)	(2)	(2)
Michigan	-------	-------	-------	(2)	(2)	(2)
Minnesota and Wisconsin	-------	-------	-------	(2)	(2)	(2)
Ohio	-------	-------	-------	6,786	1,126	.166
Pennsylvania	(2)	(2)	(2)	(2)	(2)	(2)
West Virginia	-------	-------	-------	(2)	(2)	(2)
Undistributed	5,191	1,223	.236	77,065	14,244	.185
Total 1967	20,039	8,559	.427	86,274	15,732	.182
At merchant plants	13,597	6,227	.458	12,579	2,116	.168
At furnace plants	6,442	2,332	.362	73,694	13,616	.185
Total 1966	20,872	8,933	.428	25,266	4,183	.166

[1] Data may not add exactly to totals shown due to independent rounding.
[2] Included with Undistributed to avoid disclosing individual company confidential data.

Table 44.—Coke-oven gas and other gases used in heating coke ovens in the United States in 1967, by States [1] [2]

(Million cubic feet)

State	Coke-oven gas	Blast-furnace gas	Natural gas	Total coke-oven gas equivalent
Alabama	34,317	---------	9	34,326
California, Colorado, Utah	17,999	3,591	43	21,633
Connecticut, Maryland, New Jersey, New York	41,058	[3] 12,830	1,198	55,086
Illinois	10,770	12,509	---------	23,279
Indiana	36,858	7,503	954	45,315
Kentucky, Missouri, Tennessee, Texas	12,574	---------	---------	12,574
Michigan	9,354	12,422	61	21,837
Minnesota and Wisconsin	6,350	---------	---------	6,350
Ohio	43,545	4,552	---------	48,097
Pennsylvania	114,004	1,994	---------	115,998
West Virginia	14,925	6,266	---------	21,191
Total 1967	341,753	61,667	2,265	405,685
At merchant plants	35,714	1,239	557	37,510
At furnace plants	306,039	60,428	1,708	368,175
Total 1966	347,041	57,884	1,212	406,137

[1] Adjusted to an equivalent of 550 Btu per cubic foot
[2] Data may not add exactly to totals shown due to independent rounding.
[3] Includes small amount of producer gas

Table 45.—Coke-oven ammonia produced in the United States and sold in 1967, by State [1]

(Thousand short tons)

State	Active plants [2]	Produced: Sulfate equivalent	Produced: Pounds per ton of coal coked	Produced: As sulfate [3]	Produced: As liquor (NH_3 content)
Alabama	7	76	19.64	74	(4)
California, Colorado, Utah	3	57	22.11	52	(4)
Connecticut, Maryland, New Jersey, New York	5	111	19.14	103	(4)
Illinois	4	32	19.09	32	------
Indiana	5	125	21.12	116	(4)
Kentucky Tennessee, Texas	3	17	15.88	(4)	(4)
Michigan	3	28	12.24	23	(4)
Minnesota and Wisconsin	2	7	13.37	(4)	(4)
Ohio	11	95	17.36	84	(4)
Pennsylvania	12	243	18.51	243	------
West Virginia	3	44	18.59	44	------
Undistributed	----	------	-------	8	14
Total 1967	58	834	18.68	[5] 778	14
At merchant plants	12	64	17.25	24	10
At furnace plants	46	770	18.81	755	4
Total 1966	58	862	18.79	810	14

State	Sold [6]: As sulfate [3] Quantity	Sold: As sulfate Value	Sold: As liquor (NH_3 content) Quantity	Sold: As liquor Value	On hand Dec. 31: Sulfate [3]	On hand Dec. 31: Liquor (NH_3 content)
Alabama	69	$1,920	(4)	(4)	17	(7)
California, Colorado, Utah	52	3,581	(4)	(4)	7	(7)
Connecticut, Maryland, New Jersey, New York	99	2,765	(4)	(4)	15	(7)
Illinois	27	785	------	------	7	------
Indiana	104	2,956	(4)	(4)	21	1
Kentucky, Tennessee, Texas	(4)	(4)	(4)	(4)	1	(7)
Michigan	(4)	(4)	(4)	(4)	7	(7)
Minnesota and Wisconsin	(4)	(4)	(4)	(4)	(7)	(7)
Ohio	78	2,116	(4)	(4)	19	1
Pennsylvania	229	5,644	------	------	54	------
West Virginia	40	992	------	------	6	------
Undistributed	31	1,821	12	683	------	------
Total 1967	[8] 729	22,579	12	683	156	2
At merchant plants	24	667	8	563	5	2
At furnace plants	705	21,912	4	120	150	1
Total 1966	866	25,548	12	748	107	2

[1] Data may not add exactly to totals shown due to independent rounding.
[2] Number of plants that recovered ammonia.
[3] Includes diammonium phosphate.
[4] Includes with "Undistributed" to avoid discling individual company confidential data.
[5] Comprises 738,000 tons of ammonium sulfate and 41,000 tons of diammonium phosphate disclosing produced in California, Colorado, and Michigan.
[6] Includes 86,000 tons of ammonium sulfate valued at $2,122,000 exported.
[7] Less than ½ unit.
[8] Comprises 687,000 tons of ammonium sufate valued at $18,469,000 and 42,000 tons of diammonium phosphate valued at $4,110,000.

Table 46.—Coke-oven tar produced in the United States, used by producers, and sold in 1967, by States [1]

(Thousand gallons)

State	Produced		Used by producers			Sold for refining into tar products [3]			On hand Dec. 31
	Total	Gallons per ton of coal coked	For refining or topping	As fuel	Otherwise	Quantity	Value: Thousand dollars	Value: Average per gallon	
Alabama	56,313	7.24	[2]	--------	--------	35,429	$3,611	$0.102	6,291
California, Colorado, Utah	49,230	9.63	[2]	[2]	[2]	30,838	2,832	.092	3,512
Connecticut, Maryland, New Jersey, New York	108,032	8.88	[2]	[2]	--------	24,567	2,346	.095	5,036
Illinois	23,282	6.80	--------	--------	--------	23,900	2,235	.094	957
Indiana	100,530	8.47	[2]	[2]	--------	40,828	3,711	.091	4,140
Kentucky, Missouri, Tennessee, Texas	17,876	6.47	--------	--------	[2]	17,701	1,841	.104	524
Michigan	31,129	6.92	--------	[2]	[2]	23,550	2,176	.092	2,175
Minnesota and Wisconsin	7,357	5.80	--------	--------	[2]	7,618	726	.095	434
Ohio	104,183	9.04	[2]	49,704	1,513	50,620	4,872	.096	9,464
Pennsylvania	234,286	8.93	117,189	42,076	829	73,642	7,164	.097	14,684
West Virginia	48,118	10.06	[2]	--------	--------	25,982	2,173	.084	1,346
Undistributed	-------	-------	174,435	37,229	126	--------	--------	--------	--------
Total 1967	780,334	8.53	291,624	129,009	2,468	354,674	33,686	.095	48,564
At merchant plants	50,603	5.85	581	--------	--------	50,563	4,865	.096	1,479
At furnace plants	729,732	8.82	291,043	129,009	2,468	304,111	28,822	.095	47,085
Total 1966	801,867	8.53	302,873	131,890	2,192	361,272	34,593	.096	43,790

[1] Data may not add exactly to totals shown due to independent rounding.
[2] Included with "Undistributed" to avoid disclosing individual company confidential data.
[3] Comprises 29,018,000 gallons valued at $2,787,000 sold to affiliated companies and 325,656,000 gallons valued at $30,899,000 sold to other purchasers. Also includes small amount exported.

Table 47.—Coke-oven crude light-oil produced in the United States and derived products produced and sold in 1967, by State

(Thousand gallons)

State	Active plants [1]	Crude light oil				Derived products		
		Pro-duced	Gallons per ton of coal coked	Refined on prem-ises [2]	On hand Dec. 31	Pro-duced	Sold [3]	
							Quan-tity	Value (thou-sands)
Alabama	7	18,169	2.33	17,847	888	14,290	12,950	$2,961
California, Colorado, Utah	3	16,694	3.26	10,561	594	14,693	9,976	2,067
Connecticut, Maryland, New Jersey, New York	6	36,947	3.04	23,909	995	19,817	18,249	4,692
Illinois and Michigan	7	20,177	2.58	1,997	525	(4)	(4)	(4)
Indiana	4	31,123	2.75	406	1,865	(4)	(4)	(4)
Kentucky, Missouri, Tennessee, Texas, West Virginia	7	21,754	3.00	2,451	751	2,412	2,407	446
Ohio	11	30,519	2.70	20,316	1,110	16,036	15,193	3,195
Pennsylvania	11	76,755	2.93	76,384	1,877	60,271	58,403	13,570
Total 1967	56	252,138	2.84	153,871	8,496	127,517	117,178	26,930
At merchant plants	3	14,651	2.17	9,116	1,101	9,815	8,551	2,259
At furnace plants	53	237,487	2.89	144,755	7,386	117,702	108,627	24,672
Total 1966	59	262,640	2.86	179,757	7,796	r 152,740	r 147,173	r 33,872

r Revised.
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 38.
3 Excludes 94,504,000 gallons of crude light oil valued at $13,229,000 sold as such.
4 Included with California, Colorado, Utah to avoid disclosing individual company confidential data.

Table 48.—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
1964	62.3	13.3	3.7	2.3	4.3
1965	63.0	12.8	3.5	2.8	4.1
1966	63.4	12.7	3.4	1.8	3.5
1967	58.9	12.6	3.6	2.4	5.4

1 Included with "Solvent naphtha (crude and refined)."

Table 49.—Benzene and toluene produced at oven-coke plants in the United States, by grade

(Thousand gallons)

Year	Benzene		Toluene (all grades)
	Specification grades (1°, 2°, 90%)	Other industrial grades	
1964	116,292	3,516	25,521
1965	117,991	3,927	24,816
1966	110,223	3,709	22,791
1967	86,683	3,959	19,358

Table 50.—Light-oil derivatives produced at oven-coke plants in the United States and sold in 1967, by States [1]

(Thousand gallons)

State	Benzene (all grades)				Toluene (all grades)			
	Produced	Yield from crude light oil refined (percent)	Sold: Thousand short tons	Sold: Thousand dollars	Produced	Yield from crude light oil refined (percent)	Sold: Thousand short tons	Sold: Thousand dollars
Alabama	11,085	62.1	10,057	$2,413	2,022	11.3	1,705	$329
Colorado, Michigan, Utah	6,419	60.8	6,185	1,238	1,499	14.2	1,479	306
Illinois, Indiana, Ohio	12,851	56.6	12,577	2,740	3,240	14.3	3,188	637
Maryland and New York	16,224	67.9	15,461	3,734	2,089	8.7	2,026	395
Pennsylvania	42,451	55.6	42,269	10,465	10,281	13.5	9,993	1,988
Tennessee, Texas, West Virginia	1,611	65.7	1,619	351	227	9.3	229	40
Total 1967	90,642	58.9	88,169	20,941	19,358	12.6	18,620	3,694
At merchant plants	6,841	75.0	6,566	1,460	1,580	17.3	1,497	296
At furnace plants	83,801	57.9	81,603	19,481	17,777	12.3	17,123	3,398
Total 1966	113,932	63.4	112,095	27,333	22,791	12.7	22,622	4,309

State	Xylene (all grades)				Solvent naphtha (crude and refined)			
	Produced	Yield from crude light oil refined (percent)	Sold: Thousand short tons	Sold: Thousand dollars	Produced	Yield from crude light oil refined (percent)	Sold: Thousand short tons	Sold: Thousand dollars
Alabama	605	3.4	728	$168	118	0.7	112	$18
Colorado, Michigan, Utah	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Illinois, Indiana, Ohio	1,161	3.5	1,179	263	1,617	3.4	552	76
Maryland and New York	(3)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
Pennsylvania	3,570	3.6	3,719	1,189	1,898	2.1	1,894	317
Tennessee, Texas, West Virginia	152	6.2	137	26	(3)	(3)	(3)	(3)
Total 1967	5,488	3.6	5,763	1,646	3,633	2.4	2,558	411
At merchant plants	346	3.8	320	481	37	0.4	25	7
At furnace plants	5,142	3.6	5,443	1,165	3,596	2.5	2,533	404
Total 1966	6,124	3.4	6,410	1,405	3,161	1.8	2,954	547

[1] Data may not add exactly to totals shown due to independent rounding.
[2] Included with Illinois, Indiana, and Ohio to avoid disclosing individual company data.
[3] Included with Pennsylvania to avoid disclosing individual company data.

Table 51. Estimated consumption of commercial benzene (excluding motor grade) in the United States, by uses [1]

(Thousand gallons)

Use	1964	1965	1966 r	1967
Styrene	283,000	312,000	360,000	366,000
Phenol (synthetic)	146,000	161,000	178,000	171,000
Dodecylbenzene	31,000	34,000	42,000	48,000
Cyclohexane	117,000	160,000	184,000	160,000
Aniline	21,000	24,000	29,000	27,000
DDT	12,000	14,000	14,000	10,000
Dichlorobenzene and monochlorobenzene	20,000	20,000	20,000	20,000
Maleic anhydride	20,000	22,000	28,000	31,000
Diphenyls	5,000	5,000	5,000	5,000
Nitrobenzene	2,000	2,000	2,000	2,000
Miscellaneous	20,000	20,000	20,000	27,000
Exported	87,000	45,000	97,000	100,000
Total	764,000	819,000	979,000	967,000

r Revised.
[1] Coal Chemicals Committee, American Coke and Coal Chemicals Institute, Washington, D.C.

Columbium and Tantalum

By Richard F. Stevens, Jr.[1]

Consumption of columbium and tantaum raw materials continued to increase during 1967 and end-use consumption of columbium and tantalum reached new alltime record highs. The primary use of columbium in the form of ferrocolumbium increased 18 percent although steel production decreased from its record high set in 1966. The use of tantalum continued to be primarily in capacitors and other electronic applications required by the military in the Viet Nam conflict. About 1.5 million pounds of combined pentoxides ($Cb_2O_5+Ta_2O_5$) containing some 800,000 pounds of columbium was released from government stockpiles in 1967 compared with releases of approximately twice these amounts made in 1966.

Legislation and Government Programs.—On January 13, 1966, the General Services Administration (GSA) announced a plan for the disposal of about 5 million pounds (columbium content) of columbium concentrate from the Defense Production Act Inventory over several years. Five releases were made in 1966 and three releases were made in 1967. Although classified as columbite (Cb_2O_5), the material is actually columbite-tantalite (Cb_2O_5–Ta_2O_5) and much of it was purchased for its tantalum content. The Cb_2O_5 to Ta_2O_5 ratio of the material sold varied from about 47 to 1 to about 0.95 to 1. Material purchased for its columbium content sold at an average price of between $0.97 and $1.20 per pound of contained pentoxides while material purchased primarily for its tantalum content ranged in price from about $2 to $6 per pound of contained pentoxides.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient columbium statistics

(Thousand pounds)

	1963	1964	1965	1966	1967
United States:					
Mine production of columbite-tantalite concentrates	-----	------	------	W	W
Releases from Government stocks (Cb content)[1]	-----	------	------	1,659	779
Consumption of concentrate: Columbium metal contained in all raw materials consumed (Cb content)[1]	2,054	2,758	2,749	3,873	4,366
Production of primary products: Columbium metal (Cb content)	104	95	W	W	W
Ferrocolumbium and ferrotantalum-columbium (Cb+Ta content)	1,576	820	1,961	3,664	1,960
Consumption of primary products:					
Columbium metal (Cb content)	NA	124	33	100	111
Ferrocolumbium and ferrotantalum-columbium (Cb+Ta content)	1,346	1,479	2,199	2,697	3,192
Exports:					
Columbium ore and concentrate (gross weight)	47	343	NA	NA	NA
Columbium metal, compounds and alloys (gross weight)	14	5	4	7	6
Imports for consumption:					
Columbium mineral concentrate (gross weight)	5,910	4,601	4,892	9,278	7,431
Columbium metal and columbium-bearing alloys (Cb content)	1	4	10	4	(²)
Ferrocolumbium (gross weight)[e]	NA	172	691	1,280	629
World: Production of columbium-tantalum concentrates (gross weight)	9,853	11,726	14,618	22,988	20,801

[e] Estimate. [r] Revised. W Withheld to avoid disclosing individual company confidential information.
NA Not available.
[1] Includes columbium content in raw materials from which columbium is not recovered.
[2] Less than ½ unit.

Table 2.—Salient tantalum statistics

(Thousand pounds)

	1963	1964	1965	1966	1967
United States:					
Mine production of columbium-tantalum concentrates	-----	------	------	W	W
Releases from Government stocks (Ta content)[1]	-----	------	------	634	307
Consumption of concentrate: Tantalum metal contained in all raw materials consumed (Ta content)[1]	502	510	775	r 1,392	1,730
Production of primary products:					
Tantalum metal (Ta content)	418	448	712	1,064	1,021
Ferrocolumbium and ferrotantalum-columbium (Cb+Ta content)	1,576	820	1,961	3,664	1,960
Consumption of primary products:					
Tantalum metal (Ta content)	NA	214	435	493	443
Ferrocolumbium and ferrotantalum-columbium (Cb+Ta content)	1,346	1,479	2,199	2,697	3,192
Exports:					
Tantalum ore and concentrate (gross weight)	56	200	284	163	75
Tantalum metal, compounds, and alloys (gross weight)	44	32	21	35	59
Tantalum and tantalum alloy powder (Ta content)	14	32	25	51	157
Imports for consumption:					
Tantalum mineral concentrate (gross weight)	944	981	1,196	2,143	1,675
Tantalum metal and tantalum-bearing alloys (Ta content)	2	3	26	48	55
World: Production of columbium-tantalum concentrates (gross weight)	9,853	11,726	14,618	22,988	20,801

r Revised.
W Withheld to avoid disclosing individual company confidential data.
NA Not available.
[1] Includes tantalum content in raw materials from which tantalum is not recovered.

Table 3.—Columbium materials in Government inventories as of December 31, 1967

(Thousand pounds, columbium content)

Material	Objective	National (strategic) stockpile	Defense Production Act (DPA) inventory	Supplemental stockpile	Total
Columbium concentrates:	-----	[1] 6,247	5,557	376	12,180
Columbium carbide powder:					
Stockpile grade	20	21	---------	---------	21
Ferrocolumbium:					
Stockpile grade	930	368	---------	---------	368
Nonstockpile grade	-----	553	---------	---------	553
Columbium metal:					
Stockpile grade	45	33	---------	---------	33
On order-upgrading [2]	-----	11	---------	---------	11
Columbium oxide powder:					
Stockpile grade	-----	23	---------	---------	23
On order-upgrading [2]	-----	90	---------	---------	90

[1] Includes 83,437 pounds columbium content, reserved for upgrading.
[2] Material on order is to be acquired through upgrading contracts.

Table 4.—Tantalum materials in Government inventories as of December 31, 1967

(Thousand pounds, tantalum content)

Material	Objective	National (strategic) stockpile	Defense Production Act (DPA) inventory	Supplemental stockpile	Total
Tantalum minerals:					
Stockpile grade	2,947	[1] 2,968	849	2	3,819
Tantalum carbide powder:					
Stockpile grade	27	29	--------	---------	29
Tantalum metal:					
Stockpile grade	360	116	--------	---------	116
On order-upgrading [2]	-------	85	--------	---------	85

[1] Includes 111,611 pounds, tantalum content, reserved for upgrading.
[2] Material on order is to be acquired through upgrading contracts.

DOMESTIC PRODUCTION

Two small companies, one in South Dakota and the other in New Mexico, produced columbium-tantalum concentrates during the year. Output increased by a factor of about 30 over that of 1966. Most of the 1967 output and all of the 1966 output remained in mine stocks at yearend.

Production of columbium metal powder continued to increase, although data are withheld to avoid disclosing individual company confidential data. Production of columbium metal ingots totaled 47 tons in 1967. E. I. du Pont de Nemours & Co., Inc., did not produce columbium metal in either 1966 or 1967 but continued to hold significant stocks of the metal. In 1967 the du Pont Metals Center in Baltimore, Md., was sold to Fansteel Metallurgical Corp.

Production of tantalum metal powder (including capacitor-grade powder) in 1967 decreased 4 percent to 510 tons from the 532 tons reported in 1966. Production of tantalum metal ingots increased 15 percent to 291 tons during the year from the 252 tons reported in 1966.

Ferrocolumbium, ferrotantalum-columbium, and columbium-base master alloys were produced by the thermite process by Kawecki Chemical Co., Reading Alloys Co., and Shieldalloy Corp. These ferroalloys were produced in electric furnaces by Molybdenum Corporation of America, Union Carbide Corp., and by the Vancoram Division of Foote Mineral Co. (formerly Vanadium Corporation of America). Union Carbide Corp. (UCC) continued to produce high-purity ferrocolumbium (FeCb) and nickel-columbium (NiCb) at Niagara Falls from Cb_2O_5 recovered by solvent-extraction at UCC's Marietta, Ohio, plant.

Michigan Chemical Corp., Chicago, Ill., purchased the equipment and leases of the Porter Brothers Corp., Boise, Idaho, in 1966. The dredge and related equipment, including a bunkhouse and a small school building, were maintained on a "standby" basis during 1967.

During the year Kawecki Chemical Co. reportedly began construction of a tin slag recovery and concentrating plant at Reading, Pa., to recover the tantalum from this "synthetic" tantalite source.

A placer deposit of potential significance in the Sawtooth Primitive Area of Idaho was examined by Bureau of Mines engineers and reportedly contains reserves of some 200 million cubic yards of gravel containing values in gold, platnium, euxenite, and columbium-tantalum minerals. The deposit extends approximately 6 miles along the South Fork of the Payette River.

Table 5.—Major domestic columbium and tantalum processing and producing companies in 1967

Company	Location	Columbium	Tantalum	Tantalum carbide	Ferrocolumbium	Ferrotantalum-columbium
Fansteel Metallurgical Corp	Muskogee, Okla	X	X	X	-------	--------
General Electric Co	Euclid, Ohio	X	X	-------	-------	--------
Kawecki Chemical Co	Boyertown, Pa	X	X	X	X	--------
Kennametal, Inc	Latrobe, Pa	X	X	X	-------	--------
Linde Division, Union Carbide Corp.	Indianapolis, Ind	X	X	X	-------	--------
Mallinckrodt Chemical Works	St. Louis, Mo	X	X	X	-------	--------
Mining and Metals Division, Union Carbide Corp.	Niagara Falls, N.Y; Marietta, Ohio	X	X	-------	X	X
Molybdenum Corporation of America.	Washington, Pa	------	-------	-------	X	X
Metals Division, Norton Co. (formerly National Research Corp., a subsidiary of Norton Co.)	Newton, Mass	X	X	-------	-------	--------
Reading Alloys Co., Inc	Robesonia, Pa	------	-------	-------	X	X
Shieldalloy Corp	Newfield, N.J	------	-------	-------	X	X
Stellite Division, Union Carbide Corp.	Kokomo, Ind	X	X	X	-------	--------
Vancoram Division, Foote Mineral Co. (formerly Vanadium Corporation of America).	Cambridge, Ohio; Vancoram, Ohio; Graham, W. Va	------	-------	-------	X	X
Wah Chang Albany (A Teledyne Company).	Albany, Oreg	X	X	-------	-------	--------

CONSUMPTION AND USES

Use of columbium in ferroalloys for additions to steels to control grain size accounted for approximately 85 to 95 percent of the metal consumed. Columbium consumed in the form of high-purity metal totaled 111,195 pounds, an 11-percent increase over the 100,106 pounds reported consumed in 1966. Tantalum metal (including capacitor-grade powder) consumed during the year decreased to 443,095 pounds from the 493,062 pounds reported in 1966 and continued to be used primarily in powder or ingot form in the manufacture of capacitors and other electronic equipment and in corrosion-resistant chemical equipment. About 65 to 75 percent of tantalum consumption was in electronic applications, 20 to 30 percent in the chemical industry, and 5 to 10 percent as carbides.

Total consumption of columbium plus tantalum in ferroalloys rose about 18 percent to a new record high of 3,191,711 pounds in 1967. The consumption of ferrocolumbium (FeCb) and ferrotantalum-columbium (FeTa-Cb) in stainless steels, permanent magnet alloys and gray and malleable castings applications decreased compared with that of 1966 while consumption in other steels, carbon steels, welding rods, nickel-base alloys and miscellaneous applications increased. The consumption of tool steels increased slightly while high-temperature nonferrous alloy usage decreased slightly. The greatest single volume increase in the usage of these ferroalloys was reported in other alloy steels. Domestic consumption of ferrocolumbium during 1967, by major use categories, was as follows: Other alloy steels (44 percent), high-temperature nonferrous alloys (17 percent), carbon steels (15 percent), stainless steels (14 percent), and welding rods, nickel-base alloys, permanent magnet alloys, and tool steels (1 percent). Consumption of ferrotantalum-columbium continued to be small and amounted to only slightly more than 2 percent of the total reported FeCb plus FeTa-Cb consumption (table 6) compared with slightly more than 1 percent of the total 1966 consumption. The major uses of ferrotantalum-columbium in 1967 were in the production of stainless steels (61 percent), nickel-base alloys (5 percent), carbon and alloy steels (5 percent), high-temperature nonferrous alloys (3 percent), and cemented carbides (2 percent).

Additional data on ferrocolumbium and ferrotantalum-columbium are contained in the "Ferroalloy" chapter of the 1967 Minerals Yearbook.

The General Electric Co. announced the development of molds and dies composed of the refractory metal alloys, columbium, tantalum, molybdenum, and tungsten, which allowed satisfactory die-casting of steel and iron.

In addition to the high-purity (99.9 percent) columbium and tantalum oxides and chlorides, the Rare Metals Division of CIBA (A.R.L.) Ltd. has available tantalum and columbium pentachlorides for evaluation and has announced plans to make lithium columbate, potassium tantalate, and potassium columbate available shortly.

Gallard-Schlesinger Manufacturing Corp. commercially offered pentamethoxy and pentaethoxy compounds of columbium and tantalum for use in the preparation of high-purity metal powder, dielectric films, coatings, and catalysts.

Randomly or specifically oriented tantalum single crystals of 99.999 percent purity were commercially available from Materials Research Corp. in sizes up to ½ inch in diameter by 3 inches long for $200 per inch. Produced by electron-beam floating-zone refining techniques, these tantalum crystals are believed to have the highest purities available to date.

Tantalum-clad copper bayonet heaters developed by National Research Corp. for use in acid concentrators combine the chemical corrosion resistance of tantalum with the strength and the electrical and heat conductivity of copper.

Fansteel Metallurgical Corp. has successfully produced the widest sheet (42 inches) of tantalum that has ever been rolled in coil form. Virtually any thickness of tantalum sheet can be rolled by this process. At its plant in Torrance, Calif., the firm developed a method of explosive-cladding tantalum on steel for use in chemical reactor vessels to replace glass-coated steel. Fansteel has also developed and made commercially available new tantalum powder which allows the fabrication of superior, but less costly, capacitors at low sintering temperatures.

Designated FD powder, this material is available in both anode and bulk powder form.

A copper-nickel casting alloy modified with columbium additions has been developed which offers excellent corrosion resistance and enhanced weldability for applications in the marine, aerospace, chemical food handling, and petroleum industries.

During 1966, the General Electric Co. completed the construction of a second-generation pilot plant in Philadelphia, Pa., to electroform and electroclad tantalum coatings for nuclear fuel elements.

Two detailed reports on ferroalloys and a comprehensive columbium-tantalum market guide were published which discussed the use of columbium and tantalum in alloy steels, and included a directory of free world companies in the columbium and tantalum industry, their products, programs, and capacities.[2]

[2] Metal Bulletin (London). Ferro-Alloys, A Metal Bulletin Special Issue. July 1966, 158 pp.
Metals Week. Ferro Alloys—Review and Outlook. V. 38, No. 7, Feb. 13, 1967, pp. 13–36.
———. Columbium-Tantalum Market Guide. V. 38, No. 17, Apr. 24, 1967, pp. 21–39.

Table 6.—Consumption by end uses of ferrocolumbium and ferrotantalum-columbium in the United States

(Pounds of contained columbium plus tantalum)

Product	1965	1966	1967
Stainless steels	601,247	567,307	437,116
Other alloy steels	974,999	1,181,467	1,400,805
Carbon steels	265,545	362,114	491,460
Tool steels [1]	1,268	6,013	6,053
Welding rods [2]	11,492	10,813	12,654
Gray and malleable castings	158	857	[e] 300
High-temperature nonferrous alloys	313,043	537,370	536,572
Permanent-magnet alloys	5,222	4,512	[e] 1,700
Nickel-base alloys	11,468	16,684	12,965
Miscellaneous [3]	14,302	9,666	13,662
Unspecified	---------	-----------	278,424
Total	2,198,744	2,696,803	3,191,711

[e] Estimate.
[1] Includes high-speed steel.
[2] Includes hard facing alloys and cutting and wear resistant alloys.
[3] Includes electrical resistance alloys, premixed powders, cemented carbides, capacitors, flame plating high-nickel chromium alloy coatings, metal-to-glass seal materials, and unspecified alloy powders.

STOCKS

Except for pyrochlore stocks which decreased 42 percent, consumer and dealer stocks increased from 11 to 39 percent as consumers built up their inventories which at yearend 1966 and 1967 totaled as follows: (in short tons)—1966 figures in parenthesis: Columbite, 1,298 (936); tantalite, 1,819 (1,640); pyrochlore, 433 (749); and tin slag, 32,852 (26,461).

In addition the following yearend columbium and tantalum inventories (given in pounds) were reported.

Material	*December 31, 1966*	*December 31, 1967*
Columbium:		
Primary metal	37,450	63,873
Ingot	35,728	46,658
Scrap	73,003	35,723
Oxide	431,546	597,438
Other compounds	33,938	24,703

Material	*December 31, 1966*	*December 31, 1967*
Tantalum:		
Primary metal	103,195	111,071
Capacitor-grade powder	88,492	139,829
Ingot	42,597	136,286
Scrap	178,292	152,292
Oxide	26,784	156,724
Potassium tantalum fluoride (K_2TaF_7)	123,865	268,630
Other compounds	28,720	56,440

Consumer inventories of ferrocolumbium and ferrotantalum-columbium as of December 31, 1967, (with 1966 yearend stocks in parenthesis), were as follows: Ferrocolumbium, 681,778 pounds contained columbium plus tantalum (Cb

+Ta) (799,991); and ferrotantalum-columbium, 21,117 pounds contained Cb+Ta (13,502). Producer stocks of ferrocolumbium at yearend 1967 were 682,000 pounds contained Cb (560,000); producer stocks of ferrotantalum-columbium were withheld to avoid disclosing individual company confidential data.

PRICES

Spot prices for columbite ore, c.i.f. U.S. ports, as reported by Metals Week decreased from $1.05 to $1.15 per pound of contained pentoxides for material having a Cb_2O_5 to Ta_2O_5 ratio of 10:1 at the beginning of the year to $0.90 per pound at yearend. Long-term prices of this material were quoted at $1.03 and material having a ratio of 8.5:1 was quoted at $1.20 (nominal) per pound of contained pentoxides at the beginning of the year. By yearend, these price quotations were discontinued. During 1967 the quoted spot prices for Canadian pyrochlore fell from $1.18 to $1.25 per pound Cb_2O_5, f.o.b. mine or mill, to $1.02 to $1.07. The quoted long-term price decreased from $1.12–$1.15 to $0.95. During the year long-term price quotations for Brazilian phyrochlore dropped from $1.00 to $0.955 per pound of Cb_2O_5, c.i.f. U.S. ports. The price for tantalite ores during 1967, 60 percent basis, c.i.f. U.S. ports, fell from the 1966 high of about $13 per pound to approximately $9.50 to $11 per pound of contained pentoxides having a Ta_2O_5 to Cb_2O_5 ratio of 3:1. The price quotations for various grades of ferrocolumbium per pound of columbium content, ton lots, f.o.b. shipping point, at the beginning of the year were as follows: Low alloy grade, $2.80 to $3.02; standard grade, $3.17 to $3.24; and high purity, $3.82 to $4.50. Quotations for both low alloy grade and standard grade fell to $2.45 to $2.60 at yearend while the quoted price for the high-purity grade remained constant throughout the year.

Through January, tantalum metal was quoted at $30 to $49 per pound for powder, $47 to $60 per pound for roundels, and $52 to $65 per pound for rod. In February these prices were quoted at $32 to $46, $36 to $60, and $40 to $52 respectively, where they remained throughout the remainder of 1967.

Throughout the year, columbium-powder, roundels, 99.5 to 99.8 percent purity, was quoted at $11 to $22 per pound for metallurgical-grade material and at $12 to $23 per pound for reactor grade material. During this period, 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 1967 by country of origin

(Percent of contained pentoxides)

Country	Columbite			Tantalite	
	Cb_2O_5	Ta_2O_5	Ratio	Ta_2O_5	Cb_2O_5
Australia	----	--------	--------	47	20
Brazil [1]	55	0.10	550:1	38	31
Canada [2]	51	.72	71:1	------	--------
Congo (Kinshasa)	38	35	1.1:1	37	33
Malaysia	56	16	3.5:1	26	50
Mozambique	62	7.5	8.3:1	60	14
Nigeria	67	7	9.6:1	38	32
Portugal	37	31	1.2:1	35	30
Rhodesia, Southern	----	--------	--------	30	27
South Africa, Republic of	69	12	5.8:1	65	8
Spain	35	32	1.1:1	31	31
Thailand	----	--------	--------	38	21
Uganda	60	15	4.0:1	53	20

[1] Material reported from Brazil as columbite represents primarily pyrochlore.
[2] Pyrochlore concentrate.

FOREIGN TRADE

Most columbium and tantalum exports during 1967 (table 8) were destined chiefly for India, Japan, and Eastern Europe. The largest item, tantalum metal and alloy powder, was exported primarily to India (68 percent), the United Kingdom (9 percent), Italy (6 percent), West Germany (5 percent), France (4 percent), and Japan and the Netherlands (3 percent each). Tantalum ore and concentrate, believed not to be of domestic origin, was exported to Japan (49 percent), Czechoslovakia (44 percent), France (4 percent), and Canada (3 percent).

Table 8.—U.S. exports of columbium and tantalum, by classes

(Thousand pounds (gross weight) and thousand dollars)

Class	1966		1967	
	Quantity	Value	Quantity	Value
Columbium and columbium alloys unwrought and waste and scrap	4	$93	2	$57
Columbium and columbium alloys, wrought	3	156	4	284
Tantalum ores and concentrates	163	453	75	224
Tantalum and tantalum alloys, wrought	13	1,096	10	704
Tantalum metals and alloys in crude form and scrap	22	249	49	796
Tantalum and tantalum alloy powder	51	1,564	157	1,839

Imports for consumption of unwrought columbium metal decreased slightly to 437 pounds from the 453 pounds reported in 1966. Imports of unwrought columbium alloys in 1967 were reported to total only 14 pounds, columbium content, all from France, and were valued at $47.71 per pound. This represented a significant change from the 3,978 pounds valued at $6,533 ($1.64 per pound) reported in 1966. Imports for consumption of unwrought tantalum metal, including waste and scrap, continued to increase during the year to 54,887 pounds from the 47,507 pounds reported in 1966 and the 26,162 pounds reported in 1965. In 1967 this material was imported primarily from the Netherlands (33 percent), Switzerland (31 percent), the United Kingdom (12 percent), France (8 percent), Belgium-Luxembourg (7 percent), and West Germany (5 percent). In addtion, 102 pounds of unwrought tantalum alloy was imported from West Germany and 32 pounds of wrought tantalum metal was imported from the United Kingdom in 1967 compared with the corresponding figures of 10 pounds and 231 pounds reported in 1966.

Table 9.—Receipts of microlite and tin slags reported by consumers

(Thousand pounds)

Material	1965			1966			1967		
	Gross weight	Cb_2O_5 content	Ta_2O_5 content	Gross weight	Cb_2O_5 content	Ta_2O_5 content	Gross weight	Cb_2O_5 content	Ta_2O_5 content
Microlite	131	3	91	9	(1)	6	--------	-------	-------
Tin slags	8,822	564	429	10,220	889	560	28,913	2,902	1,572

1 Less than ½ unit.

Table 10.—U.S. imports for consumption of columbium-mineral concentrates, by countries

(Thousand pounds)

Country	1965	1966	1967
Argentina	------	--------	11
Australia	------	--------	1
Belgium-Luxembourg [1]	------	12	33
Brazil	675	4,995	3,536
Burundi and Rwanda	34	--------	15
Canada	1,861	1,524	891
Congo (Kinshasa)	44	128	66
Finland	------	2	--------
Germany, West	------	--------	80
Ivory Coast	------	15	--------
Kenya	------	7	--------
Malagasy Republic	------	--------	7
Malaysia	83	74	202
Mexico	25	--------	--------
Mozambique	32	--------	11
Netherlands [1]	8	--------	--------
Nigeria	2,112	2,421	2,519
Peru	------	14	--------
Portugal	------	28	18
Rhodesia, Southern	------	--------	8
South Africa, Republic of	------	11	--------
Spain	------	10	--------
Switzerland [1]	------	22	--------
Uganda	18	15	4
United Kingdom [1]	------	--------	18
Western Africa, n.e.c.	------	--------	11
Total:			
Pounds (thousands)	4,892	9,278	7,431
Value (thousands)	$2,712	$5,678	$5,266

[1] Presumably country of transshipment rather than original source.

Table 11.—U.S. imports for consumption of tantalum-mineral concentrates, by countries

(Thousand pounds)

Country	1965	1966	1967
Argentina	------	10	3
Australia	12	29	58
Belgium-Luxembourg [1]	55	27	60
Brazil	281	287	356
Burundi and Rwanda	15	20	45
Central African Republic	------	--------	5
Congo (Kinshasa)	160	993	313
France	12	--------	--------
French Guiana	1	1	--------
Germany, West [1]	------	109	--------
Indonesia	20	--------	--------
Japan	6	--------	--------
Kenya	------	27	21
Malagasy Republic	8	1	15
Malaysia	97	36	33
Mozambique	276	175	241
Netherlands [1]	82	166	42
Nigeria	36	40	135
Portugal	48	67	99
Rhodesia Southern }	8	16	41
Malawi }		--------	--------
South Africa, Republic of	12	8	18
Spain	13	13	11
Surinam	15	--------	--------
Thailand	27	89	138
Uganda	5	7	24
Uruguay	------	2	--------
Western Africa, n.e.c.	------	--------	17
Western Portuguese Africa	7	20	--------
Total:			
Pounds (thousands)	1,196	2,143	1,675
Value (thousand)	$2,150	$4,782	$5,510

[1] Presumably country of transshipment rather than original source.

Table 12.—Estimated U.S. imports for consumption of ferrocolumbium by major countries

(Thousand pounds, gross weight)

Country	1964	1965	1966	1967
Austria	93	236	231	22
Brazil	10	370	904	466
Canada	29	52	70	41
Germany, West	20	33	75	90
United Kingdom	20	-----	-------	10
Total	172	691	1,280	629

Table 13.—U.S. imports duties

(Per pound)

Tariff classification	Articles	Rate of duty [1]	
		Through Dec. 31, 1967	Effective Jan. 1, 1968
601.21	Columbium concentrate	Free	Free.
601.42	Tantalum concentrate	Free	Free.
607.80	Ferrocolumbium	10 percent ad valorem	9 percent ad valorem.
	Columbium:		
628.15	Unwrought	10 percent ad valorem	9 percent ad valorem.
628.20	Wrought	18 percent ad valorem	16 percent ad valorem.
628.17	Unwrought Cb alloys	15 percent ad valorem	13 percent ad valorem.
	Tantalum:		
629.05	Unwrought	10 percent ad valorem	9 percent ad valorem.
629.10	Wrought	18 percent ad valorem	16 percent ad valorem.
629.05	Unwrought Ta Talloys	15 percent ad valorem	13 percent ad valorem.
423.00	Columbium and tantalum chemicals	10.5 percent ad valorem	9 percent ad valorem.

[1] Not applicable to Communist countries.

Estimated data on imports of ferrocolumbium are reported in table 12. Because U.S. ferrocolumbium import statistics are not separately classified, exact data are unavailable. This information was obtained from various industry and government sources and from foreign trade statistics.

Imports of both columbium- and tantalum-mineral concentrates fell from the alltime highs reached in 1966 but remained at levels higher than that of most previous years. As in 1966 the bulk of columbium concentrate imports came primarily from Brazil, Nigeria, and Canada. The relative total, provided by these countries in 1967 however varied somewhat from that of 1966. Brazil and Canada supplied primarily pyrochlore concentrate whereas Nigeria supplied columbite concentrate. Relative to the tantalum import pattern in 1967, Brazil replaced the Congo (Kinshasa) as principal supplier. Important quantities of tantalum mineral concentrates were also supplied by Mozambique, Thailand and Nigeria. Most of the tantalum concentrate reported as coming from Europe is believed to represent transshipments of material of African origin.

Receipts of microlite and tin slags came primarily from Mozambique (microlite) and from the Congo (Kinshasa), Malaysia, Nigeria, and Thailand.

In accordance with the Kennedy Round Tariff Negotiations which were completed during the year, the duties on columbium and tantalum were to be reduced in stages by 50 percent over the 5-year period 1968–72. In the first stage, the duties which became effective January 1, 1968, are reported in table 13.

WORLD REVIEW

Australia.—Greenbushes Tin N. L., Australia's new producer of tantalum concentrates, announced that its dredge, which was damaged in late 1965, was back in operation by April 1966. The estimated 1966 output of 12 to 15 tons of 53 to 55 percent Ta_2O_5 concentrate was contracted to Philipp Brothers Corp. of New York. The production goal for 1967 and subsequent years is 45 tons of tantalite concentrate annually.

Tantalum also was recovered as a byproduct of tin mining by Northwest Tantalum N.L. in which Philipp Brothers has acquired 13.9 percent interest. Other tantalum production centers were Pilbara and Warra Warra.

During 1967 the Canadian firm, Goldrim Mining Co., explored and began initial recovery of tantalum from the Wodgina dike deposit in the Pilbara area of Western Australia. In addition, Goldrim is exploring some of its holdings in the Northern Territory which are reported to contain tantalum, columbium, and tin.

It was announced that Electrolytic Zinc Co. of Australia, Ltd., is seeking mineral rights to look for possible tantalum deposits in the Port Hedland area of Western Australia.

Brazil.—During 1967 Brazil continued its standing, achieved in 1966, as the major world producer of columbium minerals. The leading producer, Companhia Brasileira de Metalúrgia e Mineraçao (CBMM), known formerly as Distribuidora e Exportadora de Minérios e Adubas, S.A. (DEMA), at Araxá, Minas Gerais, continued to recover columbium concentrates from extremely rich pyrochlore ore (4+percent Cb_2O_5). Operating on a one-shift-per-day basis, CBMM increased production from its open pit mine to about 12 million pounds annually in 1966 to feed the expanded flotation mill adjacent to the mine. About 500 tons per month of 58 percent Cb_2O_5 concentrate was recovered. Early in 1967, CBMM expanded its ferroalloy plant adjoining the mine, which uses the thermite batch process, from 40 to 50 tons per month of ferrocolumbium, and announced plans to increase the total capacity of its three reactors to 1,000 tons per year early in 1968.

Because the pyrochlore concentrate contains significant amounts of radioactive thorium (about 1.5 percent ThO_2), permission to export it was denied by the Comissas Nacional de Energia Nuclear (CNEN) until CBMM arranged to supply the radioactive equivalent of the thorium content to the Government of Brazil in the form of uranium oxide from the Republic of South Africa and more recently from Spain and Portugal.

CBMM plans to increase production of ferrocolumbium, which contains no thorium, obviating need for a special export license. The thorium content remains in a slag which CBMM will stockpile in drums for the account of CNEN.

Because its thorium content presents a radioactive hazard, special licensing for its processing is required in the United States. As a result, the Brazilian concentrate was priced about $0.20 per pound less than Canadian pyrochlore during 1966.

Companhia de Ferro Ligas da Bahia became associated with Thermo-Ligas Metalúrgicas, S.A. (Thermo-Liga), and announced plans for the production of ferrocolumbium and other ferroalloys in northern Brazil.

Canada.—Production of pyrochlore concentrate by St. Lawrence Columbium and Metals Corp. Canada's sole producer, at its mine and mill near Oka, Quebec, decreased during 1967 from the peak reached in 1966. Output, which had been primarily from open pit operations in previous years, was entirely from the underground facilities completed during the year. The company began underground mining early in 1967 at a rate of about 4,000 tons per day. Diamond drilling has indicated that the deposit extends onto property of Oka Columbium & Metals Ltd., a wholly owned subsidiary, and of Main Oka Mining Corporation (N.P.L.). St. Lawrence purchased 42 percent of the outstanding shares of Main Oka during 1966. Columbium Mining Products Ltd., also located in the Oka district near the St. Lawrence mine, announced that it had signed a contract with Continental Ore Corp. of New York to deliver approximately 2.6 million pounds of Cb_2O_5 in pyrochlore concentrate annually over a 10-year period

Table 14.—Free world production of columbium and tantalum concentrates (gross weight) by countries [2] [3]

(Pounds)

Country	1963		1964		1965		1966		1967 p	
	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum
North America: Canada [4]	2,941,303	--------	4,150,388	--------	4,541,745	--------	5,073,000	--------	4,244,000	--------
South America:										
Argentina	--------	[5] 4,520	--------	--------	--------	--------	--------	r 2,013	--------	[5] 3,309
Brazil:										
Columbite-tantalite [6]	42,763	231,000	24,643	180,777	88,317	364,466	r 130,611	r 351,796	225,500	452,991
Pyrochlore	--------	--------	712,081	--------	2,636,686	--------	r 10,527,000	--------	10,177,000	--------
French Guiana	5,031		2,000		1,850		r 2,000		2,200	
Europe:										
Norway	783,000	--------	408,000	--------	330,689	--------	--------	--------	--------	--------
Portugal [5]	4,464	72,711	21,526	32,280	--------	47,772	27,000	66,998	17,973	99,306
Spain [5]	--------	--------	14,610	--------	--------	13,483	10,000	13,000	--------	10,950
Africa:										
Burundi	4,000		NA		NA		NA		NA	
Congo, (Kinshasa) [5] [7]	163,435	147,255	--------	101,159	44,000	160,000	128,000	993,000	66,289	313,307
Malagasy Republic	38,000		7,900		9,000		--------	[5] 990	--------	[5] 14,909
Mozambique [8]	337,924		415,697		r 302,637		r 313,700		360,639	
Nigeria	4,506,850	33,600	5,239,324	22,400	5,707,486	29,000	4,986,211	26,900	4,309,760	e 24,000
Rhodesia, Southern	--------	151,016	--------	141,318	--------	77,000	--------	e 88,000	--------	--------
Rwanda	e 70,000		64,421		109,239		54,756		69,224	
South Africa, Republic of	--------	64,000	--------	14,000	--------	6,000	--------	4,000	--------	e 9,900
South-West Africa, Territory of	419	4,142	448	1,027	1,080	1,135	1,892		NA	
Uganda	20,000		12,857		17,924		24,648		61,085	
Asia:										
Malaysia	197,100	--------	125,400	--------	103,000	--------	152,400	--------	186,006	--------
Thailand [7]	--------		--------		--------		--------		101,412	
Oceania: Australia	--------	r 30,889	--------	r 33,600	--------	25,580	--------	10,549	--------	51,520
Total	r 9,853,422		r 11,725,856		r 14,618,089		r 22,988,464		20,801,280	

e Estimate. p Prelimanary. r Revised.

[1] Frequently the composition (Cb_2O_5-Ta_2O_5) of this concentrate lies in an intermediate position, neither Cb_2O_5 nor Ta_2O_5 being strongly predominant. In such cases, the production figure has been centered. This data excludes columbium- and tantalum-bearing tin slags.

[2] The U.S.S.R. is also known to have produced columbium and tantalum concentrates, but specific data are not available.

[3] Compiled mostly from data available May 1968.

[4] Represents pyrochlore concentrates containing approximately 52 percent Cb_2O_5.

[5] U.S. imports.

[6] Exports.

[7] In addition, tin-columbium-tantalum concentrate (averaging about 10 percent combined Cb_2O_5 and Ta_2O_5 content for the Congo (Kinshasa) and averaging between 19.5 and 22 percent combined Cb_2O_5 and Ta_2O_5 for Thailand) was produced; data not available.

[8] Includes microlite as follows: 1963, 160,000; 1964, 312,200; 1965, 187,350; 1966, 174,500; and 1967, 154,845.

starting in 1968. A 1,000 ton-per-day mill to be built will employ a different process than that used by St. Lawrence. Initially, open pit mining will be used. Ore reportedly contains approximately 0.43 percent Cb_2O_5, about the same as at St. Lawrence. Implementation of this contract did not materialize owing to lack of sufficient financing and the contract lapsed. However, Continental Ore holds an option to reinstate the contract in the event that Columbium Mining is successful in obtaining the required capital.

A major pyrochlore deposit was being explored in the James Bay Area lowlands of Northern Ontario about 50 miles south of Moosohee and 400 miles north of Toronto by a group of companies headed by Imperial Oil Enterprises and including Consolidated Morrison Explorations Ltd., Goldray Mines, and Argor Explorations. Exploratory drillings indicated a deposit containing more than 40 million tons of pyrochlore ore averaging at least 0.52 percent Cb_2O_5 and extending to a depth of 1,000 feet. Additional columbium exploration work was conducted by Consolidated Manitoba Mines on its property in the James Bay lowlands adjoining the Imperial Oil-Consolidated Morrison property.

During 1967, Min-Ores Mines began diamond drilling operations to evaluate the grade and extent of the columbium ore discovered in 1966 beneath Callander Bay, Lake Nippissing, Northern Ontario.

International Bibis Tin Mines optioned the Peg Tantalum property in the Yellowknife area on the north shore of Great Slave Lake, Northwest Territory, and will explore the property jointly with the Rare Metals Division of CIBA Corp.

The complex cesium-tantalum-beryllium-lithium-gallium ore deposits of Chemalloy Minerals Ltd. (Toronto) at Bernic Lake, Manitoba, were explored by a joint venture between Chemalloy and Goldfields Corp. (New York). Preliminary investigations indicated substantial ore deposits averaging 0.39 percent Ta_2O_5. Development work will be conducted by Tantalum Mining Corp. (Ontario) owned 60 percent by Goldfield and 40 percent by Chemalloy. It is anticipated that a milling plant will be constructed adjacent to the Bernic Lake property in 1968.

Congo (Kinshasa).—The production of columbium and tantalum mineral concentrates continued to decrease during the year as GEOMINES, Compagnie Miniére des Grand Lacs Africans (MGL), and Minerga-Congo were troubled with labor relocation problems resulting from political disturbances. The Union Carbide Corp. pyrochlore deposit, which originally was being developed for production in 1967, encountered political problems which prevented the aquisition of a mineral concession from the Congolese Government and little actual development work was conducted during the year. When this property is developed further, the Congo (Kinshasa) will produce columbium concentrate from pyrochlore and tantalum concentrates from tin slag.

France.—A new Péchiney research center to be known as SOFEREC was dedicated in October at Voreppes near Grenoble. This new center will be the largest research complex for nonferrous metals in Europe and will conduct research on columbium and tantalum for use in the nuclear, aeronautical, space, chemical, and electronic industries.

Ivory Coast.—Sté. Anonyme de Recherches et d'Exploitations Miniére de Côte d'Ivoire (SAREMCI) ceased production of columbite-tantalite concentrates from the Bouke deposits.

Kenya.—Two reports on the Mrima Hill pyrochlore deposit were published which described the geology and mineralogy, ore reserves, ore treatment, and columbium recovery operations attempted.[3] Overall reserves exceed 41 million tons containing 0.67 percent Cb_2O_5 and 1.25 million tons containing 1.75 percent Cb_2O_5. Development of the deposit has been hindered by the complex and variable nature of the ore. Studies currently are being made on procedures for recovering the columbium and other constituents by pyrometallurgical methods.

Mozambique.—Production of tantalum-mineral concentrates by three local Portuguese firms, Empresa Mineira do Alto

[3] Binge, F. W., P. Joubert, and J. E. Mason. The Mrima Hill Deposit, Coast Province, Kenya. Ministry of Natural Resources, Mines and Geological Dept., Republic of Kenya, Inf. Circ. 2, 1966, 51 pp.
Harris, P. M., and D. V. Jackson. Investigations Into the Recovery of Niobium From the Mrima Hill Deposit. Trans. Inst. Min. and Met., Sec. C, v. 75, London, 1966, 17 pp.

Ligonha (EMDAL), Sociedade Mineira de Marropino, Lda., and Sociedad Mineira de Mutala, Lda., was almost entirely from the pegmatite mining area of northern Mozambique and was reported to be at a level of about 60 tons of tantalite (60 percent Ta_2O_5) and 70 tons of microlite (75 percent Ta_2O_5) annually. Higher production is anticipated as a result of the scheduled opening of two new mining areas and concentrating plants by the country's chief tantalum producers.

While the largest Mozambique pegmatite, located at Muiane, was worked in 1966 by EMDAL primarily for its beryl content, the sluice plant was believed to have also recovered about 250 grams of tantalum concentrate per ton of which it is estimated that approximately one-third is microlite (60 percent Ta_2O_5) and two-thirds is tantalite-columbite concentrate (40 percent Ta_2O_5 and 30 percent Cb_2O_5). EMDAL is reportedly installing extra concentrating equipment including a screen, jig, and two tables to treat 80 tons of ore per 8-hour day. EMDAL is also working the small Gelo pegmatite deposit about 16 miles from Muiane on the Gilé road. The yield from this working was estimated to be about 500 grams of 40 percent Ta_2O_5 concentrate per metric ton of ore.

Marropino produced microlite concentrate from a pegmatite deposit at Morrua about 23 miles northeast of Mulevala and tantalite concentrate from a second deposit at Marropino, about 18 miles south of Morrua. The average concentrate grade from these two operations was 60 percent Ta_2O_5, and during the first half of 1966 recovery reportedly averaged 500 grams per ton while recovery during the second half of the year was believed to average 1,000 grams per ton as a result of encountering a pocket of higher grade ore. The problem of lack of water, which had previously restricted production at Marropino, was remedied by the construction of three dams to store and provide a constant year-round water supply.

Foreign investment, represented by Derby & Co., a subsidiary of Philipp Brothers Corp. of New York, by Rand Mines of Johannesburg, and by the Johannesburg Consolidated Investment Co., expressed interest in acquiring the tantalite properties of Mutala and of Marropino.

Netherlands.—Capacity was doubled at the aluminum-base columbium and tantalum master alloy facility in Arnhem, operated by N.V. Kawecki-Billiton Matallindustrie, a subsidiary of Kawecki Chemical Co., and N. V. Billiton Maatschappij.

Nigeria.—Columbium continued to be recovered almost exclusively as a coproduct of tin mining. All columbite and tantalite mining operations were in the Northern Province of Nigeria. High-grade tantalite (65 percent Ta_2O_5) ore was recovered by hand-sorting primarily during the rainy season when enough water is available. Most of the larger companies were emphasizing mechanization to overcome the labor availability and cost problems involved in hand-sorting operations.

Although several major producers have increased production of columbite and tantalite by the use of modern equipment, internal disturbances within Nigeria have caused several small operations to close.

Juntar Nigeria Co. Ltd., one of the country's largest columbite producers, reportedly has reserves of almost 10 million pounds of columbium concentrate.

Norway.—Mining rights to the low-grade pyrochlore deposit at Sove, near Ulefoss in the Telemark district, were transferred from Norsk Bergverk A/S, the state-owned company which suspended mining operations in the fall of 1965, to a partnership between the West Germany company Metallgesellschaft A. G. and Fangel and Co. A/S of Norway for an initial period of 3 years. The partnership was seeking to develop a method of economically working the large, low-grade deposit.

Rhodesia, Southern.—Kamativi Tin Mines, Ltd., a Dutch-controlled company near Wankie, continued to be the major producer of tantalite which was recovered as a magnetic byproduct from tin concentrates before smelting. Kamativi reportedly increased its total productive capacity to 50,000 tons of ore per month in 1966.

Although official production figures on columbium and tantalum ceased to be reported by Southern Rhodesia following its unilateral declaration of independence (UDI) proclaimed in November of 1965, an indication of the country's continued Cb-Ta production is given by U. S. imports, tables 10 and 11.

South Africa, Republic of.—The newly formed company, Thermometallurgical Corporation (Pty.) Ltd., will be the country's first ferroalloy producer and will produce ferrocolumbium, ferrotantalum, and other ferroalloys from domestic and imported ores.

U.S.S.R.—Trade journals reported that for the first time ferrocolumbium of Soviet origin was being offered for sale on the free world market and that small quantities were purchased in Western Europe for examination during 1966.

United Kingdom.—A new plant was constructed by Kawecki Chemical Co. in Darley Dale, England, early in the year to produce the aluminium-base columbium and tantalum master alloys required by the U. K. ferroalloy industry.

TECHNOLOGY

To develop alloys suitable for use at elevated temperatures, columbium and tantalum were combined with tungsten, hafnium, zirconium, molybdenum, vanadium, and titanium, and the resulting alloys were evaluated with respect to strength at elevated temperatures, oxidation resistance, and fabricability.[4] Of the alloys investigated, the Cb-Hf-W-Ti and the Cb-Hf-Mo series exhibited the optimum combination of high temperature properties.

In another Bureau of Mines study, additions of carbon, aluminum and chromium were made to high-temperature columbium-base alloys to evaluate the effects of solid solution strengthening and precipitation hardening caused by these alloy additions.[5]

The trend toward higher operating temperatures to improve the efficiency of space power and propulsion systems has led to the development of extruded tubing of columbium and tantalum alloys (B–66 and T–111, respectively), which can serve reliably in extremely rigorous high-temperature environments.[6] In addition to their good high-temperature, high-strength properties, these alloys possess the ductility, fabricability, and corrosion resistance that make them suitable for tubing to conduct liquid metal coolants in space reactors.

Studies by U. S. Atomic Energy Commission contractors evaluated the effects of radiation of columbium and tantalum metals and their alloys.[7] Special attention was given to determining the effects of fast neutron irradiation on Cb- and Ta-based alloys being considered for cladding and structural materials in fast "breeder" reactors. Preliminary data indicates that neutron irradiation does not adversely effect the structural and cladding properties of these alloys.

Studies of the compatibility of construction materials with liquid and vapor alkali metals indicated that columbium, columbium-base alloys, tantalum, and tantalum-base alloys, possessed excellent compatibility with sodium, sodium-potassium (NaK), potassium, lithium, and cesium metal coolants and should be suitable for use in nuclear reactors using these coolants.[8] Columbium and tantalum alloys are suitable for application with liquid metals when the oxygen content of the molten metals is kept low to prevent detrimental reaction of the oxygen with columbium and tantalum alloys.

Because they do not readily react with plutonium and plutonium alloy fuels, tantalum and tungsten were both satisfactory materials for fuel containment in the Los Alamos Molten Plutonium Reactor Experiment (LAMPRE), but tantalum was preferred because of its greater ease of fabrication.[9]

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4 Babitzke, H. R., and H. Kato. Columbium and Tantalum Alloy Development. BuMines Rept. of Inv. 6964, 1967, 18 pp.
Babitzke, H. R., R. E. Siemens, and H. Kato. High-Temperature Columbium and Tantalum Alloys. BuMines Rept. of Inv. 6777, 1966, 16 pp.

5 Yoda, Renpei, H. R. Babitzke, and H. Kato. Study of Columbium-Base Alloys. BuMines Rept. of Inv. 6988, 1967, 34 pp.

6 Buckman, Jr., R. William, and John L. Godshall. Refractory Alloy Tubing for Space Power Systems. Metal Progress, v. 89, No. 3, September 1966, pp. 105–110.

7 Norman, Edgar C. (ed.). Summaries of Fast Fuels and Materials Development Programs. U.S. Dept. of Commerce, Clearinghouse for Federal, Scientific, and Technical Information, USAEC–TID–6506, pt. 3, 4th ed., May 1966, 253 pp.

8 DeMastry, John A. Liquid Metals in Space Power Systems. Battelle Tech. Rev. v. 15, No. 3, March 1966, pp. 17–21.
Stang, J. H., E. M. Simons, J. A. DeMastry, and J. M. Genco. Compatibility of Liquid and Vapor Alkali Metals With Construction Materials. Battelle Memorial Inst., Columbus, Ohio, DMIC Rept. 227, Apr. 15, 1966, 112 pp.

9 Litton, Felix B., and John C. Biery. Reactor of Tantalum With Molten Cerium—Cobalt Alloys. J. Electrochem. Soc., v. 113, No. 4, April 1966, pp. 371–376.

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Copper

By J. A. Rowland [1] and Gertrude N. Greenspoon [2]

In its closing months, the year 1967 was frequently characterized as "the year of the strike." This referred to the series of strikes that closed more than 90 percent of the domestic copper producing industry and eventually developed into the longest and costliest series of strikes in the history of the copper industry. The possibility that strikes would occur in the United States was recognized by the copper producing and fabricating industries even in 1966, and stocks were built up on that basis. However, the opening months of 1967 presented more immediate problems. A January 1967 article on prospects for the new year [3] discussed numerous crises threatening the free world's copper supply, yet ignored the possibility of copper strikes in the United States. Almost 8 percent of free world copper supplies were being withheld until a dispute between the Congolese Government and Union Minière du Haut-Katanga could be settled. Also, there was the prospect of further curtailment of copper shipments from Zambia; a threat realized on January 31, when Anglo-American Corporation (Central Africa), Ltd., announced a 55-percent reduction in their normal February deliveries. There were also immediate threats of strikes in Chile and Peru.

Each of these crises assumed greater proportions in the face of a demand that gave no indication of abating from the 1966 level, when shipments and bookings of U.S. fabricators were at record levels. However, the Congolese copper was released for world consumption on February 20 when a formal agreement was signed and, despite numerous interruptions, Congolese production for 1967 closely approached the record 348,000 tons of 1966. The Zambian crisis was also alleviated, as temporary remedies were found for the fuel shortage and transportation difficulties that hampered production in that country. Furthermore, the strikes anticipated in Chile and Peru were averted for a time. In addition, a substantial decline in demand for copper and brass-mill products had become evident by May. Thus, by midyear, copper production was well in line with demand throughout the free world, and the size of U.S. consumer stocks seemed to afford adequate protection against any anticipated strikes at domestic producers. The strikes began on July 15, and for the remainder of the year their effects dominated the industry and the copper markets of the free world.

A large proportion of the labor union contracts with U.S. copper producers expired on June 30, 1967, and only a few contracts extended beyond 1967. Two large unions, The United Steel Workers of America and the International Union of Mine, Mill and Smelter Workers were allied with 12 smaller unions for the negotiation of new contracts. The major producers involved were American Smelting and Refining Company, The Anaconda Company, Kennecott Copper Corp., Phelps Dodge Corp., Inspiration Consolidated Copper Co., Magma Copper Co., and U.S. Metals Refining Co.

Negotiation of new contracts involved the usual questions of wages, pensions, and working conditions, but the crucial question concerned the establishment of a bargaining procedure. The unions demanded company-wide bargaining and company-wide contracts; the companies were adamant in rejecting that demand. Thus, no signficant progress was made in the negotiations, despite a 2-week extension following the June 30 expiration

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[3] Metals Week. Handful of Crises For the New Year. V. 33, No. 1, Jan. 2, 1967, 46 pp.

of many contracts. Therefore, all plants without binding contracts were struck on July 15.

The strikes immediately reduced mine capacity by 80 percent, smelter capacity by almost 90 percent, and refinery capacity by more than 65 percent. Further reductions followed at intervals as contracts expired at other plants. Smelter operations continued to suffer more severely than either mining or refining. Thus, by September the number of operating smelters had been reduced to one plant representing less than 2 percent of the total U.S. capacity. The overall reduction in copper producing capacity was, of course, complicated by the disproportionate loss in smelter capacity, which forced most of the operating mines to stockpile, and practically eliminated the flow of domestic blister to those refineries which remained open. Obviously, stockpiling could be only a temporary expedient. Therefore, in mid-August the Commerce Department began granting licenses for the exportation of copper concentrate, precipitate, or black copper that could not be processed domestically. The first series of licenses permitted exportation of 11,205 tons of contained copper. The opportunity to export concentrate enabled some mines in Arizona and Nevada to continue operations and, thus, relieved slightly and temporarily severe economic dislocations brought to those States by the copper strikes.

The loss of domestic blister copper supplies presented those refineries that remained open with a less serious problem than the producing mines faced. More than one-third of the available refining capacity was regularly engaged in processing foreign blister, and most of this processing was done under European contract. Such operations, of course, added nothing to the domestic supplies of refined copper. The refineries could also resort to increased use of scrap to offset the loss of the domestic blister. Of course, such expedients could not compensate fully or indefinitely for the disruption of blister copper supplies. This disruption, however, rapidly lost its significance as additional strikes reduced refinery operations to 18 percent of capacity on November 1.

The first interruption of the steady extension of the strikes came on October 15 when the 650 employees of the Pima Mining Co. ratified a new 3-year contract, an important break in the labor contract stalemate. However, it had no affect on domestic production; operations at the Pima installation had not been interrupted by the August 31 expiration of the previous union contract.

The continued operations of Tennessee Copper Co. Division, Copperhill, Tenn. unit was another exception to the strike pattern. In this instance, a new contract was negotiated with the International Chemical Workers Union without any interruption of production. Thus, the Copperhill smelter, with an annual capacity of 90,000 tons of charge, was for several months the only producing copper smelter in the United States. With these exceptions, the strikes continued to spread and to impose increasing restrictions upon domestic copper production, and there was no prospect of a remission as the year ended.

Estimates of the cost of the 1967 copper strike varied widely, and all estimates were largely subjective. A 1967 loss of 900,000 tons of U.S. copper production has been cited frequently. This estimate seems to be high: Production recorded during the second half of 1967 fell below production in the second half of 1966 by 520,000 tons at the mine, by 660,000 tons at the smelters, and by 640,000 tons at the refineries. On the other hand, any realistic estimate of the economic impact of the strike must recognize the substantial loss in byproducts and the considerable deterioration in operating efficiency, which is inevitable during a long strike. Therefore, estimates of the 1967 cost of the copper strikes ranging as high as $1 billion cannot be discounted. It should also be noted that the economic impact was buffered somewhat by abnormally high stocks accumulated at every stage of consumption in anticipation of the strikes. Despite these stocks, net imports of copper were rising rapidly by the end of the year.

Increased copper imports however, represented a growing deficit in the United States trade balance and higher costs for the domestic consumer. Also, shortages in some forms of copper, which were evident locally in November, grew more severe in the next few weeks. Before the end of December, these shortages and the increasing cost of copper had forced some manufacturers to stop production. Although the number of these manufacturers was small in December, such events warned that the strike's crucial stage would come with the new year.

Legislation and Government Programs.—No orders were issued during 1967 for the release of copper from the Government stockpile. On orders issued in the previous year, a total of 176,000 tons of stockpiled copper was distributed during the first 9 months of 1967. Of the total, 150,000 tons had been released by the President on December 5, 1966, and was restricted to defense applications, to offset increases in refined set-asides that had been ordered for the first half of 1967. This release reduced the stockpile inventory to 248,000 tons, approximately 35 percent of the objective. The first order setting aside domestic refined copper for defense applications, BDSA order M-11a, DIR 2, was issued on February 23, 1966. Previous set-asides had applied only to brass mills, wire mills, and foundries. The new order required each refinery to reserve for defense use a portion of its monthly production equal to 10 percent of its 1965 average monthly production from domestic ores. The 10-percent set-aside was increased to 13 percent on May 27, 1966, to 18 percent on August 15, and to 23 percent for the last quarter of 1966. The final increase brought set-asides for the first half of 1967 to 26 percent, and this set-aside continued for all of 1967. With the July 15 onset of the strikes they rapidly became ineffective as a means of insuring adequate supplies of copper for defense applications, and the Government resorted to voluntary cooperation in meeting defense needs.

On November 29, 1967, the General Services Administration (GSA) announced its first contract for domestic copper production expansion under a program authorized by the President on March 29, 1966. The contract was with Duval Sierrida Corporation, a subsidiary of Duval Corp. of Houston, Tex. and provided for development of an open-pit mine adjacent to Duval Corp.'s Esperanza mine in Pima County, Ariz. Under the contract, GSA will advance a total of $83,000,000 against future deliveries of copper at a price of 38 cents per pound. GSA will also guarantee a private loan of $48,750,000 at an initial rate of 70 percent of the principal. The balance of the estimated $151,000,000 required to bring the mine into production is to be supplied by the Duval Corp. and development is to be financed with private funds until August 1968 when the first installment of the Government loan will be advanced. The mine is expected to begin production late in 1969, with output expected to approximate 57,000 tons of copper per year for the first 5 years and 68,000 tons per year over the next 15 years. The mine is also expected to produce approximately 12,000,000 pounds of molybdenum and 455,000 ounces of silver each year.

The contract with Duval obligates $83 million of the $100 million commitment authority provided in the Defense Production Act of 1950, as amended.

Table 1.—Salient copper statistics

	1963	1964	1965	1966	1967
United States:					
Ore produced_____thousand short tons__	146,450	155,200	173,286	186,966	127,066
Average yield of copper_____percent__	0.74	0.73	0.70	0.67	0.63
Primary (new) copper produced—					
From domestic ores, as reported by—					
Mines____________short tons__	1,213,166	1,246,780	1,351,734	1,429,152	954,064
Value__________thousands__	$747,310	$812,901	$957,028	$1,033,850	$729,401
Smelters__________short tons__	1,258,126	1,301,115	1,402,806	1,429,863	841,343
Percent of world total_______	23	23	23	24	14
Refineries_________short tons__	1,219,342	1,259,852	1,335,660	1,353,087	846,551
From foreign ores, matte, etc. as reported by—refineries short tons__	377,009	396,543	376,133	357,897	286,431
Total new refined, domestic and foreign___short tons__	1,596,351	1,656,395	1,711,793	1,710,984	1,132,982
Secondary copper recovered from old scrap only______________short tons__	421,843	473,521	513,436	534,860	482,659
Exports:					
Metallic copper____________do____	344,960	381,432	379,498	319,314	200,078
Refined___________________do____	311,479	316,230	324,965	273,071	159,353
Imports, general:					
Unmanufactured______short tons__	539,396	586,064	523,141	583,507	648,941
Refined__________________do____	119,219	139,974	137,443	162,602	330,347
Stocks Dec. 31, producers:					
Refined_____________short tons__	52,000	37,000	35,000	43,000	27,000
Blister and materials in solution short tons__	252,000	246,000	246,000	270,000	220,000
Total__________________do____	304,000	283,000	281,000	313,000	247,000
Withdrawals (apparent) from total supply on domestic account:					
Primary copper________short tons__	1,423,000	1,495,000	1,526,000	1,593,000	1,320,000
Primary and old copper (old scrap only)______________short tons__	1,845,000	1,969,000	2,039,000	2,128,000	1,803,000
Price: Weighted average cents per pound__	30.8	32.6	45.3	36.2	38.2
World:					
Production:					
Mine________________short tons__	5,087,916	5,290,698	5,527,819	5,788,603	5,435,787
Smelter_________________do____	5,447,055	5,770,736	6,078,188	6,072,744	5,849,748
Price: London, average cents per pound___________________________	29.25	43.88	58.52	69.04	51.19

DOMESTIC PRODUCTION

PRIMARY COPPER

Mine Production.—In the first half of 1967, U.S. mine production was almost 6 percent greater than in the first half of 1966. In the second half, however, the strikes limited production to slightly more than one-quarter of the tonnage mined in the preceding half year. Thus, mine production for the entire year was reduced to two-thirds of that in 1966.

The impact of the strikes was fairly well distributed among producing States; but there were some noteworthy exceptions. Montana's 1967 production ended on July 15, the day the strikes began. Tennessee, on the other hand, escaped the strikes entirely and produced more copper in the second half of 1967 than in the first half. Also, Pennsylvania's relatively small tonnage of coproduct copper actually increased in 1967 by a considerable percentage over the 1966 production.

Recovery of precipitate copper was affected to a much lesser extent by the strikes than by other mining operations. In some instances, recovery of precipitate was continued after other mining operations had been halted to avoid pollution of streams. A substantial increase in facilities for recovering precipitate copper also had an effect in 1967. These two sets of circumstances brought 1967 precipitate recovery to within 84 percent of the 1966 tonnage. They also raised the ratio of precipitate copper to copper recovered by other methods from 11 percent in 1966 to 16 percent in 1967. Undoubtedly, a substantial portion of this increase must be attributed to the effect of the strikes. It is also certain, however, that the trend toward an increasing dependence on leaching for recovery of a significant portion of the domestic copper continued during 1967.

Smelter Production.—Although smelter capacity was reduced by the strikes to less than 2 percent for a significant portion of the second half of the year, smelter production for 1967 approached 59 percent of the 1966 tonnage. Much of the production was concentrated in the first half of 1967, and followed the normal distribution between domestic, foreign, and secondary copper. As with mine production, the steady increase in production capacity was concealed by the effects of the strike.

Refinery Production.—The U.S. strikes had a less drastic effect on refinery capacity than on either mining or smelter capacity. About 65 percent of refinery capacity was cut off on July 15, but 20 percent was maintained throughout the year. A part of this capacity was employed totally in refining foreign copper. However, sufficient capacity was available to bring the year's total production to approximately 63 percent of the 1966 total. Due to the disruption of mine and smelter production, refineries were forced to depend to an abnormal extent upon secondary materials and to a somewhat lesser extent on imports. Therefore, refined copper production from secondary materials and from foreign ores amounted to 78 percent and 66 percent of the corresponding production in 1966, respectively.

Copper Sulfate.—Operations of the copper sulfate-producing industry were also adversely affected by the strikes, and production declined 22 percent, the smallest since 1962. Shipments, also 22 percent below that of 1966, totaled 40,600 tons, of which producers' reports indicated 17,000 tons was for agricultural uses, 22,600 for industrial uses, and 1,000 for other uses, chiefly for export. **Stocks** at yearend were 21 percent less than at the end of 1966.

Byproduct Sulfuric Acid.—Sulfuric acid produced from the sulfur content of sulfide ores at copper smelters decreased 26 percent in 1967 as a result of the almost 90-percent reduction in smelting capacity. An 8-percent decrease in output at zinc plants was due principally to reduced activity at those plants.

SECONDARY COPPER AND BRASS

Recovery of copper in the United States, in alloyed and unalloyed form, from all classes of purchased nonferrous scrap totaled 1.16 million tons in 1967, down 13 percent from the record set in 1966. Copper recovered in all forms from copper-base scrap was only slightly less than that recovered in 1966 at secondary smelters but was down 22 percent at primary copper producers, 13 percent at brass mills, and 18 percent at foundries, chemical plants and miscellaneous manufacturers. Copper recovered from new scrap was 58 percent of the total copper recovered in 1967; (60 percent in 1966).

Consumption of purchased copper-base scrap totaled 1.5 million tons, a decrease of 17 percent from that of 1966. Use at secondary smelters dropped 3 percent to 423,000 tons, of which 77 percent (76 percent in 1966) was old scrap. Primary producers used 480,000 tons, a 30-percent decrease from that used in 1966, and brass-mill consumption fell 14 percent to 539,000 tons. Foundries and other plants used 100,000 tons compared with 125,000 tons in 1966.

Primary producers recovered 343,000 tons of refined copper from secondary materials, 22 percent less than in 1966. Secondary smelters recovered 63,300 tons of refined copper, an increase of 19 percent, but output of brass and bronze ingots fell 11 percent. Production of brass-mill products decreased 13 percent.

CONSUMPTION

Apparent withdrawals of primary copper totaled 1.3 million tons, 17 percent below 1966; the lowest amount since 1961.

Actual consumption of refined copper also dropped substantially. At the beginning of 1967 copper consumption was at the high monthly rates of 1966 and in March 1967 rose to 215,000 tons exceeding the previous high for the month set in 1966. Consumption fell sharply in July, rose to 139,000 tons in August, but dropped thereafter to 119,000 tons monthly in the last 2 months of the year. Data on actual consumption are based on consumers' reports of quantities entering processing, with no adjustments of stock changes of material in process. Unlike table 25, in which only new copper is included as far as possible, table 26 does not distinguish between old and new copper but includes all copper in refined form.

Distribution of actual consumption by use groups followed the usual pattern with wire mills consuming 64 percent (58 percent in 1966) and brass mills 34 percent (39 percent) of the total.

STOCKS

High consumption during the early months of 1967 coupled with reduced domestic production caused stocks of refined copper held by primary producers to drop 37 percent to the lowest figure since 1959. Unrefined copper stocks rose to a high of 303,000 tons on May 31 but fell in each month thereafter to the yearend total of 220,000 tons.

Fabricators' stocks of refined copper, including in-process metal and primary fabricated shapes, were 479,600 tons at yearend, 14 percent less than at the beginning of the year. Working stock inventories increased 8,400 tons during the year.

PRICES

On January 5, Phelps Dodge Corp. increased its domestic price for electrolytic copper from 36 cents per pound to 38 cents per pound. Other major producers followed suit, and by Monday, January 9, domestic producers' electrolytic wire bar was quoted at 38 cents to 38.25 cents per pound. Kennecott Copper Corp. quoted the 38.25 cent price. The January 9 price range was maintained for the remainder of the year. However, there was practically no U.S. produced copper available during the last 2 or 3 months of 1967; thus, the quoted producers' price was irrelevant in the last quarter of the year.

The Metals Week January quotation for primary copper sold in the United States, f.o.b. refinery, was 37.9 cents per pound. This monthly quotation is the average of the weighted daily averages for sales of copper in the United States regardless of the origin of that copper. The quotation for domestic copper fluctuated between 37.9 cents per pound and 38.2 cents per pound during the first 6 months of 1967. In July the price rose to 38.3 cents. In August, it was 39.1 cents per pound, and in September the quotations were discontinued, because domestic sales had declined to an insignificant quantity. The quotation for primary copper exported from the United States, f.o.b. refinery, was 49.8 cents for the month of January 1967. After rising to 50.2 cents in February, the price declined to less than the January quotation and remained at that level until the year's high, 54.7 cents per pound, was reached in November. The December price for export copper was 53.6 cents per pound.

The London Metal Exchange spot price for copper wire bar averaged 56.3 cents for the month of January. The February spot price declined to 55.3 cents per pound; this decline continued to an April low for the year of 45.1 cents per pound. The price then fluctuated to slightly higher values until it rose to 51.3 cents in October, and then to the year's high of 62.2 cents in November. The December spot price on the London Metal Exchange averaged 60 cents per pound. Although these monthly averages concealed some of the wider daily fluctuations, reaction on the London Metal Exchange to the U.S. strikes was moderate during practically the entire second half of the year. The market reacted briefly to apparent changes in the strike status in the United States; but there was no sustained rise in prices until it became obvious in October that U.S. fabricators were being forced into increasing dependence on European markets for their copper supplies. To a significant extent, this moderation in the London Metal Exchange spot quotations could be attributed to the dampening effect of a sluggish European demand for copper during the first three quarters of the year.

FOREIGN TRADE

During the first 6 months of 1967, United States export controls permitted the exportation of 16,500 tons of copper content in copper scrap, 25,000 tons of domestic refined copper, 1,000 tons of copper contained in copper-base alloy, and 9,000 tons of copper contained in semifabricated copper products and master alloys. The controls were retained for July and August, with a 2-month quota equal to one-third of the 6-month quota, and then continued at that rate for the remainder of the year.

A virtual embargo had been placed on exports of domestic origin copper on January 20, 1966. However, the strikes rapidly disrupted the normal relations between domestic mines, smelters, and refineries, immediately closing the smelters that had been the only domestic outlet for most of those mines remaining in operation. The mines, therefore, began to accumulate concentrate at a rate that would soon force an interruption of their operations. To relieve this situation, export regulations for copper ore, concentrate, matte, and blister were amended to permit licensing for export of those commodities when domestic facilities were not available for their further processing. Details of the amendment were published in the Federal Register.[4] The licensing arrangement was later modified to permit the exportation of scrap that could not be processed in the United States for technical or economic reasons or because of the strike.

The protracted strikes were the basic cause of substantial changes in the patterns of U.S. copper exports. An increase in exports of ore, concentrate, and matte to 25 times the 1966 level came in the last 5 months of 1967, after tight export controls were relaxed to release stocks accumulating at mines. Scrap exports were also concentrated in the last 5 months of 1967; but relatively small first half exports left the annual total at about the 1966 level. On the other hand, the drastic reduction in domestic production of refined copper brought a corresponding reduction in the exportation of refined copper. Exports in the first 7 months of 1967 approximated the monthly averages for 1966; but for the remaining 5 months exports fell to one-fifth of that average. This brought the year's exports of refined copper to less than 60 percent of the 1966 total. Although exports of mill products declined significantly as the strikes affected domestic supplies, the decline was far less than in the case of refined copper.

Most of the substantial increase in concentrate exports was distributed to four countries; Japan received the largest portion, and Canada, West Germany, and Belgium-Luxembourg shared much of remainder. This distribution was determined to some extent by the available smelter capacities in each country and by geographical location.

A 50-percent increase in exports of copper-base alloy scrap accounted for most of the 1967 increase in alloy exports.

General imports of unmanufactured copper increased in 1967 by about the same amount as in 1966. However, the pattern of imports was altered by the strikes to the extent that imports of refined copper accounted entirely for the overall increase offsetting substantial declines in all other import categories. Imports for consumption followed a pattern somewhat similar to the one for general imports with two exceptions: Consumption, early in 1967, of concentrates imported under bond in previous years caused a sharp increase in 1967 imports of ore, concentrate, and matte. Also, imports of refined copper for consumption emphasized the loss of domestic refined copper as a result of the strikes. Canada provided most of the increased imports of refined copper; West Germany and Chile also contributed substantially.

Tariff.—A June 30, 1967, agreement at Geneva, under the Trade Expansion Act of 1962, scheduled tariff reductions for unwrought copper for each of 5 years beginning January 1, 1968. The scheduled rates for 1968 through 1972, in chronological order, were 1.5 cents, 1.3 cents, 1.1 cents, 1 cent, and 0.8 cent per pound of copper content.

The 1.5 cent per pound duty on ore, unwrought copper, waste, and scrap was suspended during all of 1967 by Public Law 89–468.

[4] Federal Register. Licensing Policies and Related Special Provisions. V. 32, No. 186, Sept. 26, 1967, 7 pp.

WORLD REVIEW

On June 1, representatives of Chile, the Congo, Peru, and Zambia met in Lusaka, Zambia, to discuss common problems concerning copper. The Lusaka meeting was probably one of the most significant developments of the year, with respect to the future of the world copper industry. Although the meeting brought no real commitments, it did formalize a level of cooperation that had not previously existed between the four nations. The first positive evidence of this cooperation came with the establishment, at the meeting, of a permanent "Inter-Governmental Council Of Copper Exporting Countries." Since the four participating countries produce about 40 percent of the world's copper supply, their coordinated actions can, undoubtedly, have considerable effect on copper supply and price. There were, however, numerous assurances from the participants that no cartel to control price was planned.

NORTH AMERICA

Canada.—A record output of copper was reported in Canada with mine production 17 percent greater than in 1966. Increases of 33 percent in Ontario, 55 percent in British Columbia, and 16 percent in Saskatchewan more than offset decreased output in Quebec, Manitoba, and New Brunswick. Operations throughout Canada were uninterrupted during the year and six new mines were brought into production. Output was recorded in Yukon for the first time since 1962. Production of refined copper rose 15 percent over that of 1966 to 500,000 tons. Consumption fell nearly 15 percent to 224,400 tons.

Canada's leading producer, The International Nickel Company of Canada, Ltd. (Inco), produced a record 20.4 million tons of ore, 3 percent more than the company's previous high of 19.8 million tons in 1965. Deliveries of copper totaled 155,500 tons compared with 146,500 tons in 1966. A program of development work was carried forward at the nine operating mines in the Sudbury District, Ontario, and at the Thompson mine in Manitoba. By the end of 1967, the Thompson No. 3 shaft, extensions at the Clarabelle open-pit mine, and the open-pit operation adjacent to the Crean Hill mine were in operation. When this development program is completed, Inco is scheduled to have 18 operating mines in Canada, of which five new mines are in Ontario and three in Manitoba. In Ontario, the Copper Cliff North mine is schedued to begin production in 1968 with full output in 1970, the Coleman and Little Stobie mines in 1969, and full production at the Kirkwood mine in early 1970. In late 1967, development of the Copper Cliff South mine was begun; production is expected in about 3 years. In Manitoba, production from the Birchtree mine is planned for the last quarter of 1968 and from the Soab mine in the first quarter of 1969. Work was started on the Pipe mine, and production is scheduled for 1970.

Mill, smelter, and refinery facilities were being expanded to handle increased ore output resulting from the mine development program. The 22,500-ton-per-day Frood-Stobie mill produced its first copper-nickel concentrate in the latter part of 1967. Major changes in the flotation circuit and dewatering facilities were made at the Copper Cliff mill in order to process Frood-Stobie concentrate. An addition to the Levack mill, under construction at yearend, will permit removal of up to 1,500 tons per day of pyrrhotite concentrate and thus release smelting capacity of Copper Cliff. Expansion of the Thompson mill, smelter, and refinery, begun in early 1967, will enable the company to process increased ore production in that area.

Falconbridge Nickel Mines, Ltd., treated 2.2 million tons of ore compared with 2.1 million in 1966. Delivery of 16,200 tons of copper was slightly below the 16,400 tons delivered in 1966. Expansion and development programs at the Strathcona, Longvack South, and Lockerby properties continued throughout the year. The 6,000-ton-per-day Strathcona mill was nearing completion.

At the Geco mine in the Manitouwadge District, Ontario, Noranda Mines, Ltd., produced 1.46 million tons of ore averaging 2.02 percent copper from a copper-zinc ore body. The concentrate output contained 27,800 tons of copper (26,800 in 1966) and was shipped to the Noranda smelter.

Willroy Mines, Ltd., milled 503,500 tons of ore, of which 338,400 tons were treated on a custom basis for Willecho Mines, Ltd. Copper content of the concentrate decreased to 900 tons from 1,100 tons in 1966.

Ecstall Mining, Ltd., a subsidiary of Texas Gulf Sulphur Co., mined and milled 3 million tons of ore during the first full year's operation of the Kidd Creek mine and concentrator near Timmins. By mid-February all three concentrating units were in operation, and 205,000 tons of copper concentrates containing 25 percent copper was produced. At the Kidd Creek open-pit mine a zinc-copper ore and a zinc-lead-silver ore were produced. Each type of ore is handled separately from the mine through the mill. The copper concentrate is shipped to Noranda for smelting, and the blister copper is refined at Montreal East, Quebec. The company continues to study plans for constructing its own copper and zinc smelters and refinery facilities in Canada.

Production in Quebec was 8 percent less than in 1966 and the lowest since 1964.

Gaspé Copper Mines, Ltd., Canada's second largest producer, mined 2.86 million tons of ore averaging 1.12 percent copper from the Needle Mountain mine, of which 1.54 million tons came from the open-pit mine. The concentrator treated 2.76 million tons of ore and produced 105,900 tons of copper concentrate. The smelter treated 298,600 tons of concentrate and flux, including 97,800 tons of custom concentrate. Anode production amounted to 54,500 tons, a 16-percent increase over 1966. After removal of 13.1 million tons of waste and low grade material, the Copper Mountain open-pit mine was ready for production. Construction of the new crushing plant and expansion of the concentrator were virtually completed by yearend. Preliminary operations were scheduled to begin in early 1968.

In the year ending June 30, 1967, Merrill Island Mining Corp. treated 174,700 tons of ore, of which 115,600 tons was produced from the Merrill and Chib-Kayrand mines, 45,500 tons for Bruneau, and 13,600 tons for Icon. Copper production totaled 1,900 tons compared with 1,700 tons in 1966. Mining at the Merrill and Chib-Kayrand mines is being conducted on a limited basis and the ore stockpiled for future milling. An agreement was made with Icon Sullivan Joint Venture whereby Merrill would mine and mill the ore as operator for Icon Syndicate. Preparations for mining began in November 1966 and on May 23, 1967, the first ore was milled.

Noranda Mines, Ltd., produced 979,000 tons of ore averaging 1.99 percent copper from the Horne mine. Of the total, 855,500 tons was milled from which 138,500 tons of copper concentrate was produced. A total of 1.6 million tons of ore, concentrate, flux, and scrap, including 807,700 tons of custom material, was smelted. The 19-percent increase in receipts of custom concentrate resulted in a record output of 215,890 tons of anodes containing 212,400 tons of copper. The pilot plants for testing the Noranda continuous smelting process and a process for leaching Gaspé oxide ores were nearing completion at yearend.

Output of copper by Canadian Copper Refiners, Ltd., a subsidiary of Noranda, rose to a record 324,000 tons as capacity was increased to 28,500 tons per month in May. Difficulties encountered in operating at the higher rate were being overcome by the rearrangement of several facilities, particularly in the flow and handling of materials through the process.

Campbell Chibougamau Mines, Ltd., milled 980,500 tons of ore which was the largest annual output in the history of the company. The average grade of the ore rose from 1.75 percent copper to 1.77 percent in the fiscal year ending June 30, 1967. The Henderson Division contributed 410,400 tons or 42 percent of the total ore produced in fiscal 1967 (380,000 tons or 39 percent in fiscal 1966). The Main Mine Division produced 287,800 tons or 29 percent, compared with 337,000 tons or 35 percent in the previous fiscal year. Ore production from Cedar Bay Division was 210,200 tons or 21 percent, compared with 229,000 tons or 24 percent in 1965–66. At the Kokko Creek Division where known ore bodies were exhausted, 9,700 tons of ore was mined on a salvage basis during the summer months. In January, the company entered into a contract agreement with Grandroy Mines, Ltd., whereby Campbell would mine an estimated 200,000 tons of ore on a profit-sharing basis. The ore was mined by open-pit methods and hauled to the Campbell concentrator. In the 1966–67 fiscal year, 62,400 tons of ore averaging 1.05 percent copper was treated. Copper output from all divisions totaled 15,700 tons. Deepening of the shaft at Cedar Bay to 2,400 feet was completed, and the No. 2 shaft at the Henderson mine was sunk to a depth of 2,348 feet by the end of the fiscal year.

The amount of ore milled at the concentrator of Mattagami Lake Mines, Ltd., was essentially unchanged from 1966 and totaled 1.4 million tons of ore averaging 0.61 percent copper (0.62 percent in 1966) and 10.0 percent zinc (13.2 percent). In 1967, copper concentrate totaling 30,700 tons (30,300 tons in 1966) with a grade of 20.57 percent copper (21.27 percent in 1966) was shipped to the smelter of Noranda Mines, Ltd.

The concentrator of Quemont Mining Corp., Ltd., treated 443,800 tons of ore (578,000 tons in 1966) and produced 23,200 tons of concentrate containing 3,900 tons of copper. Normetal Mining Corp., Ltd., milled 348,400 tons of ore averaging 1.50 percent copper. The concentrator also treated 1,000 tons of ore averaging 1.06 percent copper from the adjacent Normetmar property. The 21,000 tons of concentrate produced contained 4,800 tons of copper and was shipped to the Noranda smelter.

Sullico Mines, Ltd., subsidiary of East Sullivan Mines, Ltd., ceased operations on November 29, 1966. In the first 3 months of the year ending August 31, 1967, 160,600 tons of ore was mined and milled, and 931 tons of copper was produced. From January 1949, when operations began until November 1966, the mill treated 15.9 million tons of ore averaging 1.092 percent copper. At Solbec Copper Mines, Ltd., a subsidiary of Hastings Mining and Development Co., Ltd., operations were adversely affected by a work stoppage from September 9, 1966, to March 7, 1967. As a result, only 3,400 tons of the 74,400 tons mined were milled; the remainder was stockpiled. The Solbec treatment plant was sold to Cupra Mines, Ltd., and Solbec ore will be treated on a custom basis until known ore reserves are depleted. During the financial year ended August 31, 1967, Cupra Mines, Ltd., processed 232,300 tons of ore averaging 3.52 percent copper, and 7,700 tons of copper was produced.

Opemiska Copper Mines (Quebec), Ltd., milled 737,300 tons of ore in 1967 compared with 766,100 tons in 1966. The average grade of ore treated was 2.93 percent copper (3.02 percent in 1966). Copper in the concentrate totaled 20,800 tons, compared with 22,300 tons in 1966. The Springer mine produced 54 percent of the ore milled; the Perry mine supplied the remainder.

Lake Dufault Mines, Ltd., milled 493,000 tons of copper-zinc ore averaging 3.96 percent copper. This was an increase of 4,000 tons from the 1966 figure; but 1967 copper production fell to 18,700 tons from the 22,600-ton production of 1966.

Output of copper in Manitoba-Saskatchewan increased 3 percent over that of 1966 and exceeded 50,000 tons for the second successive year.

Hudson Bay Mining and Smelting Co., Ltd., milled 1.59 million tons of ore, compared with 1.69 million tons in 1966, from mines in Manitoba and Saskatchewan. The grade of ore treated rose from 2.49 percent copper in 1966 to 2.64 percent in 1967. Of the ore treated, the Flin Flon mine supplied 59 percent, Chisel Lake 16 percent, Stall Lake 17 percent, and Schist Lake 8 percent. The smelter treated 346,600 tons of Hudson Bay concentrate and residue (371,800 tons in 1966); also, 29,600 tons (26,500) of custom materials were treated. Blister output totaled 38,600 tons and 38,400 tons of refined copper was produced.

Sherritt Gordon Mines, Ltd. milled 1.1 million tons of nickel-copper ore at the Lynn Lake concentrator compared with 1.2 million tons in 1966. Concentrate produced contained 5,400 tons of copper (5,700 tons in 1966).

A high record output of 81,900 tons of copper was attained in British Columbia, 55 percent more than in 1966. Craigmont Mines, Ltd., milled 2 million tons of ore averaging 1.71 percent copper in the fiscal year ending October 31, 1967. Concentrate produced totaled 118,300 tons and averaged 28.12 percent copper. In the 1966 fiscal year, the mines of Craigmont were closed by a strike that began in September 1965 and terminated in April 1966. Consequently, mill throughput was only 1 million tons of 1.54 percent copper, and 53,300 tons of 26.98 percent-copper concentrate was produced. Mining of the open pit was completed in March, and operations were begun at the underground mine. By yearend, 21 percent of the mill feed was supplied by the underground mine, and planned tonnage of 3,000 tons per day was expected by April 1968. The Phoenix Copper Division of The Granby Mining Co., Ltd. treated 714,000 tons, (701,000 in 1966), of ore averaging 0.84 percent copper. Salable copper produced totaled 4,900 tons compared with 4,400 tons in 1966. The concentrator of Granisle Copper, Ltd., located in Copper Island in Babine Lake, British Columbia, began production in mid-November 1966. In its first full year of operation, 1.9 million tons of ore averaging 0.78 percent copper was treated. Concentrate totaling 35,900 tons was shipped to smelters in Japan. Salable copper produced was 12,300 tons.

Development of an underground copper mine by Granduc Operating Co. (a wholly-owned subsidiary of Newmont Mining Corp.) continued during the year. The access tunnel from Tide Lake, about 31 miles from the port of Stewart, was advanced 34,300 feet from its portal. Construction of the 7,000-ton-per-day flotation mill at Tide Lake was well advanced, and underground development to prepare the mine for production was started. Production is expected to begin in late 1969. The Granduc property is leased from Granduc Mines, Ltd., by Granduc Operating Co. and American Smelting and Refining Company in equal shares with Granduc Operating Co. the operator and manager of the property.

The Coast Copper Co., Ltd., 83-percent owned by Cominco, Ltd., produced 290,500 tons of copper averaging 1.4 percent copper. The ore was treated at the Cominco Benson Lake concentrator. Production totaled 12,000 tons of copper concentrate which was shipped to Japan.

In New Brunswick, copper production decreased 21 percent. The Wedge mine of Cominco, Ltd. produced 257,000 tons of ore, and output of concentrate was 20,000 tons. Brunswick Mining and Smelting Corp., Ltd., produced complex zinc-lead-copper ore at the rate of 4,600 tons per day, a record high output. A total of 1.7 million tons of ore averaging 0.29 percent copper was milled, and 5,800 tons of copper concentrate was produced.

Production of copper in Newfoundland was slightly higher than in 1966. Atlantic Coast Copper Corp., Ltd., treated 341,000 tons of ore averaging 1.125 percent copper compared with 319,000 tons and 1.30 percent copper in 1966. Copper output totaled 3,700 tons compared with 3,900 tons in the previous year. The Buchans Unit of American Smelting and Refining Company operated without interruption throughout the year, and produced 9,200 tons of copper concentrate as well as lead concentrate and zinc concentrate.

Exports of copper in ore, concentrate, and matte rose to 128,900 tons (95,000 tons in 1966). Of the total, 93,600 tons (56,500 tons) went to Japan, 15,200 tons (16,600) to Norway, and 7,200 tons (9,700) to the United States. Sweden received 4,900 tons, West Germany 3,100 tons, Spain 2,300 tons, United Kingdom 1,500 tons and Belgium-Luxembourg 1,100 tons. Exports of ingots, bars, and billets were as follows:

Destination:	*Short tons* 1966	1967
United States	84,980	147,101
United Kingdom	91,881	94,006
France	9,193	11,059
Germany, West	700	7,773
Japan	-------	4,798
India	-------	2,952
Switzerland	1,528	1,748
Italy	83	1,548
Brazil	2	1,498
Netherlands	809	1,257
Sweden	448	785
Portugal	449	785
Other countries	618	609
Total	190,691	275,919

In addition, 37,300 tons (46,400 tons in 1966) of rods, strips, sheet, tubing and other shapes was exported, of which 16,500 tons went to the United States, 3,100 tons to Pakistan, 2,800 tons to Switzerland, 2,400 tons to New Zealand, 2,100 tons to United Kingdom, and 2,000 tons to Norway.

Mexico.—Compañia Minera de Cananea, S.A. de C.V. produced 35,500 tons of copper (33,000 tons in 1966). Modifications and expansion at the concentrator to increase output to 41,000 tons was nearing completion.

Asarco Mexicana, S.A. operated without interruption throughout 1967. Ore mined totaled 1.91 million tons (1.92 million in 1966), and 19,300 tons of blister copper was produced compared with 23,000 in 1966. Mine and plant expansion continued, and substantial increases in ore and concentrate production were expected by yearend.

SOUTH AMERICA

Chile.—Despite a number of work stoppages at properties of The Anaconda Company, Chilean mine production in 1967 was virtually the same as that in 1966. As a result, a new production record was set, and the nation was in third place among major producing countries in the world.

In addition to copper exports by the large producers known as Gran Minería (table 46), the small and medium mines shipped 40,200 tons (16,000 tons in 1966) of electrolytic copper, 23,400 tons (27,100) of fire refined copper, and 39,500 tons (33,700) of blister copper.

Output of copper from The Anaconda Company's Chilean mines totaled 397,200 tons, 7 percent below the record 426,100 tons achieved in 1966. At the Chuquicamata mine of Chile Exploration Co., 305,200 tons of copper was produced compared with 334,600 tons in 1966. The 9-percent decrease from the 1966 record output was due to a number of work stoppages. Mine and plant expansion to increase capacity to 390,000 tons annually continued on schedule. Although operations at the El Salvador mine of Andes Copper Mining Co. were interrupted by a 35-day strike, output, nearly 86,000 tons, was virtually unchanged from that of 1966. Improvement and expansion of the mine and the Potrerillos refinery which is scheduled for completion in 1970 will increase capacity to 110,000 tons. La Africana mine of Santiago Mining Co. produced 6,000 tons of copper compared with 5,500 tons in 1966. Stripping operations at the Exotica mine, near the Chuquicamata, began September 1. Production of ore was expected to begin by mid-1970 when approximately 90 million tons of waste will have been removed. An annual mine capacity of 112,500 tons of copper is planned. Ore will be treated on a toll basis at the oxide plant of Chile Exploration Co.

On April 13, 1967, the assets and liabilities of the Kennecott Copper Corp. wholly-owned subsidiary, Braden Copper Co., were transferred to a Chilean company, Sociedad Minera El Teniente, S.A. (El Teniente Mining Company, Inc.). Braden received all of the authorized shares of El Teniente stock and then sold 51 percent to the Chilean Government for $80 million. Kennecott retained a 49-percent interest, and through Braden Copper Co. operates the El Teniente Mine under a property management contract. Kennecott Sales Corp. will represent El Teniente Mining Company in the sale of copper and byproducts. A $230-million expansion program to increase the present capacity of 180,000 tons annually by 60 percent was initiated. The project, scheduled for completion in 1971, includes mine expansion, construction of a new concentrator, expansion of the smelter and related power water installations, and a new highway to replace the existing railroad. Copper production was not affected by the changeover; 13.2 million tons of ore was mined and milled compared with 9.9 million tons in 1966. The average grade of ore rose from 1.75 percent copper in 1966 to 1.83 percent, and a record output of 203,800 tons (160,400 tons in 1966) of copper was produced.

Companía Minera Andina, S.A., 75 percent owned by Cerro Corp., and 25 percent by Corporacion del Cobre, an agency of the Chilean Government, began full-scale construction of the Rio Blanco mine in early 1967. The mine is scheduled for completion in 1971; copper concentrates containing about 65,000 tons of copper annually will be shipped.

Peru.—Operations of the Cerro de Pasco Corp. (Cerro-Peru) were adversely affected by work stoppages, and copper production was slightly lower than in 1966. Purchased ore was the source of 32 percent of the 41,200 tons produced compared with 35 percent and 43,800 tons in 1966. In December, somewhat ahead of schedule, production began at the Cobriza mine, 115 miles southeast of La Oroya. About 1,000 tons of ore are milled daily for shipment to La Oroya for smelting and refining. The concentrate shipped will contain about 10,000 tons of copper annually. In order to handle this production the capacity of La Oroya refinery was being expanded from 43,500 to 56,500 tons of refined copper a year. Until the expansion is completed in late 1968, excess blister copper will be exported.

A record high tonnage of ore was produced at the Toquepala mine of Southern Peru Copper Corp. Ore mined and milled totaled 13.6 million tons averaging 1.18 percent copper compared with 12.6 million tons and 1.22 percent in 1966. Blister copper output was 139,400 tons in 1967 and 125,600 tons in 1966.

A pilot plant was installed at Toquepala for treating ores from the nearby Cuajone property. Cuajone is the larger of Southern Peru's two undeveloped deposits and is estimated to contain 530 million tons of ore containing 1.0 percent copper. Further work toward bringing the property into production will depend upon several factors including legislative developments in Peru with respect to Southern Peru's ability to obtain financing.

Exports of copper from Peru in 1967 were as follows:

	Short tons
Belgium	23,379
Germany, West	24,947
Japan	26,333
Netherlands	6,996
Poland	1,250
Sweden	3,007
United States	123,748
Other countries	987
Total	210,647

EUROPE

Total refined copper produced in Western Europe rose 2 percent over output in 1966; increases of 10 and 3 percent in Belgium and West Germany, respectively, more than offset a 5-percent decrease in the output of the United Kingdom. Total consumpion of refined copper, however, fell 3 percent, the third successive decrease. Of the principal consuming countries, only West Germany, Italy, and Sweden registered increased use. Consumption of refined copper was as follows:

Country	Thousand short tons	
	1966 r	1967 p
Belgium	118.8	95.2
France	321.1	307.0
Germany, West	526.1	568.7
Italy	215.0	233.7
Spain	72.3	67.0
Sweden	92.2	98.0
Switzerland	45.6	43.4
United Kingdom	653.1	566.9
Other	203.1	200.1
Total	2,247.3	2,180.0

p Preliminary. r Revised.
Source: British Bureau of Nonferrous Metal Statistics.

United Kingdom.—Production of refined copper in the United Kingdom was adversely affected by substantially reduced imports from Zambia. Consumption dropped 13 percent and totaled 566,900 tons of primary and secondary copper compared with 653,100 tons in 1966. In addition, 149,400 tons (155,700 tons in 1966) of copper in scrap was used. Output of semimanufactured products consumed 552,200 tons (636,000) of refined copper and 95,500 tons (97,700) of copper scrap. Manufacture of castings, sulfate and miscellaneous products used 14,700 tons (17,100) of refined copper and 53,900 tons (58,100) of scrap. Production of copper sulfate was 24,600 tons (23,000).

Exports of refined copper increased to 63,000 tons (55,500) while reexports dropped to 3,800 tons (4,900). Total exports and reexports were 11 percent larger than in 1966. Imports of unwrought copper totaled 497,800 tons, 12 percent less than in 1966.

AFRICA

Congo (Kinshasa).—The Congolese Government after assuming control of all Union Minière du Haut-Katanga assets on January 1, 1967, conferred them on a new company, Société Générale Congolaise des Minerais (GECOMIN), incorporated under Congolese law and controlled by the Government. Satisfactory operating conditions were maintained in the Katanga region, and copper production increased 2 percent. Total ore production, however, was 9.7 million tons compared with 10.7 million tons in 1966. Increased ore extraction was recorded from the Kamoto open pit in the Western Group and from the Kakanda mine in the Central Group.

The Western Group produced 6.6 million tons of copper and cobalt ore, of which 1.4 million tons came from the Musonoi mine, 3.3 million from Kamoto open pit, and 1.9 million from Ruwe. The Kamoto underground mine produced 51,800 tons of ore. Production from the Kipushi mine in the Southern Group totaled 1.14 million tons. In the Central Group, the Kambove underground mine production totaled 226,500 tons; output at the Kakanda mine increased to 958,000 tons of ore, and the M'sesa mine produced 718,000 tons of ore.

The Kolwezi concentrator produced 557,400 tons of oxide concentrate containing 138,900 tons of copper, 106,600 tons of sulfide concentrate, 42,200 tons of copper, and 105,000 tons of dolomitic oxide concentrate, 20,000 tons of copper. During the year, the Kipushi concentrator produced 189,600 tons of sulfide concentrate containing 53,100 tons of copper. Output at the Kambove concentrator consisted of 98,000 tons of oxide concentrate containing 23,800 tons of copper, 16,500 tons of sulfide concentrate (8,300 tons of copper), and 48,800 tons of dolomitic oxide concentrate containing 9,600 tons of copper. At the Kakanda concentrator, 37,200 tons of copper was produced from 150,300 tons of oxide concentrate. The Ruwe washery produced 18,100 tons of copper from 72,000 tons of fine and gravelly concentrate and 82,400 tons of washed product containing 6,700 tons of copper for reprocessing at the concentrator. The Kambove washing plant produced 41,400 tons of washed products containing 5,800 tons of copper and 7,000 tons of other products containing 400 tons of copper.

Copper production for the year totaled 351,600 tons as follows:

	Short tons
Shituru refinery (electrolytic copper ingots)	177,300
Luilu refinery (cathodes)	89,800
Lubumbashi smelter (blister and other unrefined)	84,500
Total	351,600

Exports of copper rose to 357,500 tons, 4 percent more than in 1966. Of the total, 192,500 tons were shipped through Matadi, Congo (Kinshasa); 38,900 tons through Beira, Mozambique; 48,100 tons through Dar-es-Salaam, Tanzania; and 78,000 tons through Lobito, Angola. Electrolytic copper accounted for 178,400 tons of the total shipments; cathodes, 90,300 tons; and blister and other unrefined, 88,800 tons.

Rhodesia, Southern.—In the year ending September 30, 1967, mines controlled by Messina (Transvaal) Development Co., Ltd., and its subsidiary M.T.D. (Mangula), Ltd., produced 32,300 tons of copper. At Mangula, 1.2 million tons of sulfide ore was produced from the following sources: Stopes 683,000 tons assaying 1.14 percent copper; stope pillars, 398,000 tons, 1.31 percent copper; from development 108,000 tons averaging 0.94 percent copper; and from the open pit 16,000 tons. Mill throughput totaled 1.8 million tons, of which 567,000 tons went to the leach plant. Cement copper containing 5,200 tons of copper was produced and shipped to the Alaska smelter. The Messina mine produced 1.1 million tons of ore averaging 1.18 percent copper, and 1.05 million tons of 1.25 percent copper was milled. Refined copper output totaled 12,900 tons. Production of ore at the Umkondo mine was 96,000 tons assaying 2.48 percent copper. The concentrator treated 100,000 tons of 2.49 percent copper, 6,000 tons in excess of planned throughput. At the Alaska mine, 300,000 tons of ore averaging 1.36 percent copper was produced, and 321,000 tons, 7,000 tons more than in fiscal 1966, was milled. The grade of ore, however, decreased from 1.52 percent copper to 1.38 percent. The Alaska smelter of The Messina Rhodesia Smelting and Refining Co., Ltd., produced 19,400 tons of refined copper, mostly for Mangula and Alaska mines. The tonnage included 4,400 tons of copper produced from cement copper from Mangula.

South Africa, Republic of.—Smelter production of copper by O'okiep Copper Co., Ltd., decreased slightly from 43,500 tons in 1966 to 42,500 tons in 1967. A total of 3.2 million tons of ore averaging 1.51 percent copper was mined and milled. Nearly half the ore treated came from the relatively low-grade Carolusberg mine.

Palabora Mining Co., Ltd., produced 84,400 tons of anode copper during 1967, its first full year of operation. Ore mined totaled 14.6 million tons (13.2 million tons in 1966) averaging 0.71 percent copper (0.78 percent in 1966), and with an average copper content of 0.69 percent of ore reserves estimated to be in excess of 300 million tons. Construction of the tankhouse section of the new 45,000-ton-per year electrolytic refinery was completed, and the first cathodes were produced in October. Most of the refined copper produced will be sold in the Republic of South Africa. The wirebar casting plant under construction is scheduled to begin operations in the first half of 1968, and a continuous rod casting plant is scheduled for completion later in that year.

South-West Africa.—The Tsumeb mine and mill of Tsumeb Corp., Ltd., mined and milled 728,000 tons of complex sulfide and oxide ore averaging 4.32 percent copper. The Kombat operation mined and milled 324,000 tons of ore averaging 1.91 percent copper. Blister copper output totaled 38,000 tons, slightly below the 38,900 tons in 1966. Difficult operating conditions at the Tsumeb mine resulted in an 8.5-percent decrease in production, but output at Kombat was unchanged from 1966.

Uganda.—Kilembe Copper Cobalt, Ltd., milled 953,000 tons of ore and produced 16,000 tons of blister copper compared with 1.03 million tons of ore and 18,000 tons of blister copper in 1966. The decrease was due to problems encountered in the changeover from open stope to cut-and-fill stope mining methods.

Zambia.—Mine production in Zambia was not seriously affected by labor, transport, or fuel problems; output increased 6 percent. A strike which began in August spread rapidly to other mines on the Copper Belt and lasted until September 23. Two short work stoppages of contractors' employees affected operations at the Chambishi mine. The severe shortage of fuel from October 1966 to May 1967 did not affect mining and concentrating operations and a substantial stockpile of concentrates had been built up by yearend. Operations at the Chibuluma mine were curtailed at the end of September when the mine was flooded by the collapse of a stope on the Norrie shaft. Full production was restored December 9.

The Luanshya Division of Roan Selection Trust, Ltd., (RST Group) produced 6.04 million tons of ore averaging 1.92 percent total copper and 0.12 percent oxide copper in the fiscal year ended June 30, 1967. In the same period of 1966, 6.53 million tons averaging 1.85 percent total copper and 0.12 percent oxide copper was produced. The Roan Extension mine supplied 76 percent of the total production in fiscal 1967 and 77 percent in 1966. As in previous years, the Roan Basin supplied the remainder of the ore. Smelter output totaled 98,400 tons compared with 124,700 tons in 1966. Refined copper production was 86,200 tons (109,300 tons in 1966).

In the fiscal year ending June 30, 1967, Chibuluma Mines, Ltd., mined 650,300 tons of ore with an average copper content of 4.31 percent. Production of copper concentrate totaled 88,100 tons, and output of salable copper was 19,800 tons compared with 25,400 tons in 1966.

Mufulira Copper Mines, Ltd., produced 7.19 million tons of ore averaging 2.44 percent total copper and 0.03 percent oxide copper. Block caving methods supplied 36 percent of the ore; open stoping, 29 percent; cascade stoping, 9 percent; and development, 14 percent. Smelter production, including anodes produced from concentrates smelted for Luanshya Division, Chibuluma and Chambishi mines, totaled 149,200 tons (205,100 tons in 1966). Electrolytic copper output was 132,600 tons compared with 162,700 tons in fiscal 1966. Concentrate containing 25,300 tons of copper was stockpiled at yearend.

The Chambishi mine produced 15,500 tons of copper compared with 11,300 tons in fiscal 1966. During the fiscal year, 4.1 million cubic yards of overburden, 351,000 cubic yards of sulfide ore, and 50,000 cubic yards of oxide ore were excavated; a total of 718,600 tons of sulfide ore and 103,700 tons of oxide ore were crushed. The concentrator produced 38,200 tons of concentrate, which was smelted at Luanshya and Mufulira, and 2,600 tons of low grade concentrate for further treatment in the roast-leach-electrowinning plant. Vat leaching operations were disappointing, and a number of modifications were made in the roaster and filter sections of the plant. Cathode copper, including that for Chibuluma, produced by roasting, leaching and electrowinning was 10,100 tons, virtually the same as that produced in 1966.

Ore reserves of the Roan Selection Trust, Ltd., as of June 30, 1967, were as follows:

Mine	Short tons [1]	Percent	
		Total copper [2]	Cobalt
Mufulira	167,067,000	3.37	----
Luanshya (Roan Basin, Roan Extension, and Muliashi Grant)	85,516,000	2.86	----
Chibuluma	6,892,000	4.83	0.18
Chambishi	35,785,000	3.05	----
Baluba	112,000,000	2.41	.16
Kalengwa	600,000	16.00	----

[1] Gross tons subject to mining losses.
[2] Grades subject to dilution in mining.

Ndola Copper Refineries, Ltd., produced 131,400 tons of copper all of which was for associated companies of the RST Group. Output in 1966 was 130,400 tons. The first copper cast from the ASARCO furnace was made in October 1966. Operations were somewhat erratic at the outset, but by the last quarter of the year a record high production was attained.

Nchanga Consolidated Copper Mines, Ltd., mined 6.5 million tons of ore averaging 4.42 percent copper during the year ending March 31, 1967. A total of 2.8

million tons was hoisted from the lower ore body—central and west—of which 60,900 tons was sent to the smelter for flux, and 262,800 tons was mined from the upper ore body. Nchanga open pit supplied 2.1 million tons and Chingola open pit, 1.3 million tons. The Nchanga concentrator treated 5.2 million tons of ore and produced concentrates containing 207,100 tons of copper. Output of finished copper totaled 209,600 tons, 27 percent below the record 288,600 tons in the 1965–66 fiscal year. Of the total, 54,800 tons (83,000 in 1966) was blister, and 154,800 tons (205,600) was electrolytic copper. In the year ending March 31, 1967, Bancroft milled 1.54 million tons of its own copper ore, assaying 3.34 percent sulfide and oxide copper, and 1.20 million tons of Nchanga ore, containing 1.99 percent sulfide copper and 2.00 percent oxide copper. Copper output of 34,800 tons (41,100 in 1966) was reported for Bancroft Mines, Ltd.; production of refined copper totaled 36,700 (40,900) tons. Estimated ore reserves for Nchanga on March 31, 1967, were 259 million tons containing 4.01 percent copper compared with 238 million tons and 4.22 percent copper on March 31, 1966.

Rhokana Corporation, Ltd., mined and milled 5.3 million tons of ore averaging 2.01 percent copper in the fiscal year ending June 30, 1967, compared with 5.5 million tons and 2.16 percent in the same period of 1966. Concentrate production was 293,900 tons, of which 36,300 tons was stockpiled. Stripping of overburden at the Mindola open pit amounted to 373,800 bank cubic yards, and about 54,600 tons of oxide ore were removed and stockpiled. About 80,000 tons of stockpiled ore was sent to the treatment of refractory copper ores (TORCO) plant. Smelter output totaled 239,900 tons of anode and blister copper compared with 290,000 tons in 1966. Of the total, 20,700 tons of blister and 63,500 tons of anodes were recovered for Rhokana; 58,100 tons of blister and 97,500 tons of anodes, for Nchanga, Bancroft, and the RST Group.

ASIA

Cyprus.—Cyprus Mines Corp. continued to conduct mining operations at the Skouriotissa open pit and the Mavrovouni underground mine. Ore produced totaled 870,000 tons compared with 816,000 tons in 1966, but the average grade of the ore milled declined from 1.80 percent in 1966 to 1.69 percent. Present plans call for phasing out production from Mavrovouni and Skouriotissa in 1968 and 1969, respectively. Stripping operations continued at two new ore bodies, known as Apliki and Lefka A, so that ore from these mines will be available when the other properties are closed. Shipments in 1967 consisted of 23,900 tons (41,200 tons in 1966) of copper concentrate, 80,300 tons (91,400 tons) of cupreous pyrite and 8,200 tons (13,900 tons) of copper precipitate. In addition, 451,300 tons (457,000 tons) of pyrite concentrate was produced by flotation.

Japan.—Mine production of copper was 129,700 tons, 5 percent more than in 1966. Smelter production from primary materials increased and totaled 426,300 tons. Refinery output was 681,100 tons, of which 518,100 tons and 163,000 tons were derived from primary and secondary materials, respectively.

Philippines.—Output of copper increased 14 percent to 92,300 tons. Increased production at all mines except Philex Mining Corp. contributed to the high output in 1967. Lepanto Consolidated Mining Co., Ltd., milled 800,600 tons of ore averaging 2.86 percent copper compared with 748,000 tons and 2.89 percent copper in 1966. Copper production rose from 20,400 tons in 1966 to 21,500 tons.

At the open pit and underground mines of Atlas Consolidated Mining & Development Corp., Toledo, Cebu, copper production totaled 33,300 tons compared with 30,400 tons in 1966. Marinduque Mining and Industrial Corp. produced 9,400 and 14,300 tons of copper from the Bagacy and Sipalay projects, respectively. The Philex Mining Corp. produced 6,800 tons compared with 7,400 tons in 1966.

Small outputs of copper were reported by Samar Mining Co., Inc., 1,900 tons; Benguet Consolidated, Inc., 3,300 tons; and other companies, 1,800 tons.

OCEANIA

Australia.—Mine production in Australia decreased 20 percent from that of 1966. A shortage of miners and difficulties encountered in extracting ore from the Mount Isa Mines, Ltd., accounted for much of the decrease.

Mount Isa Mines, Ltd., Queensland, a subsidiary of American Smelting and Refining Company, treated 4.2 million tons of copper and silver-lead-zinc ores and produced 58,300 tons of blister copper in the year ended June 30, 1967. In the same period of 1966, 4.1 million tons of ore were treated and 85,100 tons of blister copper produced. Underground mining operations were adversely affected by a shortage of skilled miners and difficulties associated with extraction of the ore from the high-temperature ground in one of the ore bodies. Output of refined copper by Copper Refineries, Pty., Ltd., fell 27 percent from the record high of 82,400 tons attained in 1966. Production totaled 59,800 tons, of which 28,400 tons was wire bars; 600 tons, cathodes; 14,300 tons, cakes and billets; and 16,500 tons, rod and wire.

The Mount Lyell Mining and Railway Co., Ltd., Tasmania, mined 2.1 million tons of ore averaging 0.81 percent copper from open pit and underground mines in the fiscal year ending June 30, 1967. Recoverable copper in concentrate increased from 15,300 tons to 16,000 tons. Blister copper production was 16,400 tons compared with 15,600 tons in 1966. The electrolytic refinery has been closed since October 1965. In its 37 years of operation, the refinery produced 405,000 tons of cathode and slimes containing 210,000 ounces of gold and 2.3 million ounces of silver. The last cathode production from the electrolytic refinery totaled 4,400 tons in fiscal 1966.

TECHNOLOGY

Technologic developments in the copper industry have responded primarily to a limited number of circumstances the influence of which has rapidly increased in the past few years. Because these circumstances are closely interrelated, any modification in one alters the others. However, they can be listed in three distinct categories, in the order of their influence on the industry. First, the producers are faced with a growing dependence on reserves of decreasing copper content, inconsistent composition, or refractory nature. Second, labor has become a critical factor in all phases of copper production. Third, other materials are competing strongly with copper for its major applications. The industry has reacted to these circumstances with a variety of accomplishments ranging from improvements in mineral exploration to more efficient end use, and some involve nothing more spectacular than the coordinated and consistent application of good engineering practices.

The new Twin Buttes open-pit mine of The Anaconda Company is an example of the quality engineering required for continued expansion of copper reserves. The mine will exploit a 0.5 percent to 0.7 percent copper deposit in a 30,000-tons-per-day operation. Also, 200 million tons of overburden must be removed. These tasks are complicated further by the company's frank recognition of a clear responsibility for landscaping. Thus, the undertaking represents a huge problem in earth moving and waste disposal. The various steps taken to solve this problem have been described in recent publications.[5] The success of the operation depends upon the effective selection, deployment, and integration of modern earth-moving equipment. For instance, optimum utilization of belt conveyors has reduced the substantial cost of transporting ore and overburden. The overburden conveyor consists of two belts. One belt moves 850 feet, up a 25-percent grade, to a surface belt that travels 8,300 feet at a speed of 950 feet per minute. The surface belt is the longest one in use at any U.S. open-pit mine.

Another innovation in ore transporting was put into operation recently at the White Pine mine of Copper Range Co.[6] The Dashaveyor is a robot hauler capable of moving covered cars of ore at speeds up to 3,502 feet per minute. The cars can be loaded or unloaded while in motion.

The extensive modernization program at the White Pine mine provides many other examples of optimum use of avail-

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[5] Engineering and Mining Journal. Anaconda's Twin Buttes. V. 168, No. 4, April 1967, pp. 91–99.

[6] Skilling's Mining Review. Copper Range Co. Mining Operations in 1966. V. 56, No. 14, April 8, 1967, p. 12.

able technology.[7] In 1966, the average grade of ore removed from the mine declined to 22.15 pounds per ton, from the 1965 grade of 23.70 pounds per ton. Many of the steps taken to counter this decline were adaptations from other industrial operations. For instance, White Pine's "values-only" technique is an adaptation of an established coal mining procedure that provides for more selective mining. This method will allow the company to mine only copper-bearing rock and ignore the barren strata. Use of the values-only technique is a significant step in a modernization program that is expected to increase production by at least 20 percent and to add 150 percent to the mine's reserves.

The most impressive single step in White Pine's modernization program is the installation of an 18-foot-diameter, hard-rock tunnel borer. It is the largest rotary boring machine ever sold to a mining company. It is capable of producing a thrust of 1,500,000 pounds on a drill head of 63, 11-inch bits. Boring is guided by laser beam, and the machine has its own dust control and air filtration systems. This machine is a much enlarged and improved version of a 7-foot boring machine that has been proved in the White Pine mine. The smaller machine was originally designed for driving irrigation tunnels, but it was adapted to the White Pine operation, where the compressive hardness of ores begins at 15,000 psi. The new 18-foot borer will be tested on ores with as much as 30,000-psi compressive hardness.

Manpower accounts for about one-third of the cost of producing copper. Thus, automation and mechanization are obvious means of reducing the cost of producing copper. Recognition of such possibilities was evident throughout the industry in 1967. It was especially evident at the modernized plants of Kennecott's Utah Copper Division. The sophisticated instrumentation and control systems at these plants were described, in August 1967, as the most advanced in the copper mining-processing industry.[8] The new crushing and grinding installation illustrates the instrumented control and mechanization that has been used to modernize all of the Division's plants. This plant, which receives 27,000 tons of ore per day, has an interlocking control system and fully automated ore distribution. Instrumental control and automation begins with primary crushing and continues through level control of fine ore at the storage bins. When operations are seriously interrupted at any stage, the interlocking controls give audible warning and shut down critical equipment.

Leaching, an old process for extracting copper, has come increasingly into use as the search for new sources of copper extends to ever lower grades of ore, and even to the massive accumulations of overburden and mill tailings. The increasing dependence on leaching has brought about numerous technological advances that improve or supplement that operation.

Kennecott's new cone-type precipitator for cementing copper from leach solution is one example of the progress made in the leaching process. These 14 foot diameter, 24-feet-tall precipitators have replaced all launder-type units at the modernized Utah Copper Division, where daily production of precipitate copper has been increased from the previous 150,000 pounds to the present 400,000 pounds. Apparently, the cone-type precipitators have been effective in the first complete installation for they are rapidly replacing the older precipitators at other Kennecott operations. According to published information, the cones are more efficient than launders in regard to treatment time and iron consumption.[9] They are also designed to be self-cleaning and to discharge precipitate automatically. The precipitate has been reported to have the following typical analysis: 90 to 95 percent copper, 0.1 to 0.2 percent silica, 0.1 to 0.2 percent Al_2O_3.[10]

The relatively low efficiency of the cementation process, the increasing cost

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[7] Business Week. How White Pine Got to Pay Dirt. July 29, 1967, pp. 120–122.
World Mining. White Pine Copper Buys Robbins Tunnel Borer. V. 3, No. 8, July 1967, p. 40.
American Metal Market. Copper Range Plans 20% Boost in Copper Production This Year. V. 74, No. 52, Mar. 17, 1967, p. 11.

[8] Seck, Heinz R. New Servo-Systems Bolster Kennecott Output. Eng. and Min. J., v. 168, No. 8, August 1967, pp. 75–81.

[9] Spedden, H. R., E. E. Malouf, and J. D. Prater. Use of Cone-Type Copper Precipitators To Recover Copper From Copper-Bearing Solution. Trans. S.M.E., December 1966, pp. 432–438.

[10] Spedden, H. R., E. E. Malouf, and J. D. Prater. Cone-Type Precipitators for Improved Copper Recovery. Min. Eng., v. 18, No. 4, April 1966, pp. 57–62.

of the iron it consumes, and the low quality of the copper it produces have all encouraged search for an alternate process. Three possible alternatives were brought to pilot trials during 1967.[11] All three methods depended on liquid ion exchange to separate a relatively pure copper solution from the impure leach liquor. Two of the processes then recover the copper as cathodes; the other recovers copper powder by hydrogenation of the purified copper-acid solution.

Cyanide-leaching continued to attract attention as a means of recovering a high-grade copper product from low-grade ores, mill tailings, or copper-bearing solutions. The cyanide-leaching technique is sometimes applicable where other methods are impracticable; it can also be used to recover relatively pure metal from a copper sulfate leach solution. Five recently patented cyanide-leaching processes were reviewed in the September 1967 issue of Engineering and Mining Journal. One of these processes was put into use at the White Pine, Michigan, mine of Copper Range Co., where it is reported to be highly efficient.[12]

Another development related to leaching, that is still in the proposal stage deserves mention due to its great potential. The proposal, given the title Project Sloop when it was submitted to the U.S. Atomic Energy Commission by Kennecott Copper Corp. is intended to explore the possibility of using a contained nuclear explosion to fracture low-grade copper deposits into structures suitable for in situ leaching. Several years will be required to complete the experiment and evaluate the results. However, if successful, it will create substantial new copper reserves by lowering the cost of in situ leaching of low-grade copper deposits.

Probably, the most important advance in copper smelting during 1967 was Kennecott Copper Corp.'s decision to use oxygen-enriched air at some of its copper smelters. Two years of pilot trials have indicated that this new practice will increase the smelting rate and reduce air pollution.[13]

The British Non-Ferrous Metals Research Association began production testing a new process during 1967 that could provide substantial savings in the processing of electrorefined copper wire and tube. The Association has experimented successfully with the simultaneous electrorefining and electrodeposition of electrical grade copper into ¼-inch square section rod. By modifying the electrolytic processes, rods have been produced with the ductility and the blemish free surface required for drawing wire.[14]

The general realization that continued accumulation of industrial waste cannot be tolerated has stimulated vigorous efforts to convert waste materials into resources. One simple and direct solution to the problem of accumulating copper concentrator tailings is being tested at Great Salt Lake. Four hundred thousand tons of the tailings have been deposited in the lake to form a 3,600-foot-long, 300-foot-wide test dike. If the dike shows sufficient resistance to erosion by wind and water, concentrator tailing will be used to construct a series of dikes intended to stabilize the lake's water level.[15]

Recent studies have revealed that copper leaching solutions used at mines in Arizona, Utah, and Nevada contain considerable quantities of uranium that can be recovered by ion exchange methods. Preliminary estimates by the Federal Bureau of Mines indicate that as much as 1,000 tons of U_3O_8 can be recovered from the solutions each year at a cost of about $8 per pound.[16]

In the competition for markets, the copper industry recognizes the imperative need of assuring the consumer an adequate and dependable supply. Thus, the first concern of the industry is copper production. However, the search for new uses, and efforts to improve established ones were not neglected in 1967.

Considerable attention was given to developing new markets for three uses where copper has certain natural ad-

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11 Chemical and Engineering News. Ion Exchange Recovery of Copper Promising. V. 45, No. 17, April 17, 1967, pp. 62–64.
Chemical and Engineering News. Pilot Trials Set for Copper Electrowinning. V. 45, No. 26, June 19, 1967, pp. 50–51.

12 Engineering and Mining Journal. Copper Leaching With Cyanide—, V. 168, No. 9, September 1967, pp. 123–127.
Engineering and Mining Journal. Patent Is Granted for Copper Recovery From Discarded Ores. V. 167, No. 7, July 1966, p. 116.

13 Oil, Paint and Drug Reporter. Kennecott To Use Oxygen For Its Copper Smelting. V. 193, No. 1, Jan. 1, 1968, p. 4.

14 Steel. Refining and Forming . . . in One Step. V. 160, No. 16, Apr. 17, 1967, p. 75.

15 Mining Congress Journal. V. 53, No. 5, May 1967, p. 16.

16 Mining Engineering. Byproduct Uranium Recovered With New Ion Exchange Techniques. V. 20, No. 1, January 1968, pp. 73–76.

vantages. Probably, the most promising of these three markets is created by the rapidly expanding use of desalinization. Therefore, the selection of copper alloys for heat exchangers in salt water stills received careful study during the year.[17] The concern over water pollution seems to justify reconsideration of the antifouling advantages of copper as compared to devices that release a toxin into the water surrounding the ship bottom. Therefore, a number of ships have been constructed with a copper-nickel alloy midship section. The service of these hulls will be compared with the service obtained from hulls constructed of steel, aluminum, and reinforced plastic.[18]

Properties that facilitate fabrication, such as soldering, and excellent thermal conductivity have established copper's excellent competitive position in the auto radiator market, but they do not insure that position. Therefore, the industry is continually engaged in the development of new alloys or methods of fabrication that will add to copper's advantage in the radiator market. Thus, in response to the auto makers' insistence on operating radiators at higher temperatures and pressures, the copper industry has been able to propose a copper-zirconium alloy that is expected to withstand twice the present operating pressure at temperatures up to 285° F. The alloy can also be soldered at temperatures well above the required 800° F. A new Mash-lap weld for copper tubing also offers definite advantages to the fabricator of copper radiators. The new welding technique is said to use 8 percent less copper and considerably less solder.[19] Application of the new weld is, of course, not limited to the fabrication of radiators.

The utility of copper in a variety of applications has been improved substantially by the development of a tarnish and corrosion resistant coating with a life of 25 years.[20] The coating has the special advantage of enduring ordinary forming operations without loss of its protective capacity.

Advances in the technology of utilization, as exemplified in the last few paragraphs, reinforce copper's strong market position. However, the inherent characteristics of high thermal and electrical conductivity and excellent ductility remain the major sources of copper's strength in the competition among materials.

Table 2.—Copper produced from domestic ores, by sources

(Short tons)

Year	Mine	Smelter	Refinery
1963	1,213,166	1,258,126	1,219,342
1964	1,246,780	1,301,115	1,259,852
1965	1,351,734	1,402,806	1,335,660
1966	1,429,152	1,429,863	1,353,087
1967	954,064	841,343	846,551

Table 3.—Copper ore and recoverable copper produced, by mining methods

(Percent)

Year	Open pit		Underground	
	Ore	Copper [1]	Ore	Copper [2]
1963	81	74	19	26
1964	82	75	18	25
1965	84	77	16	23
1966	85	80	15	20
1967	86	83	14	17

[1] Includes copper from dump leaching.
[2] Includes copper from in-place leaching.

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[17] Mining Journal (London). C.D.A. Development Projects. V. 268, No. 6871, April 28, 1967, p. 315.

[18] Chemical Week. Launching Copper Into New Markets. V. 100, No. 23, June 10, 1967, pp. 81–82.

[19] American Metal Market. Copper Fighting Back for Radiator. V. 74, No. 100, May 25, 1967, p. 1.

[20] Electronic News. Copper Group Tells of 25-Year Coat. V. 12, No. 619, Sept. 18, 1967, p. 39.

Table 4.—Mine production of recoverable copper in the United States, by months

(Short tons)

Month	1966	1967
January	118,048	122,498
February	106,925	117,887
March	123,324	132,977
April	120,497	131,996
May	126,246	130,444
June	121,451	121,911
July	107,071	66,536
August	114,867	33,001
September	116,777	24,893
October	125,430	23,675
November	123,087	24,323
December	125,429	23,923
Total	1,429,152	954,064

Table 5.—Mine production of recoverable copper in the United States, by States

(Short tons)

State	1963	1964	1965	1966	1967
Alaska	---------	11	32	[1] 2,545	[2] 2,766
Arizona	660,977	690,988	703,377	739,569	501,741
California	916	1,035	1,165	1,078	788
Colorado	4,169	4,653	3,828	4,237	3,993
Idaho	4,172	4,666	5,140	4,961	4,210
Michigan	75,262	69,040	71,749	73,449	58,458
Missouri	1,816	2,059	2,331	3,913	3,215
Montana	79,762	103,806	115,489	128,061	65,483
Nevada	81,738	67,272	71,332	78,720	50,771
New Mexico	83,037	86,104	98,658	108,614	75,008
North Carolina	[3] 70	---------	---------	---------	-------
Oklahoma	---------	---------	[4] 282	(1)	(2)
Oregon	(3)	15	(4)	(1)	-------
Pennsylvania	4,434	3,614	4,354	3,178	4,401
South Dakota	1	---------	---------	---------	-------
Tennessee	13,717	13,889	14,823	15,410	14,600
Utah	203,095	199,588	259,138	265,383	168,609
Washington	(3)	35	30	34	21
Wyoming	---------	5	6	---------	-------
Total	1,213,166	1,246,780	1,351,734	1,429,152	954,064

[1] Alaska, Oklahoma, and Oregon combined to avoid disclosing individual company confidential data.
[2] Alaska and Oklahoma combined to avoid disclosing individual company confidential data.
[3] North Carolina, Oregon, and Washington combined to avoid disclosing individual company confidential data.
[4] Oklahoma and Oregon combined to avoid disclosing individual company confidential data.

Table 6.—Twenty-five leading copper-producing mines in the United States in 1967 in order of output

Rank	Mine	State	County	Operator	Source of copper
1	Utah Copper	Utah	Salt Lake	Kennecott Copper Corp	Copper ore, copper precipitates, gold-silver ore.
2	Morenci	Arizona	Greenlee	Phelps Dodge Corp	Do.
3	Chino	New Mexico	Grant	Kennecott Copper Corp	Copper ore, copper precipitates.
4	San Manuel	Arizona	Pinal	Magma Copper Co	Copper ore.
5	Pima and Northeast	do	Pima	Pima Mining Co	Do.
6	White Fine	Michigan	Ontonagon	White Pine Copper Co	Do.
7	Ray	Arizona	Pinal	Kennecott Copper Corp	Copper ore, copper precipitates.
8	New Cornelia	do	Pima	Phelps Dodge Corp	Copper, gold-silver ores.
9	Berkeley Pit	Montana	Silver Bow	The Anaconda Company	Copper ore.
10	Mission	Arizona	Pima	American Smelting and Refining Co	Do.
11	Copper Queen-Lavender Pit	do	Cochise	Phelps Dodge Corp	Copper ore, copper precipitates.
12	Inspiration	do	Gila	Inspiration Consolidated Copper Co	Do.
13	Mineral Park	do	Mohave	Duval Corp	Do.
14	Butte Hill Copper Mines	Montana	Silver Bow	The Anaconda Company	Do.
15	Silver Bell	Arizona	Pima	American Smelting and Refining Co	Do.
16	Yerington	Nevada	Lyon	The Anaconda Company	Copper ore.
17	Esperanza	Arizona	Pima	Duval Corp	Copper ore, copper precipitates.
18	Bagdad	do	Yavapai	Bagdad Copper Corp	Do.
19	Copperhill	Tennessee	Polk	Tennessee Copper Co	Copper-zinc ore.
20	Copper Cities	Arizona	Gila	Miami Copper Co	Copper ore, copper precipitates.
21	Veteran Pit	Nevada	White Fine	Kennecott Copper Corp	Copper ore.
22	Magma	Arizona	Pinal	Magma Copper Co	Do.
23	Liberty Pit	Nevada	White Pine	Kennecott Copper Corp	Do.
24	Copper Canyon	do	Lander	Duval Corp	Do.
25	Christmas	Arizona	Gila	Inspiration Consolidated Copper Co	Do.

Table 7.—Copper ore sold or treated in the United States in 1967, with copper, gold, and silver content in terms of recoverable metals.[1]

State	Ore sold or treated (short tons)	Recoverable metal content: Copper, Pounds	Copper, Percent	Gold (troy ounces)	Silver (troy ounces)	Value gold and silver per ton of ore
Arizona	74,289,203	901,853,500	0.61	66,933	3,996,587	$0.11
California	15	2,100	7.00	1	63	8.87
Colorado	2,309	193,000	4.18	197	45,608	33.60
Idaho	60,887	2,924,200	2.40	1,880	3,532	1.17
Michigan [2]	7,398,008	116,916,000	.79	-------	301,992	.06
Montana	9,014,687	118,056,000	.65	8,304	1,817,009	.34
Nevada	9,161,699	97,640,800	.53	28,466	236,441	.15
New Mexico	4,452,994	61,084,800	.69	2,314	47,354	.03
Tennessee [3]	1,605,590	29,200,000	.91	181	130,078	.13
Utah	20,895,061	274,675,800	.66	213,122	1,762,264	.49
Other States	185,644	5,532,000	1.49	-------	10,495	.09
Total	127,066,097	1,608,078,200	.63	321,398	8,351,423	.19

[1] Excludes copper recovered from precipitates as follows: Arizona, 98,718,600 pounds; Montana, 12,782,000 pounds; New Mexico, 85,209,500 pounds; Nevada, 3,871,000 pounds; and Utah, 57,427,500 pounds.
[2] Includes tailings.
[3] Copper-zinc ore.

Table 8.—Copper ore concentrated in the United States in 1967, with content in terms of recoverable copper [1]

State	Ore concentrated (Short tons)	Recoverable copper content: Pounds	Percent
Arizona	74,085,317	888,410,300	0.60
Colorado	200	3,900	.98
Idaho	60,808	2,916,200	2.40
Michigan [2]	7,398,008	116,916,000	.79
Montana	9,006,661	117,529,000	.65
Nevada	9,108,624	96,599,100	.53
New Mexico	4,417,581	61,036,700	.69
Tennessee [3]	1,605,590	29,200,000	.91
Utah	20,894,964	274,658,000	.66
Other States	185,644	5,532,000	1.49
Total	126,763,397	1,592,801,200	.63

[1] 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.
[2] Includes tailings.
[3] Copper-zinc ore.

Table 9.—Copper ore shipped to smelters in the United States in 1967 with content in terms of recoverable copper

State	Ore shipped to smelters: Short tons	Recoverable copper content: Pounds	Percent
Arizona	203,886	13,443,200	3.30
California	15	2,100	7.00
Colorado	2,109	189,100	4.48
Idaho	79	8,000	5.06
Montana	8,026	527,000	3.28
Nevada	[1] 53,075	1,041,700	.98
New Mexico	[1] 35,413	48,100	.07
Utah	97	17,800	9.18
Total	302,700	15,277,000	2.52

[1] Primarily smelter fluxing material.

Table 10.—Copper ores produced in the United States and average yield in copper, gold, and silver

Year	Smelting ores: Short tons	Smelting ores: Yield in copper, percent	Concentrating ores: Short tons [1]	Concentrating ores: Yield in copper, percent	Total: 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
1963	615,570	3.32	141,284,319	0.73	146,449,540	0.74	0.0030	0.070	$0.19
1964	553,493	3.20	149,834,616	.72	155,200,464	.73	.0028	.074	.19
1965	624,629	2.43	172,661,569	.70	173,286,198	.70	.0033	.074	.21
1966	549,223	2.34	[2]186,416,819	.66	186,966,042	.67	.0029	.071	.19
1967	302,700	2.52	[2]126,763,397	.63	127,066,097	.63	.0025	.066	.19

[1] Includes some ore classed as copper-zinc and some 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.

Table 11.—Copper produced by primary smelters in the United States

(Short tons)

Year	Domestic	Foreign	Secondary	Total
1963	1,258,126	38,574	97,986	1,394,686
1964	1,301,115	37,318	88,365	1,426,798
1965	1,402,806	31,244	93,895	1,527,945
1966	1,429,863	36,573	114,671	1,581,107
1967	841,343	20,997	70,746	933,086

Table 12.—Primary and secondary copper produced by primary refineries in the United States

(Short tons)

	1963	1964	1965	1966	1967
Primary:					
From domestic ores, etc.: [1]					
Electrolytic	1,095,377	1,139,494	1,200,532	1,213,918	754,175
Lake	64,146	62,598	71,241	69,126	54,004
Casting	59,819	57,760	63,887	70,043	38,372
Total	1,219,342	1,259,852	1,335,660	1,353,087	846,551
From foreign ores, etc.: [1]					
Electrolytic	357,015	371,003	332,593	321,302	258,473
Casting and best select	19,994	25,540	43,540	36,595	27,958
Total refinery production of primary copper	1,596,351	1,656,395	1,711,793	1,710,984	1,132,982
Secondary:					
Electrolytic [2]	240,620	276,954	368,232	409,986	318,709
Casting	17,993	23,172	19,879	27,977	24,568
Total secondary	258,613	300,126	388,111	437,963	343,277
Grand total	1,854,964	1,956,521	2,099,904	2,148,947	1,476,259

[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 13.—Copper cast in forms at primary refineries in the United States

Form	1966		1967	
	Thousand short tons	Percent	Thousand short tons	Percent
Billets	246	11	149	10
Cakes	236	11	98	7
Cathodes	157	7	136	9
Ingots and ingot bars	186	9	154	10
Wire bars	1,305	61	926	63
Other forms	19	1	13	1
Total	2,149	100	1,476	100

Table 14.—Production, shipments, and stocks of copper sulfate

(Short tons)

Year	Production		Shipments	Stocks Dec. 31 [1]
	Quantity	Copper content		
1963	41,636	10,409	41,188	5,480
1964	41,908	10,477	43,684	3,416
1965	47,340	11,835	45,640	5,048
1966	51,676	12,919	51,816	4,464
1967	40,128	10,032	40,644	3,516

[1] Some small quantities are purchased and used by producing companies, so that the figures given do not balance exactly.

Table 15.—Byproduct sulfuric acid [1] (100-percent basis) produced in the United States

(Short tons)

Year	Copper plants [2]	Zinc plants [3]	Total	Year	Copper plants [2]	Zinc plants [3]	Total
1963	358,503	861,763	1,220,266	1966	469,728	983,118	1,452,846
1964	330,273	924,100	1,254,373	1967	348,497	900,170	1,248,667
1965	369,321	961,591	1,330,912				

[1] Includes acid from foreign materials.
[2] Includes acid produced at a lead smelter. Excludes acid made from pyrites concentrates in Arizona, Montana, Tennessee, and Utah.
[3] Excludes acid made from native sulfur.

Table 16.—Secondary copper produced in the United States

(Short tons)

	1963	1964	1965	1966	1967
Copper recovered as unalloyed copper	314,643	366,197	462,811	509,084	423,054
Copper recovered in alloys [1]	659,783	726,824	790,439	825,165	736,853
Total secondary copper	974,426	1,093,021	1,253,250	1,334,249	1,159,907
Source:					
New scrap	552,583	619,500	739,814	799,389	677,248
Old scrap	421,843	473,521	513,436	534,860	482,659
Percentage equivalent of domestic mine output	80	88	93	93	122

[1] Includes copper in chemicals, as follows: 1963, 10,191; 1964, 7,755; 1965, 6,129; 1966, 6,043; and 1967, 4,965.

Table 17.—Copper recovered from scrap processed in the United States, by kinds of scrap and form of recovery

(Short tons)

Kind of scrap	1966	1967	Form of recovery	1966	1967
New scrap:			As unalloyed copper:		
Copper-base	789,262	667,080	At primary plants	437,963	343,277
Aluminum-base	10,000	10,000	At other plants	71,121	79,777
Nickel-base	117	157			
Zinc-base	10	11	Total	509,084	423,054
Total	799,389	677,248	In brass and bronze	783,236	700,636
			In alloy iron and steel	2,167	2,805
Old scrap:			In aluminum alloys	33,432	28,148
Copper-base	528,097	476,471	In other alloys	287	299
Aluminum-base	6,000	5,500	In chemical compounds	6,043	4,965
Nickel-base	726	623			
Tin-base	18	15	Total	825,165	736,853
Zinc-base	19	50			
			Grand total	1,334,249	1,159,907
Total	534,860	482,659			
Grand total	1,334,249	1,159,907			

Table 18.—Copper recovered as refined copper, in alloys and in other forms from copper-base scrap processed in the United States

(Short tons)

	From new scrap		From old scrap		Total	
	1966	1967	1966	1967	1966	1967
Recovered by—						
Secondary smelters	63,329	60,474	250,890	250,514	314,219	310,988
Primary copper producers	249,330	216,385	188,633	126,892	437,963	343,277
Brass mills	452,916	372,744	18,969	39,830	471,885	412,574
Foundries and manufacturers	22,060	15,687	64,997	56,142	87,057	71,829
Chemical plants	1,627	1,790	4,608	3,093	6,235	4,883
Total	789,262	667,080	528,097	476,471	1,317,359	1,143,551

Table 19.—Production of secondary copper and copper-alloy products in the United States

(Short tons)

Item produced from scrap	1966	1967
Unalloyed copper products:		
Refined copper by primary producers	437,963	343,277
Refined copper by secondary smelters	53,361	63,337
Copper powder	15,711	14,994
Copper castings	2,049	1,446
Total	509,084	423,054
Alloyed copper products:		
Brass and bronze ingots:		
Tin bronze	17,871	19,137
Leaded tin bronze	19,291	17,964
Leaded red brass and semired brass	190,801	164,244
High-leaded tin bronze	42,937	34,588
Leaded yellow brass	18,470	18,626
Manganese bronze	16,595	16,246
Aluminum bronze	11,817	12,358
Nickel silver	4,650	5,251
Low brass	3,738	2,772
Silicon and conductor bronze	8,250	7,367
Copper-base hardeners and special alloys	17,146	13,339
Total	351,566	311,892
Brass-mill products	613,984	531,139
Brass and bronze castings	64,276	54,342
Brass powder	1,325	978
Copper in chemical products	6,043	4,965
Grand total	1,546,278	1,326,370

Table 20.—Composition of secondary copper-alloy production

(Short tons)

	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze production: [1]							
1966	274,571	17,217	23,572	35,174	951	81	351,566
1967	244,974	14,583	20,098	31,280	885	72	311,892
Secondary metal content of brass-mill products:							
1966	471,976	363	5,280	129,956	6,378	31	613,984
1967	412,554	485	2,912	108,912	6,256	20	531,139
Secondary metal content of brass and bronze castings:							
1966	50,789	2,357	6,660	4,357	50	63	64,276
1967	42,709	2,006	5,621	3,190	49	45	53,620

[1] About 90 percent from scrap and 10 percent from other than scrap.

Table 21.—Stocks and consumption of purchased copper scrap in the United States in 1967
(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks Dec. 31
Secondary smelters:						
No. 1 wire and heavy copper	3,156	43,394	5,524	37,642	43,166	3,384
No. 2 wire, mixed heavy and light copper	2,510	80,653	15,053	64,643	79,696	3,467
Composition or red brass	4,404	87,819	17,938	68,933	86,871	5,352
Railroad-car boxes	159	921	-------	872	872	208
Yellow brass	7,465	64,489	9,036	55,691	64,727	7,227
Cartridge cases and brass	162	1,205	-------	1,073	1,073	294
Auto radiators (unsweated)	3,428	54,018	-------	54,221	54,221	3,225
Bronze	2,253	34,565	5,776	27,640	33,416	3,402
Nickel silver	893	5,576	615	4,888	5,503	966
Low brass	276	4,417	3,226	932	4,158	535
Aluminum bronze	116	621	265	232	497	240
Low-grade scrap and residues	6,238	49,055	39,613	8,867	48,480	6,813
Total	31,060	426,733	97,046	325,634	422,680	35,113
Primary producers:						
No. 1 wire and heavy copper	6,977	W	W	W	W	3,880
No. 2 wire, mixed heavy and light copper	17,045	211,426	145,780	68,867	214,647	13,824
Refinery brass	1,190	W	W	W	W	398
Low-grade scrap and residues	19,188	149,388	50,547	102,322	152,869	15,707
Total	44,400	469,349	267,907	212,033	479,940	33,809
Brass mills: [1]						
No. 1 wire and heavy copper	4,983	129,352	107,009	22,343	129,352	14,499
No. 2 wire, mixed heavy and light copper	10,339	32,867	31,881	986	32,867	5,744
Yellow brass	18,902	214,720	214,720	------	214,720	27,013
Cartridge cases and brass	5,047	97,851	73,690	24,161	97,851	8,272
Bronze	791	3,872	3,872	-------	3,872	1,041
Nickel silver	7,511	22,354	22,354	-------	22,354	9,518
Low brass	2,986	31,488	31,488	-------	31,488	5,868
Aluminum bronze	432	206	206	-------	206	738
Mixed alloy scrap	11,765	6,470	6,470	-------	6,470	7,091
Total [1]	62,756	539,180	491,690	47,490	539,180	79,784
Foundries, chemical plants, and other manufacturers:						
No. 1 wire and heavy copper	3,394	22,927	8,007	14,973	22,980	3,341
No. 2 wire, mixed heavy and light copper	2,538	17,797	4,389	14,055	18,444	1,891
Composition or red brass	788	4,782	1,147	3,784	4,931	639
Railroad-car boxes	1,056	25,777	-------	25,000	25,000	1,833
Yellow brass	1,262	6,561	3,487	3,340	6,827	996
Auto radiators (unsweated)	2,643	7,043	-------	8,171	8,171	1,515
Bronze	430	2,120	982	1,073	2,055	495
Nickel silver	4	134	-------	133	133	5
Low brass	126	811	174	639	813	124
Aluminum bronze	240	615	357	247	604	251
Low-grade scrap and residues	3,745	8,768	3,877	5,849	9,726	2,787
Total	16,226	97,335	[2] 22,420	[2] 77,264	[2] 99,684	13,877
Grand total:						
No. 1 wire and heavy copper [3]	18,510	195,673	120,540	74,958	195,498	25,104
No. 2 wire, mixed heavy and light copper	32,432	342,743	197,103	148,551	345,654	24,926
Composition or red brass	5,192	92,601	19,085	72,717	91,802	5,991
Railroad-car boxes	1,215	26,698	-------	25,872	25,872	2,041
Yellow brass	27,629	285,770	227,243	59,031	286,274	35,236
Cartridge cases and brass	5,209	99,056	73,690	25,234	98,924	8,566
Auto radiators (unsweated)	6,071	61,061	-------	62,392	62,392	4,740
Bronze	3,474	40,557	10,630	28,713	39,343	4,938
Nickel silver	8,408	28,064	22,969	5,021	27,990	10,489
Low brass	3,388	36,716	34,888	1,571	36,459	6,527
Aluminum bronze	788	1,442	828	479	1,307	1,229
Low-grade scrap and residues [3] [4]	30,361	207,211	94,037	117,038	211,075	25,705
Mixed alloy scrap	11,765	6,470	6,470	-------	6,470	7,091
Total	154,442	1,532,597	879,063	662,421	1,541,484	162,583

W Withheld to avoid disclosing individual company confidential data.
[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 876 tons of new and 2,226 old; copper-base alloy scrap 3,676 tons of new and 3,712 old.
[3] Excludes data withheld to avoid disclosing individual company confidential data.
[4] Includes stocks of refinery brass.

Table 22.—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
1966:						
Copper scrap	683,907	624,023	---------	124,845	435,165	1,867,940
Refined copper [1]	-------	928,490	1,370,842	40,931	19,691	2,359,954
Brass ingot	-------	6,559	---------	[2] 335,435	-------	341,994
Slab zinc	-------	170,649	---------	4,381	10,522	185,552
Miscellaneous	-------	-------	---------	150	9,050	9,200
1967:						
Copper scrap	479,940	539,180	---------	99,684	422,680	1,541,484
Refined copper [1]	-------	650,374	1,240,236	36,004	8,978	1,935,592
Brass ingot	-------	4,361	---------	[2] 319,536	-------	323,897
Slab zinc	-------	117,638	---------	3,807	10,092	131,537
Miscellaneous	-------	-------	---------	150	6,728	6,878

[1] Detailed information on consumption of refined copper will be found in table 26.
[2] Shipments to foundries by smelters plus decrease in stocks at foundries.

Table 23.—Foundry consumption of brass ingot, by types, in the United States

(Short tons)

	1963	1964	1965	1966	1967
Tin bronze	8,295	9,334	9,999	11,174	10,691
Leaded tin bronze	25,655	27,683	31,331	31,699	28,048
Leaded red brass	163,153	176,423	181,773	174,270	145,579
High-leaded tin bronze	18,850	21,014	22,930	23,595	20,928
Leaded yellow brass	11,815	12,938	19,767	17,349	15,866
Manganese bronze	8,497	9,264	9,816	10,331	10,254
Hardeners	3,889	4,071	4,349	4,035	4,096
Nickel silver	2,789	3,084	3,398	3,577	4,094
Aluminum bronze	8,053	7,820	8,122	8,361	7,953
Low brass	1,316	1,929	2,503	3,575	2,761
Total	252,312	273,560	293,988	287,966	250,270

Table 24.—Foundry consumption of brass ingot by types, refined copper, and copper scrap, in the United States in 1967, 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	121	547	3,698	162	1,666	128	13	12	393	60	6,800	306	878
Massachusetts	691	1,689	7,884	472	49	261	52	276	82	295	11,751	487	870
Maine, New Hampshire, Rhode Island, Vermont	95	281	2,679	210	195	296	3	364	17	63	4,203	79	13
Total	907	2,517	14,261	844	1,910	685	68	652	492	418	22,754	872	1,761
Middle Atlantic:													
New Jersey	997	492	3,207	250	110	293	21	74	139	129	5,712	1,873	5,178
New York	1,081	1,725	14,089	971	421	1,033	47	149	1,148	170	20,834	1,483	5,769
Pennsylvania	1,563	6,913	17,226	3,459	1,118	1,573	1,364	470	1,161	232	35,079	6,656	11,992
Total	3,641	9,130	34,522	4,680	1,649	2,899	1,432	693	2,448	531	61,625	10,012	22,939
East North Central:													
Illinois	451	1,556	14,211	775	103	562	161	188	860	330	19,197	1,608	5,004
Indiana	80	571	8,628	783	131	297	1,030	335	33	64	11,952	1,514	4,855
Michigan	284	245	6,712	473	2,746	1,722	289	23	518	70	13,082	3,403	1,084
Ohio	1,470	9,257	18,087	7,391	177	1,509	228	86	604	230	39,039	4,858	7,912
Wisconsin	1,168	438	7,081	2,354	1,272	273	494	1,318	282	477	15,157	5,580	1,302
Total	3,453	12,067	54,719	11,776	4,429	4,363	2,202	1,950	2,297	1,171	98,427	16,963	20,157
West North Central:													
Iowa, Kansas, Minnesota	436	181	5,087	1,065	90	353	139	43	260	177	6,919	771	1,533
Missouri, Nebraska, South Dakota	36	172	1,248		340	127			667		3,502	561	9,328
Total	472	353	6,335	1,065	430	480	139	43	927	177	10,421	1,332	10,861
South Atlantic:													
Delaware, District of Columbia, Florida, Georgia, Maryland	669	843	572	36	125	121	13	32	99	40	2,535	391	369
North Carolina, South Carolina, Virginia, West Virginia	146	164	6,516	333	934	193		----	331		8,632	1,973	6,101
Total	815	1,007	7,088	369	1,059	314	13	32	430	40	11,167	2,364	6,470
East South Central:													
Alabama, Kentucky, Mississipi, Tennessee	278	863	10,248	1,143	4,613	412	59	219	47	83	17,965	267	8,379
West South Central:													
Arkansas, Louisiana, Oklahoma, Texas	469	1,317	7,555	359	754	411	17	407	871	143	12,303	702	4,785
Mountain:													
Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah	124	50	382	30	64	91	3	2	20	93	859	57	557

Pacific:													
California	491	681	10,254	462	897	436	163	96	273	71	13,823	312	9,956
Oregon and Washington	41	63	215	200	61	163	-----		148	34	926	723	3,329
Total	532	744	10,469	662	958	599	163	96	421	105	14,749	1,035	13,285
Grand total	10,691	28,048	145,579	20,928	15,866	10,254	4,096	4,094	7,953	2,761	250,270	33,604	89,194

Table 25.—Primary refined copper supply and withdrawals on domestic account

(Short tons)

	1963	1964	1965	1966	1967
Production from domestic and foreign ores, etc.	1,596,351	1,656,395	1,711,793	1,710,984	1,132,982
Imports [1]	119,219	139,974	137,443	162,602	330,347
Stock Jan. 1 [1]	71,000	52,000	37,000	35,000	43,000
Total available supply	1,786,570	1,848,369	1,886,236	1,908,586	1,506,329
Copper exports [1]	311,479	316,230	324,965	273,071	159,353
Stock Dec. 31 [1]	52,000	37,000	35,000	43,000	27,000
Total	363,479	353,230	359,965	316,071	186,353
Apparent withdrawals on domestic account [2]	1,423,000	1,495,000	1,526,000	1,593,000	1,320,000

[1] May include some copper refined from scrap.
[2] Includes copper delivered by industry to the Government stockpiles.

Table 26.—Refined copper consumed by classes of consumers

(Short tons)

Year and class of consumer	Cathodes	Wire bars	Ingots and ingot bars	Cakes and slabs	Billets	Other	Total
1966:							
Wire mills	2,698	1,356,428	10,811	-------	22	883	1,370,842
Brass mills	180,350	39,503	211,500	234,156	262,834	147	928,490
Chemical plants	-------	---------	1,586	-------	-------	732	2,318
Secondary smelters	9,408	---------	9,968	111	-------	204	19,691
Foundries	2,101	57	15,678	(2)	[3] 395	1,261	19,492
Miscellaneous [1]	1,407	52	9,489	(2)	[3] 774	7,399	19,121
Total	195,964	1,396,040	259,032	234,267	264,025	10,626	2,359,954
1967:							
Wire mills	6,058	1,226,370	6,964	-------	-------	844	1,240,236
Brass mills	152,310	28,090	115,640	153,146	200,906	282	650,374
Chemical plants	-------	---------	1,386	-------	-------	1,014	2,400
Secondary smelters	4,908	---------	3,816	-------	-------	254	8,978
Foundries	1,873	93	13,096	(2)	[3] 171	893	16,126
Miscellaneous [1]	1,684	80	8,235	(2)	[3] 948	6,531	17,478
Total	166,833	1,254,633	149,137	153,146	202,025	9,818	1,935,592

[1] Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and miscellaneous manufacturers.
[2] Included with "Billets" to avoid disclosing individual company confidential data.
[3] Includes "Cakes and slabs" to avoid disclosing individual company confidential data.

Table 27.—Stocks of copper at primary smelting and refining plants in the United States, Dec. 31

(Short tons)

Year	Refined copper [1]	Blister and materials in process of refining [2]
1963	52,000	252,000
1964	37,000	246,000
1965	35,000	246,000
1966	43,000	270,000
1967	27,000	220,000

[1] May include some copper refined from scrap.
[2] Includes copper in transit from smelters in the United States to refineries therein.

Table 28.—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)
1963	474,875	100,357	382,692	163,558	28,982
1964	429,989	107,244	381,677	225,366	−69,810
1965	462,519	129,349	395,396	288,681	−92,209
1966	558,599	134,732	407,345	361,559	−75,573
1967	479,572	98,716	415,765	269,474	−106,951

[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 29.—Average weighted prices of copper deliveries[1]

(Cents per pound)

Year	Domestic copper	Foreign copper
1963	30.8	30.7
1964	32.6	33.0
1965	35.4	36.5
1966	36.2	50.5
1967	38.2	48.2

[1] Covers copper produced in the United States and delivered here and abroad and copper produced abroad and delivered in the United States.
Source: Bureau of Mines reports from copper selling agencies, 1963–65 and Metals Week 1966 and 1967.

Table 30.—Average monthly quoted prices of electrolytic copper for domestic and export shipments, f.o.b. refineries, in the United States and for spot copper at London

(Cents per pound)

Month	1966				1967			
	Domestic, f.o.b. refinery[1]	Domestic, f.o.b. refinery[2]	Export, f.o.b. refinery[2]	London, spot[3,4]	Domestic, f.o.b. refinery[1]	Domestic, f.o.b. refinery[2]	Export, f.o.b. refinery[2]	London spot[3,4]
January	35.82	36.131	41.770	76.18	37.64	37.872	49.839	56.17
February	35.82	36.045	42.845	85.01	37.95	38.103	50.201	55.18
March	35.82	36.124	44.298	84.78	37.95	38.076	46.692	49.70
April	35.82	36.150	43.438	86.15	37.95	38.170	42.996	43.81
May	35.82	36.033	55.433	75.08	37.95	38.118	43.233	46.88
June	35.82	35.928	57.278	76.54	37.95	38.083	43.802	45.87
July	35.82	36.016	57.718	70.78	37.95	38.295	43.388	45.00
August	35.82	35.964	48.797	53.93	37.95	39.090	44.966	47.09
September	35.82	36.089	47.086	50.92	37.95	(5)	45.450	47.77
October	35.82	36.333	52.376	57.60	37.95	(5)	47.431	51.29
November	35.82	36.988	53.342	58.79	37.95	(5)	54.692	62.20
December	35.82	36.245	49.763	54.84	37.95	(5)	53.615	60.16
Average	35.82	36.170	49.512	69.04	37.92	38.226	47.192	51.19

[1] American Metal Market.
[2] Metals Week.
[3] Metal Bulletin (London).
[4] Based on average monthly rates of exchange by Federal Reserve Board.
[5] Suspended.

Table 31.—U.S. exports of copper by classes and countries

(Short tons)

Year and country	Ore, concentrates, matte (copper content)	Refined	Scrap	Pipes and tubing	Plates and sheets	Wire and cable, bare	Wire and cable, insulated	Other copper manufactures [1]
1965	15,510	324,965	31,760	895	930	4,560	16,388	6,582
1966	2,149	273,071	17,968	520	311	4,192	23,252	6,934
1967:								
Africa	------	-------	------	12	2	170	1,696	81
Argentina	------	241	------	---	----	6	50	2
Belgium-Luxembourg	9,176	2,794	242	2	---	10	34	26
Brazil	------	6,918	31	---	---	27	31	2
Canada	10,407	4,785	13,722	97	75	487	7,245	1,062
Colombia	3	1	-------	25	1	210	63	858
France	------	18,821	------	2	(2)	307	161	20
Germany, West	10,837	19,497	131	115	5	13	291	14
India	------	6,415	282	94	---	331	366	77
Italy	6	27,200	70	11	12	14	103	18
Japan	20,846	29,214	2,436	1	30	1	251	79
Mexico	1	975	7	6	59	163	553	37
Netherlands	453	3,290	------	(2)	2	2	190	11
Oceania	------	124	------	1	6	13	273	97
Peru	------	-------	------	10	8	8	204	18
Spain	5,088	336	541	4	---	7	90	3
Sweden	2,719	1,126	56	1	---	75	57	3
Switzerland	------	1,341	------	9	---	275	57	1
United Kingdom	156	26,588	18	1	30	33	152	26
Other	------	9,687	80	324	17	2,819	5,309	4,135
Total	59,692	159,353	17,616	715	247	4,971	17,176	6,570

[1] Does not include wire cloth 1965, 894,753,210 square feet ($1,296,498); 1966, 948,388 square feet ($503,074); 1967, 1,394,086 square feet ($1,013,363).
[2] Less than ½ unit.

Table 32.—U.S. exports of copper, by classes

Year	Ore, concentrates, and matte (copper content)		Refined copper and semimanufactures		Other copper manufactures [1]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1965	15,510	$8,369	379,498	$317,337	6,796	$7,062	401,804	$332,768
1966	2,149	927	319,314	338,184	6,934	7,804	328,397	346,915
1967	59,692	32,951	200,078	213,604	6,570	7,472	266,340	254,027

[1] Does not include wire cloth: 1965, 894,753,210 square feet ($1,296,498); 1966, 948,388 square feet ($503,074); 1967: 1,394,086 square feet ($1,013,363).

Table 33.—U.S. exports of copper-base alloy (including brass and bronze), by classes

Class	1966		1967	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Ingots	1,441	$1,520	1,211	$1,253
Scrap and waste	43,670	27,628	64,877	40,114
Bars, rods, and shapes	1,728	3,058	2,179	3,546
Plates, sheets, and strips	1,194	3,356	1,113	3,523
Pipes and tubing	1,932	3,345	2,092	3,986
Pipe fittings	2,282	6,707	2,846	8,573
Plumbers' brass goods	887	2,014	914	2,161
Welding rods and wire	1,116	2,129	910	2,466
Castings and forgings	473	887	401	881
Powder and flakes	1,099	1,743	1,036	1,571
Foil	489	1,376	634	1,609
Articles of copper and copper base alloys, n.e.c.	(1)	6,306	(1)	6,126
Total	56,311	60,069	78,213	75,809

[1] Quantity not reported.

Table 34.—U.S. exports of unfabricated copper-base alloy [1] ingots, bars, rods, shapes, plates, sheets, and strips

Year	Short tons	Value (thousands)
1965	7,027	$11,341
1966	4,363	7,934
1967	4,503	8,322

[1] Includes brass and bronze.

Table 35.—U.S. exports of copper sulfate (blue vitriol)

Year	Short tons	Value (thousands)
1965	2,135	$1,288
1966	3,563	1,725
1967	979	776

Table 36.—U.S. imports and exports of brass and copper scrap

(Short tons)

	1965	1966	1967
Exports:			
Copper-base alloy scrap (new and old)	65,325	43,670	64,877
Copper scrap	31,760	17,968	17,616
Imports for consumption:			
Brass scrap (gross weight)	2,275	7,360	3,505
Copper scrap (copper content)	17,667	23,908	16,655

Table 37.—U.S. imports for consumption and exports of copper scrap by countries

(Short tons)

Country	Imports						Exports			
	Unalloyed copper scrap (copper content)		Copper alloy scrap				Unalloyed copper scrap		Copper alloy scrap	
			gross weight		copper content					
	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967
Australia	84	---	---	---	---	---	---	---	36	---
Belgium-Luxembourg	---	---	---	---	---	---	760	242	3,598	4,180
Canada	17,404	14,742	6,670	2,025	4,548	1,414	1,211	13,722	1,665	11,210
France	---	---	---	55	---	39	85	---	148	26
Germany, West	7	138	---	---	---	---	2,700	131	4,187	4,008
India	---	---	---	---	---	---	61	282	31	408
Italy	1	---	---	---	---	---	567	70	1,967	1,410
Japan	541	---	---	24	---	17	6,303	2,436	24,896	37,805
Mexico	2,722	1,388	127	532	99	376	17	7	83	39
Netherlands	73	2	---	---	---	---	---	---	394	330
Spain	77	52	---	---	---	---	2,600	541	2,207	884
Sweden	---	---	---	---	---	---	75	56	3,416	2,615
United Kingdom	52	27	178	142	108	101	187	18	409	91
Yugoslavia	---	---	---	---	---	---	3,243	50	238	1,126
Other countries	2,947	306	385	727	301	602	159	61	395	745
Total	23,908	16,655	7,360	3,505	5,056	2,549	17,968	17,616	43,670	64,877

Table 38.—U.S. imports [1] of copper (unmanufactured), by classes and countries

(Short tons, copper content)

	Ore, concentrates	Matte	Blister	Refined	Scrap	Total
1965	36,425	508	332,560	137,443	16,205	523,141
1966:						
Australia	1,202	---	---	---	28	1,230
Bolivia	2,462	---	---	---	---	2,462
Canada	7,746	351	596	85,723	22,558	116,974
Chile	818	---	182,662	21,326	2,241	207,047
Germany, West	---	---	6	8,120	7	8,133
Japan	---	---	348	442	54	844
Mexico	83	---	7,925	---	3,182	11,190
Netherlands	---	---	56	1,370	98	1,524
Norway	---	---	---	1,158	---	1,158
Peru	6,863	---	95,975	23,782	14	126,634
Philippines	21,023	11	---	---	21	21,055
South Africa, Republic of	228	---	50,088	336	---	50,652
United Kingdom	---	---	957	14,104	52	15,113
Other	1,146	9	11,304	6,241	791	19,491
Total	41,571	371	349,917	162,602	29,046	583,507
1967:						
Australia	708	---	---	2,247	---	2,955
Bolivia	1,284	---	---	---	---	1,284
Canada	7,151	78	336	140,602	14,588	162,755
Chile	691	---	141,629	30,791	---	173,111
Germany, West	211	---	---	33,269	11	33,491
Mexico	145	---	2,937	---	1,388	4,470
Netherlands	---	---	---	14,119	2	14,121
Norway	---	---	---	781	---	781
Peru	6,614	1	84,329	27,694	---	118,638
Philippines	16,058	---	---	---	---	16,058
Rhodesia Southern, Zambia, and Malawi	---	---	225	9,689	---	9,914
South Africa, Republic of	---	---	38,866	3,220	---	42,086
United Kingdom	---	---	---	20,468	27	20,495
Other	29	1	1,000	47,467	285	48,782
Total	32,891	80	269,322	330,347	16,301	648,941

[1] Data are general imports, that is, they include copper imported for immediate consumption plus material entering the country under bond.

Table 39.—U.S. imports [1] of copper (unmanufactured), by countries

(Short tons, copper content)

Country	1965	1966	1967
Australia	5,320	1,230	2,955
Belgium-Luxembourg	40	3,642	20,678
Bolivia	1,991	2,462	1,284
Canada	83,997	116,974	162,755
Chile	213,491	207,047	173,111
Germany, West	1,110	8,133	33,491
Mexico	9,121	11,190	4,470
Netherlands	530	1,524	14,121
Norway	1,346	1,158	781
Peru	129,317	126,634	118,638
Philippines	12,386	21,055	16,058
South Africa, Republic of	46,552	50,652	42,086
Southern Rhodesia, Zambia, and Malawi	3,189	-------	9,914
United Kingdom	396	15,113	20,495
Other	14,355	16,693	28,104
Total	523,141	583,507	648,941

[1] Data are general imports, that is, they include copper imported for immediate consumption plus material entering the country under bond.

Table 40.—U.S. imports for consumption of old brass and clippings from brass or Dutch metal [1]

Year	Short tons: Gross weight	Short tons: Copper content	Value (thousands)
1965	2,275	1,490	$1,151
1966	7,360	5,056	5,846
1967	3,505	2,549	2,479

[1] For remanufacture.

Table 41.—U.S. Imports for consumption of copper (copper content) by classes

Year	Ore and concentrates: Short tons	Ore and concentrates: Value (thousands)	Matte: Short tons	Matte: Value (thousands)	Blister: Short tons	Blister: Value (thousands)
1965	1,441	$777	83	$72	75,122	$45,262
1966	6,843	4,118	117	85	337,955	272,996
1967	35,673	28,820	2	35	272,728	218,430

Year	Refined: Short tons	Refined: Value (thousands)	Scrap: Short tons	Scrap: Value (thousands)	Total value (thousands)
1965	103,269	$70,937	17,667	$7,203	$124,251
1966	77,783	63,654	23,908	24,662	365,515
1967	332,065	311,164	16,655	14,731	573,180

Table 42.—World mine production of copper (content of ore) recoverable where indicated, by countries [1] [2]

(Short tons)

Country	1963	1964	1965	1966	1967 [p]
North America:					
Canada [3]	452,556	486,897	507,874	507,874	602,645
Cuba	[r] 7,190	[r] 6,434	NA	NA	7,000
Haiti	6,486	5,544	4,365	[r] 3,064	2,590
Mexico	[4] 60,726	[4] 57,399	[4] 60,900	[4] 62,295	[e] 62,000
Nicaragua	8,028	10,185	[r] 11,229	10,763	10,291
United States [3]	1,213,166	1,246,780	1,351,734	1,429,152	954,064
South America:					
Argentina	431	380	571	[r] 353	NA
Bolivia [5]	[r] 3,308	[r] 5,218	[r] 5,221	[r] 6,423	6,710
Brazil [e]	1,600	2,200	2,400	2,700	3,300
Chile	665,951	698,140	[r] 667,898	731,570	731,789
Ecuador	314	188	142	246	NA
Peru	[3] 198,486	[3] 194,497	[3] 198,786	194,441	199,668
Europe:					
Albania [e]	[r] 2,500	2,800	[r] 4,400	[r] 4,400	NA
Austria [3]	2,078	1,725	1,678	2,043	2,101
Bulgaria	23,369	22,487	32,959	[e] 34,200	[e] 34,200
Finland	37,368	35,605	32,849	29,090	31,783
France [6]	302	294	312	[r] 478	660
Germany:					
East [e]	22,000	22,000	22,000	22,000	NA
West	2,515	1,759	1,184	[r] 1,386	1,295
Ireland	---------	---------	---------	[r] 1,433	3,858
Italy	[r] 1,125	[r] 837	[r] 783	[r] 1,269	1,955
Norway [7]	15,724	[r] 16,505	[r] 16,278	[r] 16,331	15,654
Poland [e]	14,600	16,000	16,600	17,700	19,100
Portugal [7]	3,627	4,812	4,799	[r] 4,117	[e] 5,700
Spain [7]	7,534	[r] 10,882	[r] 9,674	[r] 8,285	9,053
Sweden	18,400	17,846	[r] 17,402	[e] [r] 16,100	[e] 16,000
U.S.S.R. [e] [8]	[r] 660,000	[r] 715,000	[r] 770,000	[r] 825,000	880,000
Yugoslavia	68,447	69,648	68,951	68,588	[e] 71,650
Africa:					
Algeria	1,142	1,204	1,130	[e] 1,110	[e] 1,190
Angola	71	---------	---------	---------	---------
Congo (Brazzaville)	320	---------	---------	---------	---------
Congo (Kinshasa) [9]	299,097	304,943	318,132	347,960	353,314
Morocco	1,991	1,927	1,998	2,956	2,784
Rhodesia, Southern	18,489	18,341	19,800	[e] 19,000	NA
South Africa, Republic of	60,792	65,579	66,640	137,414	[9] 140,583
South-West Africa, Territory of	35,774	38,698	43,456	42,906	NA
Uganda [9]	17,875	20,128	18,895	17,745	15,902
Zambia	648,239	697,047	766,924	687,226	729,995
Asia:					
Burma [e]	190	140	150	[r] 110	150
China, mainland [e]	99,000	99,000	99,000	99,000	88,000
Cyprus (exports)	29,001	18,513	21,235	27,775	49,980
India	11,034	11,553	11,153	11,354	9,480
Israel	8,509	[e] 8,800	[e] 8,900	9,370	NA
Japan	118,186	117,037	118,021	[r] 123,105	129,692
Korea:					
North [e]	9,000	11,000	[r] 11,000	13,000	13,000
South [e]	678	937	[r] 1,260	[r] 1,274	1,500
Philippines	70,202	66,643	69,159	[r] 81,304	92,333
Taiwan	1,785	1,916	1,704	2,197	2,472
Turkey	32,187	38,030	37,038	40,124	34,158
Oceania: Australia	126,523	[r] 117,200	[r] 101,235	[r] 122,372	98,188
Total [10]	[r] 5,087,916	[r] 5,290,698	[r] 5,527,819	[r] 5,788,603	5,435,787

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

[1] Czechoslovakia, Hungary, Iran, Kenya, and Malaya also produce copper, but production data are not available.

[2] Compiled from data available June 1968.

[3] Recoverable.

[4] Revised to avoid duplication of data.

[5] COMIBOL production plus exports by small and medium mines.

[6] Includes copper content of auriferous ores.

[7] Includes copper content of cupriferous pyrites.

[8] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[9] Smelter production.

[10] Total is of listed figures only, no undisclosed data included.

Table 43.—World smelter production of copper, by countries [1]

(Short tons)

Country	1963	1964	1965	1966	1967 p
North America:					
Canada	380,075	407,942	434,133	433,921	500,020
Mexico	[2] 59,150	[2] 55,383	[2] 59,534	60,889	60,000
United States [3]	1,296,700	1,338,433	1,434,050	r 1,466,436	862,340
South America:					
Brazil [4]	2,205	3,307	NA	NA	NA
Chile	614,390	647,139	r 633,573	r 688,497	695,234
Peru	173,615	167,625	174,851	166,533	172,744
Europe: [5]					
Albania	2,249	2,429	r e 4,400	r e 4,600	NA
Austria (electrolytic) [4] [6]	14,385	16,140	17,864	18,767	19,180
Bulgaria	22,622	23,261	27,831	28,660	e 30,000
Finland (electrolytic) [7]	41,664	36,571	33,645	35,177	37,697
Germany:					
East e	22,000	22,000	22,000	22,000	NA
West [4]	333,799	370,728	393,946	413,773	421,558
Norway [7]	r 19,734	r 19,301	r 22,140	r 21,960	21,938
Poland (electrolytic)	r 32,665	r 40,394	r 41,226	r 43,924	r 46,517
Spain (blister)	25,919	23,595	r 34,197	20,693	33,390
Sweden (electrolytic) [7]	r 50,112	r 50,323	r 55,383	r 56,438	e 53,000
U.S.S.R. e	r 660,000	r 715,000	r 770,000	r 825,000	880,000
Yugoslavia	55,974	57,007	62,742	r 78,640	e 80,500
Africa:					
Angola	112	----------	----------	----------	----------
Congo (Kinshasa)	299,097	304,943	318,132	347,960	353,314
Rhodesia, Southern	16,187	16,798	e 18,900	e 18,900	NA
South Africa, Republic of	60,085	60,090	60,022	r 126,799	140,583
South-West Africa, Territory of	22,904	31,428	32,745	36,412	NA
Uganda	17,875	20,128	18,895	17,745	15,902
Zambia	r 635,868	r 708,616	r 754,966	r 421,738	669,244
Asia:					
China, mainland e	110,000	110,000	110,000	110,000	99,000
India	10,574	10,422	10,318	10,404	9,450
Japan (electrolytic)	325,403	376,658	403,095	446,267	518,132
Korea:					
North (electrolytic) e	11,000	11,000	13,000	13,000	13,000
South	2,622	3,097	r 2,973	4,268	4,076
Taiwan	1,633	r 2,080	r 2,412	r 2,658	3,308
Turkey	27,326	28,639	28,991	29,340	27,988
Oceania: Australia	99,111	90,259	82,224	r 101,345	81,633
Total [8]	r 5,447,055	r 5,770,736	r 6,078,188	r 6,072,744	5,849,748

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Complied from data available June 1968.
[2] Revised to avoid duplication of data.
[3] Smelter output from domestic and foreign ores, exclusive of scrap. Production from domestic ores only, exclusive of scrap, was as follows: 1963, 1,258,126; 1964, 1,301,115; 1965, 1,402,806; 1966, 1,429,863; and 1967, 841,343.
[4] Includes secondary copper.
[5] Belgium reports a large output of refined copper which is believed to be produced principally from crude copper from Congo (Kinshasa); it is not shown here, as that would duplicate output reported under latter country.
[6] May include some scrap in raw materials; excludes fire refined copper.
[7] Includes scrap.
[8] Totals are of listed figures only, no undisclosed data included.

Table 44.—Canada: Copper production (all sources) by Provinces [1]

(Short tons)

Province	1966	1967 p
British Columbia	52,880	81,921
Manitoba	31,315	29,459
New Brunswick	7,089	5,608
Newfoundland	19,394	19,689
Northwest Territories	748	226
Nova Scotia	115	40
Ontario	202,976	269,855
Quebec	171,998	159,088
Saskatchewan	19,561	22,738
Yukon Territories	----------	3,675
Total	506,076	592,299

p Preliminary.
[1] Blister copper plus recoverable copper in matte and concentrate exported.
Source: Dominion Bureau of Statistics, Department of Trade and Commerce, Government of Canada. Preliminary Report on Mineral Production, 1967.

Table 45.—Chile: Exports of copper, by principal types

(Short tons)

Destination	1966				1967			
	Refined				Refined			
	Electrolytic	Fire refined	Blister	Total	Electrolytic	Fire refined	Blister	Total
Argentina	2,875	------	------	2,875	3,928	------	------	3,928
Austria	902	------	------	902	1,141	------	------	1,141
Brazil	1,560	127	------	1,687	8,131	------	------	8,131
Denmark	2,043	------	------	2,043	1,867	------	------	1,867
Finland	1,802	------	------	1,802	2,873	------	------	2,873
France	26,114	18,719	111	44,944	40,146	9,343	------	49,489
Germany, West	98,904	12,180	10,444	121,528	106,736	10,422	12,111	129,269
Italy	44,831	22,869	836	68,536	52,383	17,148	1,504	71,035
Japan	19,191	1,226	------	20,417	20,052	5,589	------	25,641
Netherlands	-------	------	------	-------	2,296	------	------	2,296
Norway	2,438	------	------	2,438	3,243	------	------	3,243
Spain	3,282	------	------	3,282	6,425	------	------	6,425
Sweden	18,215	4,404	5,860	28,479	18,823	5,208	9,967	33,998
Switzerland	3,129	1,916	------	5,045	2,999	1,809	------	4,808
United Kingdom	57,943	17,243	33,022	108,208	66,344	17,415	37,029	120,788
United States	112,445	------	------	112,445	104,901	3,360	------	108,261
Other	-------	------	------	-------	28	------	------	28
Total	395,674	78,684	50,273	524,631	442,316	70,294	60,611	573,221

Table 46.—Peru: Copper production

(Short tons)

Year	Blister	Refined	Other	Total
1963	130,398	40,689	24,522	195,609
1964	125,935	41,679	26,883	194,497
1965	130,250	44,600	23,936	198,786
1966	124,674	41,859	27,908	194,441
1967	134,152	38,592	26,924	199,668

Source: Bureau of Mines. Mineral Trade Notes.

Table 47.—United Kingdom: Exports and reexports, by countries

(Short tons)

Destination	1966 r	1967	Destination	1966 r	1967
Germany, West	10,392	17,052	Pakistan	1,040	662
China, mainland	6,485	11,977	Sweden	1,852	549
Netherlands	8,249	9,084	Brazil	619	382
United States	8,045	8,348	Denmark	270	137
Poland	3,628	5,244	Norway	797	122
Spain	533	3,064	Japan	926	34
India	671	2,479	Australia	1,146	8
Italy	1,739	2,107	Canada	224	------
Belgium	2,325	1,728	United Arab Republic	134	------
Czechoslovakia	465	1,289	Other countries	934	772
France	7,413	1,060			
Argentina	2,475	755	Total	60,362	66,853

r Revised.
Source: British Bureau of Nonferrous Metal Statistics.

Table 48.—United Kingdom: Imports of copper, by countries

(Short tons)

Country	1966 r			1967		
	Blister	Electrolytic	Fire refined	Blister	Electrolytic	Fire refined
Zambia	[1] 6,906	221,203	------	[1] 542	190,308	------
Chile	30,700	43,646	22,018	34,100	59,469	20,897
Canada	------	89,029	------	------	97,159	------
United States	------	40,808	7,313	------	30,305	506
Sweden	------	15,045	------	------	15,776	------
Germany, West	------	20,068	84	------	10,196	------
South Africa, Republic of	2,954	1,075	6,471	146	199	7,801
Belgium	------	10,722	------	------	6,756	------
Netherlands	------	19,648	28	------	6,003	------
Congo (Kinshasa)	------	2,266	------	------	4,817	------
U.S.S.R.	------	9,856	------	------	4,205	------
Spain	------	1,218	------	------	3,912	------
Australia	------	5,273	------	------	2,547	------
Norway	------	1,430	------	------	1,039	------
Peru	1,131	303	------	------	28	------
Other countries	103	4,054	58	------	1,075	57
Total	41,794	485,644	35,972	34,788	433,794	29,261

r Revised.
[1] Includes fire refinable anodes.
Source: British Bureau of Nonferrous Metal Statistics.

Diatomite

By Benjamin Petkof [1]

Domestic diatomite production remained strong in 1967, but showed a decline of slightly over 2 percent in both quantity and value. The United States continued to maintain its position as the major world producer of this commodity.

DOMESTIC PRODUCTION

For the first time since 1960 diatomite production declined slightly. All production to meet domestic demand came from the Western United States, with California as the major producing State. Nevada, Washington, Arizona, and Oregon contributed smaller quantities. Twelve companies with 14 plants produced diatomite during the year.

Lassenite Industries, in Lassen County, Calif., completed a plant to process and prepare diatomite for use as a pozzolan in concrete construction. Material for the plant will be obtained from a diatomaceous shale and diatomaceous volcanic tuff deposit in Long Valley north of Hallelujah Junction in eastern Lassen County.[2]

During 1967 the Johns-Manville Corp. began enlarging its diatomite processing facilities at Lompoc, Calif. When completed in 1969, production capacity will have been increased by 25 percent.[3]

Table 1.—Diatomite sold or used by producers in the United States, 3-year totals [1]

	1951–53	1954–56	1957–59	1960–62	1963–65
Domestic production (sales)........short tons..	908,448	1,105,279	1,349,340	1,446,625	1,740,833
Average value per ton........................	$29.97	$39.21	$45.73	$50.08	$50.40

[1] Annual figures are company confidential.

CONSUMPTION AND USES

The consumption and use pattern for diatomite changed only slightly from that of 1966. Almost one half of the material sold or used by producers was used for industrial or water supply filtration and the quantity used for this purpose increased 2 percent. The quantity used for insulation declined 10 percent although the percentage of total consumption for this purpose declined slightly. The quantity of material used for industrial fillers declined 9 percent. Consumption for miscellaneous purposes such as absorbents, insecticides, lightweight aggregates, paints, pozzolans, and soil conditioner declined slightly.

[1] Commodity specialist, Division of Mineral Studies.

[2] Mineral Information Service. Diatomite, California Division of Mines and Geology, v. 21, No. 2, February 1968, p. 25.

[3] Johns-Manville Corp. Annual Report for 1967, 22 pp.

Table 2.—Domestic consumption of diatomite, by principal use, in percent of total consumption

Use	1963	1964	1965	1966	1967
Filtration....................................	47	47	44	46	48
Fillers.......................................	23	24	20	20	18
Insulation....................................	5	4	6	5	4
Miscellaneous.................................	25	25	30	29	30

PRICES

The weighted average value of diatomite showed small variation from last year. Value per ton of material used for filtration, insulation and abrasives declined slightly, whereas that used for industrial fillers and miscellaneous uses showed small advances.

Table 3.—Average annual value per ton of diatomate, by uses

Use	1966	1967
Filtration	$63.48	$61.15
Insulation	55.96	54.31
Abrasives	133.72	131.73
Fillers	51.70	53.13
Miscellaneous	34.99	37.93
Weighted average	52.44	52.54

FOREIGN TRADE

Domestically produced diatomite continued to be exported throughout the world.

Imports of this commodity were almost negligible. Canada and Mexico supplied the 154 tons of material that were imported.

Table 4.—U.S. exports of diatomite

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1965	114	$9,752
1966	144	11,500
1967	148	11,324

WORLD REVIEW

The United States led world production. Other major free world producers were France, Italy, West Germany, and Denmark.

Canada.—Pacific Diatomite, Ltd., completed a pipeline to carry a slurry of pulverized diatomite from its deposit West of the Frazer River near Quesnel, British Columbia, to its processing plant at Barlow Station on the Pacific Great Eastern Railway where it is ground, dried, and prepared for shipment.[4]

Iceland.—By the end of the year the new diatomite mine and mill being developed by Johns-Manville Corp. in association with the Government of Iceland neared completion. The output of the Lake Myvatin deposit will supply diatomite products to the European market.

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[4] Minerals Processing. Diatomite Slurry Pipeline in British Columbia. V. 8, No. 6, June 1967, p. 28.

Table 5.—World production of diatomite, by countries [1] [2]

(Short tons)

Country	1963	1964	1965	1966	1967 [p]
North America:					
Canada	798	1,143	82	[r] 70	-------
Costa Rica	[e] 2,000	[e] 4,000	3,307	[e] 3,300	NA
Mexico	979	2,260	987	9,327	NA
Nicaragua	[e] 1,760	-----------	-----------	-----------	NA
United States	[3] 580,278	[3] 580,278	[3] 580,278	[3] 700,000	[3] 686,000
South America:					
Argentina	6,256	8,567	[r] 6,774	[r] 8,267	NA
Brazil	[e] 3,500	[e] 3,500	[e] 3,500	[e] 3,500	NA
Columbia	2,425	255	220	[r] ---------	NA
Peru	2,733	2,858	[r] 2,724	[3] 1,742	NA
Europe:					
Austria	4,339	4,224	4,447	4,138	4,200
Denmark:					
Diatomite [e]	22,000	20,400	13,800	[r] 11,000	11,000
Moler [e] [4]	212,000	210,750	235,000	225,000	220,000
Finland	2,535	2,392	1,047	[r] 1,323	[e] 1,100
France [5]	146,304	146,699	[r] 166,046	[r] 154,323	NA
Germany, West (marketable) [5]	47,289	52,737	58,005	[r] 57,331	[e] 55,000
Iceland	-----------	-----------	-----------	-----------	[e] 3,300
Italy	65,509	[r] 76,445	[e] [r] 66,000	[e] [r] 66,000	[e] 72,000
Portugal [5]	2,067	2,007	2,896	[r] 3,756	[e] 4,400
Spain [5]	11,229	[e] 12,500	[r] 13,131	[e] 12,600	NA
Sweden (marketable) [6]	400	239	[r] 439	[r] 440	[e] 330
U.S.S.R. [e]	340,000	[r] 350,000	[r] 360,000	[r] 385,000	395,000
United Kingdom	15,946	15,363	[r] 16,888	[e] 15,400	NA
Yugoslavia	[e] 11,600	[e] 11,600	[e] 11,600	[e] 11,600	NA
Africa:					
Algeria	19,454	22,163	18,092	[e] 18,100	[e] 18,100
Kenya	3,677	3,368	2,445	[r] 1,953	NA
Mozambique	-----------	-----------	-----------	[r] 36	[e] 30
Rhodesia, Southern [5]	301	347	[e] 530	[e] 530	NA
South Africa, Republic of	220	546	1,076	[r] 240	[e] 688
United Arab Republic	916	[7] 44,080	[7] 80,375	[r] [7] 70,111	NA
Asia: Korea, South	1,916	41,031	638	[r] 282	2,467
Oceania:					
Australia	[r] 5,749	9,780	[r] 7,793	[r] 7,967	NA
New Zealand	1,796	1,881	1,937	[r] 5,219	NA
Total [8]	[r] 1,515,976	[r] 1,631,413	[r] 1,660,057	[r] 1,778,555	NA

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

[1] Diatomaceous earth is produced in Bulgaria, Hungary, Japan and Rumania but data on output are not available.

[2] Compiled mostly from data available April 1968.

[3] Average annual production, 1963–65.

[4] Data represents estimates of moler earth used as a raw material in making refractory bricks plus moler earth exported in bulk form.

[5] Includes tripoli.

[6] Includes calcined.

[7] Includes refractory clay.

[8] Total is of listed figures only; no undisclosed data included.

Feldspar, Nepheline Syenite, and Aplite

By J. Robert Wells [1]

FELDSPAR

Domestic production of crude feldspar in 1967, although less in quantity than in 1966, established a third consecutive record high in yearly total value. Strong domestic demand counteracted the influence of large-volume imports of dinnerware, especially from the Orient, to bring the tonnage of feldspar consumed by U. S. potteries to an annual figure exceeded in only two earlier years. There was a sharp decline in the usage of feldspar for enamels, but the notable vigor of the container-glass industry, sustained by the conspicuous popularity of disposable soft-drink bottles, pushed the domestic use of glass-grade feldspar to a new high. Feldspar-formulated glass is especially favorable for making automated-machine bottles, for which production figures are impressive. Beverage "no deposit-no return's" were less than 2 million gross in 1960, about 8 million gross in 1965, over 15 million gross in 1966, and almost 25 million gross in 1967.

DOMESTIC PRODUCTION

Crude Feldspar.—North Carolina and California, leading the 12 States that produced crude feldspar in 1967, provided 43 percent and 15 percent, respectively of the total supply, and were followed in order by Connecticut, South Dakota, and Georgia, whose combined contribution amounted to an additional 31 percent: Flotation concentrate made up about 95 percent of the North Carolina production and 61 percent of total domestic output, with hand-picked feldspar somewhat outweighing, in the remaining 39 percent, the quantity contained in feldspar-silica mixtures.

Ground Feldspar.—In 1967, feldspar was ground in 19 mills situated in 10 States. North Carolina, California, Connecticut, Georgia, and South Dakota, in that order, were the leaders in production of ground feldspar and, together, supplied 89 percent of the total quantity sold by U. S. merchant mills in 1967. New Hampshire, for the second consecutive year, reported no production of ground feldspar.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient feldspar statistics

	1963	1964	1965	1966	1967
United States:					
Crude:					
Sold or used by producers long tons	548,954	587,194	624,598	655,452	615,397
Value thousands	$5,524	$5,389	$6,263	$7,020	$7,086
Average value per long ton	$10.06	$9.18	$10.03	$10.71	$11.51
Imports for consumption long tons	68	10	16	-------	280
Value thousands	$2	$1	$2	-------	$8
Average value per long ton	$23.29	$84.00	$95.00	-------	$28.04
Consumption, apparent [1] long tons	549,022	587,204	624,614	655,452	615,677
Ground:					
Sold by merchant mills short tons	598,706	646,974	664,138	703,587	663,220
Value thousands	$7,353	$7,644	$7,757	$8,944	$8,843
Average value per short ton	$12.28	$11.82	$11.68	$12.71	$13.33
Imports for consumption long tons	3,006	3,170	3,439	3,243	2,783
Value thousands	$81	$85	$92	$86	$72
Average value per long ton	$26.88	$26.95	$26.87	$26.52	$26.00
World: Production thousand long tons	1,687	1,831	1,922	1,934	1,598

[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)
1963	93,488	$643	364,676	$3,885	90,790	$996	548,954	$5,524
1964	88,046	804	380,787	3,367	118,361	1,218	587,194	5,389
1965	126,811	1,072	369,585	3,974	128,202	1,217	624,598	6,263
1966	r 116,936	r 997	407,450	r 4,803	131,066	r 1,220	r 655,452	r 7,020
1967	108,609	945	378,149	4,840	128,639	1,301	615,397	7,086

r Revised.
[1] Partly estimated.
[2] Feldspar content.

Table 3.—Ground feldspar sold by merchant mills [1] in the United States

	Mills	Domestic feldspar	
		Short tons	Value (thousands)
1963	22	598,706	$7,353
1964	20	646,974	7,644
1965	20	664,138	7,757
1966	19	703,587	8,944
1967	19	663,220	8,843

[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				
1963	6,863	58,497	W	39,128	104,488	240,783	W	W	151,777	392,560
1964	W	51,703	W	45,952	97,655	255,907	W	W	163,548	419,455
1965	W	32,535	W	75,055	107,590	256,000	W	W	162,014	418,014
1966	W	54,678	W	61,090	115,768	r 281,595	W	W	r 203,819	485,414
1967	W	38,539	W	61,473	100,012	282,861	W	--------	178,754	461,615
	Feldspar-silica mixtures [2]					Grand total [3]				
1963	65,541	W	--------	36,117	101,658	313,187	195,510	24,068	65,941	598,706
1964	W	W	--------	129,864	129,864	349,715	189,853	21,925	85,481	646,974
1965	W	W	--------	138,534	138,534	368,120	174,537	42,268	79,213	664,138
1966	W	W	--------	102,405	102,405	r 378,464	207,209	36,151	r 81,763	703,587
1967	W	W	--------	101,593	101,593	379,660	208,626	15,304	59,630	663,220

W Withheld to avoid disclosing individual company confidential data; included with "Other".
[1] Partly estimated.
[2] Feldspar content.
[3] "Other" include soaps, abrasives, and other ceramic and miscllaneous uses.

CONSUMPTION AND USES

Crude Feldspar.—Little or no feldspar is used in the form of the unground mine product, so there is practically no true end use of crude feldspar. Some manufacturers, however, continued their practice of buying small quantities of the unprocessed material for grinding to preferred specifications in their own mills.

Ground Feldspar.—Of the total quantity of ground feldspar sold by U.S. merchant mills in 1967, consumption by the glass, pottery, and enamel industries accounted for 57 percent, 31 percent, and 2 percent, respectively. It is worthy of note that the corresponding figure for enamel manufacturing in 1966 was 5 percent.

Table 5.—Ground feldspar shipped from merchant mills in the United States

(Short tons)

Destination	1963	1964	1965	1966	1967
California	78,164	120,804	111,174	109,126	100,235
Illinois	49,822	73,967	66,160	63,038	59,837
Indiana	20,688	20,998	W	W	W
Kentucky	W	W	3,775	7,052	15,433
Maryland	11,636	W	W	W	W
Massachusetts	4,231	4,407	4,787	3,980	3,539
Mississippi	------	--------	--------	--------	7,845
New Jersey	62,336	58,089	57,096	71,057	W
New York	23,631	22,117	26,037	W	W
Ohio	122,242	80,119	87,873	70,294	72,701
Pennsylvania	40,567	37,805	30,281	30,628	26,188
Tennessee	-------	--------	33,851	36,002	32,998
Texas	W	W	W	26,183	23,269
West Virginia	18,714	26,638	W	W	W
Other destinations [1]	166,675	202,030	243,104	286,227	321,175
Total	598,706	646,974	664,138	703,587	663,220

W Withheld to avoid disclosing individual company confidential data; included with "Other destinations."
[1] Includes Arkansas 1963–65, 1967; Colorado 1963–65, 1967; Connecticut 1963–65; Georgia 1963–65; Idaho 1965; Kansas 1966; Kentucky 1963–64; Louisiana 1966–67; Michigan 1966–67; Minnesota 1966–67; Mississippi 1966; Missouri 1966–67; New Hampshire 1966; Oklahoma 1963–64, 1967; Rhode Island 1963–64, 1967; Tennessee 1963–64; South Carolina 1963–65; Vermont 1963–65; Virginia 1966; Washington 1964, 1967; Wisconsin 1963–67; shipments that cannot be separated by States; and shipments indicated by symbol W. Also includes exports to Africa 1965–67; Canada 1967; Mexico, Panama, Philippines 1963–64, 1966–67; Venezuela 1963; and small quantities to other countries.

PRICES

Average per-ton values reported to the Bureau of Mines in 1967 for crude feldspar were substantially higher than in 1966. Essentially unchanged prices were quoted for domestic aplite.

Feldspar prices listed in the Materials Cost Index of the January 1968 issue of Ceramic Industry Magazine were as follows, per ton: Glass-grade, $9 to $13; 140-mesh, $18.50 to $22.50; and 200-mesh, $18.50 to $23.50. The average for the first category was substantially below the corresponding January 1967 quotation, but there were advances, although not as marked, in the other two classification averages.

FOREIGN TRADE

U.S. imports of feldspar for consumption in 1967 were the lowest since 1961, and there were no imports of crude or ground Cornwall stone. Data supplied to the Bureau of Mines by the Department of Commerce listed exports in the composite category of feldspar, leucite, nepheline, and nepheline syenite that were 12 percent less in quantity than in 1966. Canada, Mexico, and Venezuela were the principal recipients of the exported material.

Table 6.—U.S. imports for consumption of feldspar [1]

Year	Crude		Ground	
	Long tons	Value (thousands)	Long tons	Value (thousands)
1965	16	$2	3,439	$92
1966	---	------	3,243	86
1967	280	8	2,783	72

[1] All from Canada, except 1 long ton ($1,460) from Republic of South Africa in 1965, 280 long tons ($7,850) from Mexico, and 22 long tons ($767) from Sweden in 1967.

WORLD REVIEW

Canada.—The recently completed feldspar processing installation of the Golding-Keene Company at Cape Feldspar Quebec, drawing on 16 million tons of proved reserves, is said to have sufficient conveyor capacity to load its output of electrostatic-process, low-iron feldspar directly into seagoing vessels at the rate of 600 tons per hour.

Finland.—It is estimated that about 100,000 tons of feldspar, mostly for export, will be produced annually in a plant recently placed in operation at Kemio.

Japan.—Japanese industrialists at least partly averted the accusations of unfair competiti n that were provoked by the rising volume of their exports of tile and ceramic wares to the United States. Recognizing the dangers of the situation and to compensate somewhat for their advantageous labor-cost differential, ceramics manufacturers resolved upon a voluntary cutback of exports. Much of the feldspar thus displaced from export manufacturing will be absorbed in the making of container glass and porcelain enameled major appliances for domestic buyers.

Norway.—A new flotation plant at Lillesand is expected to yield 75,000 tons per year of exportable feldspar concentrate. Present total annual production in Norway is about 85,000 tons.

Pakistan.—Feldspar was one of the minerals of which large and potentially valuable deposits were found during recent exploration by the Geological Survey of Pakistan.

Yugoslavia.—Deposits of high-quality feldspar described as especially promising were discovered in Serbia, one of the six federated republics of Yugoslavia. Plans were announced for the construction of a grinding plant nearby to process 20,000 tons per year of the newly discovered mineral.

TECHNOLOGY

Progressive depletion of many of the higher grade pegmatitic deposits necessitates the increasing use of flotation processes for the extraction of feldspar from less favorable sources. Results of a number of investigations for the advancement of feldspar flotation technology were published.[2] Bureau of Mines scientists contributed to the assurance of adequate feldspar supplies far into the future by using a combination of ore-dressing and chemical techniques to demonstrate the feasibility of producing commercially acceptable feldspar and quartz concentrates from selected granites. Applied to red granite from southeastern Missouri, the process achieved 80-percent recovery of feldspar in the flotation concentrate. The Bureau also initiated research to delineate the flotative action of various groups of dyes and surface-active organic compounds when they are used as additives or replacement for other reagents in the conditioning and flotation of a number of nonmetallic minerals including feldspar. High-quality potash feldspar is desirable for some purposes, notably for making the glass for color television picture tubes, and Bureau engineers made encouraging progress in developing flotation procedures for the physical separation of potash and soda feldspars occurring together in natural mineral mixtures.

The Bureau of Mines continued an investigation of the potentialities of high-temperature roll forming of composite materials, exemplified by varying formulations of feldspar-alumina ceramics laminated between thin sheets of titanium metal, as a step in the manufacture of equipment for space exploration and atomic energy applications. A report was issued covering some aspects of this research.[3]

Choice of a new grinding medium, 1-inch-diameter cylinders of high-density alumina in place of the flint pebbles previously used in the mills of a leading feldspar supplier, resulted in "a better product in greater quantities at lower costs."[4]

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[2] Joy, A. S., R. Manser, K. Lloyd, and D. Watson. Flotation of Silicates: Adsorption of Ions on Feldspar in Relation to Its Flotation Response. Trans. Inst. Min. and Met. (London), v. 75, No. 712, March 1966, pp. C81–C86.
Smith, R. W. Activation of Beryl and Feldspars by Fluorides in Cationic Collector Systems: Discussion. Trans. Soc. Min. Eng. (London), v. 235, No. 2, June 1966, pp. 149–150.
Suliin, D. B., and R. W. Smith. Hallimond Tube Investigation of Fluoride Activation of Beryl and Feldspar in Cationic Collector Systems. Trans. Inst. Min. and Met. (London), v. 75, No. 721, December 1966, pp. C333–C336.

[3] Harris, Henry M., John E. Kelley, Paul H. Sunset, and Hal J. Kelly. Hot Rolling of Oxide-Glass Compositions. BuMines Rept. of Inv. 6967, 1967, 41 pp.

[4] Willis, Thurman, and P. C. Coleta. Grinding Cylinders Increase Production at Feldspar Corp. Plants. Pit and Quarry, v. 59, No. 1, July 1966, pp. 219–220.

Table 7.—World production of feldspar, by countries [1] [2]

(Long tons)

Country	1963	1964	1965	1966	1967 p
North America:					
Canada (shipments)	7,686	8,169	9,736	r 9,754	9,424
United States (sold or used)	548,954	587,194	624,598	r 655,452	615,397
South America:					
Argentina	12,599	9,127	r 20,962	r 19,192	NA
Chile	417	814	r 517	r 1,174	NA
Colombia	r 12,303	r 11,426	r 10,629	r 18,779	NA
Peru	217	837	926	470	NA
Uruguay	282	883	1,227	r 1,722	NA
Europe:					
Austria	2,077	1,603	1,397	1,507	2,441
Finland	r 12,677	r 14,665	11,685	r 25,901	e 35,000
France [3]	170,764	193,260	217,649	e 200,000	NA
Germany, West	273,665	299,990	313,281	r 285,797	293,195
Italy	100,487	109,852	90,803	r 135,941	145,133
Norway	r 76,105	r 70,023	r 62,986	r 86,748	e 85,000
Poland	r 26,278	e 26,300	e 26,300	e r 28,000	NA
Portugal	396	10,994	8,165	r 1,603	NA
Spain	r 12,477	16,466	r 25,166	NA	NA
Sweden	44,920	50,959	r 46,205	r 36,613	e 40,000
U.S.S.R. e	r 205,000	r 215,000	r 225,000	r 235,000	235,000
Yugoslavia	29,413	33,260	55,052	r 40,914	e 42,000
Africa:					
Angola	796	493	---	---	---
Eritrea }	e 490	e 9,800	---	r 1,526	NA
Ethiopia }	---				
Kenya	---	---	---	161	NA
Malagasy Republic	(4)	1	(4)	---	---
Mozambique	---	---	49	---	---
Rhodesia, Southern	---	---	e r 170	NA	NA
South Africa, Republic of	41,372	35,525	41,636	33,996	e 25,000
South-West Africa, Territory of	2,197	1,893	2,281	1,178	NA
United Arab Republic	---	4,653	e 4,000	3,444	NA
Asia:					
Ceylon	109	r 4	605	412	252
Hong Kong	1,680	1,556	1,119	1,343	1,135
India	r 21,829	23,997	r 26,348	25,593	NA
Japan [5]	53,339	61,445	57,245	r 50,845	52,667
Korea, South	11,392	13,468	15,595	15,053	16,551
Pakistan	1,220	48	---	---	NA
Philippines	6,564	7,924	12,095	8,479	NA
Oceania: Australia	8,842	9,012	r 8,726	r 7,260	NA
Total [6]	r 1,686,547	r 1,830,641	r 1,922,153	r 1,933,857	1,598,195

p Preliminary. r Revised. e Estimate. NA Not available.
[1] Feldspar is produced in Brazil, China, Czechoslovakia, and Rumania, but data are not available.
[2] Compiled mostly from data available April 1968.
[3] Includes pegmatite.
[4] Less ½ unit.
[5] In addition, the following quantitites of aplite and other feldspathic rock were produced; 1963, 211,814 tons; 1964, 258,510 tons; 1965, 281,759 tons; 1966, r 295,294 tons; 1967, 322,361 tons.
[6] Total is of listed figures only; no undisclosed data included.

Improvement of a product and a simultaneous solution to a troublesome disposal problem were achieved in North Carolina when it was found that feldspar-bearing mill wastes could be used to advantage in raw material batches for the making of brick instead of being discharged as hitherto into overburdened mountain streams.[5]

Benefits continued to flow from active research by a number of academic and commercial organizations, in diverse phases of glass manufacturing, the industry that provides an outlet for more than half the domestic supply of feldspar. Through technological advances and with no attendant loss of strength, the unit weight of most glass containers has been reduced since 1930 by as much as one-third, and further weight reduction is foreseen. Decorating machines can now apply as many as three ceramic colors at a time to glass bottles at the rate of 125 units per minute, and a process was devised to color bottles economically even in small batches. Three years of research led to the limited-scale start of com-

[5] Thomas, David W. Feldspathic Materials Lower Firing Temperatures. Brick & Clay Record, v. 149, No. 2, August 1966, pp. 46–49, 59.

mercial production of tires that are expected to be superior in strength and durability because they are fortified, in place of the customary rayon or nylon, with heat-dissipating cords of fiber glass. In an assessment of the suitability of glass for the construction of deeply submerged life support structures, hollow spheres of that material, even though purposely scored beforehand with severe and extensive scratches, survived undamaged the application of pressures equivalent to those encountered in the great depths of the sea. The conclusion was that scratches, although causing failure under tension, do not materially detract from the ability of glass to withstand compression.

Feldspar-based porcelain enamels, even though known and in use since the days of ancient Egypt, are still being actively studied and continually improved with respect to economy and performance. A 2-year program of research was initiated to assemble data on the rheological characteristics of porcelain enamel slips. This work, sponsored by 10 leading producers and users of porcelain enamel frits, is expected to lead to development of precise control tests and superior formulations for use by the enamel industry.[6] Two journal articles dealt with newly developed one-coat enamels which, when applied to specially prepared steel panels, yielded products that were cheaper and better than those made by the older two-coat processes even though fired at advantageously lower temperatures.[7] A permanent display, donated by the Porcelain Enamel Institute to the Smithsonian Institution for the Washington, D. C., Museum of History and Technology, illustrates the origins, evolution, and techniques of the enamel-on-metals industry.

NEPHELINE SYENITE

Nepheline syenite is a rock product consisting essentially of the alkali aluminum-silicate minerals, nepheline and feldspar, that is used in the production of glass and ceramics. In 1967, the U.S. demand for glass- and ceramics-grade nepheline syenite was met entirely by imports from Canada, 1 percent more in quantity than during 1966, the previous record year, and 8 percent more in total value. In 1966, the last year for which final figures have appeared, Canada produced about 366,000 tons of this material valued at more than $4 million. Exports to the United States during that year amounted to about 66 percent of the tonnage produced and to about 68 percent of the total value. According to a preliminary estimate, the Canadian output of nepheline syenite in 1967 was approximately 406,000 tons.

Canadian glass-grade nepheline syenite was quoted in 1966 at $10 per short ton in bulk, f.o.b. plant. The prices mentioned in Canadian Chemical Processing, October 1966, for carload lots of bagged material were $11.50 to $28.50 per short ton. Ceramic Industry Magazine, January 1968, quoted 1967 U.S. prices at $19.50 per ton, high, and $7.50 per ton, low, presumably for imported Canadian material.

Table 8.—U.S. imports for consumption of nepheline syenite

Year	Crude		Ground	
	Long tons	Value (thousands)	Long tons	Value (thousands)
1965	111	$2	216,860	$2,442
1966	205	3	253,230	2,871
1967	---	-----	256,837	3,104

APLITE

Aplite is a rock product which contains a high proportion of plagioclase feldspar and is used principally in the manufacture of amber glass. Total 1967 production was slightly less, in terms of both tons and dollars, than that of 1966, but specific production figures are withheld to avoid disclosure of individual company confidential data. International Minerals & Chemical Corp., from operations in Nelson County, Va., and M & T Chemical Inc.,

[6] American Ceramic Society Bulletin. Porcelain Enamel Study Begins at Battelle. V. 45, No. 11, Nov. 7, 1966, p. 1034.

[7] Allen, Alfred C. Less Than 5% Defects With Direct-On. Ceram. Ind., v. 87, No. 2, August 1966, pp. 46–48.

Mock, John A. Lower Cost Porcelain Enamels. Mat. in Design Eng., v. 63, No. 6, June 1966, pp. 96–98.

Hanover County, Va., were the only domestic producers of glass-grade aplite in 1967. Aplite prices published in Ceramic Industry Magazine, January 1968, were $7.30 per ton, high, and $5 per ton, low, both somewhat under the corresponding quotations of January 1967.

Ferroalloys

By John L. Morning[1]

Ferroalloy consumption decreased in 1967, owing primarily to the decrease in steel production. In 1966 and 1967 the major technological trend was toward larger furnace size, improved material handling, and new techniques in solidifying molten alloys. Foreign trade in ferroalloys dropped sharply in 1967 after showing increases each year since 1962. While the value of exports reached the highest level on record, the United States remained a net importer of ferroalloys in 1967.

Detailed information concerning the more important ferroalloys may be found in the commodity chapters for individual alloying elements.

Table 1.—Government inventory of ferroalloys (stockpile grade), December 31, 1967

(Short tons)

Alloy	National (strategic) stockpile	CCC and supplemental stockpile	Total
Ferrochromium:			
High-carbon	126,181	273,477	399,658
Low-carbon	127,738	191,155	318,893
Ferrochromium-silicon	25,644	32,716	58,360
Ferrocolumbium (contained columbium)	461	---------	461
Ferromanganese:			
High-carbon	142,739	1,033,314	1,176,053
Medium-carbon	29,700	---------	29,700
Ferromolybdenum (contained molybdenum)	349	---------	349
Ferrotungsten (contained tungsten)	751	---------	751
Ferrovanadium (contained vanadium)	1,200	---------	1,200

DOMESTIC PRODUCTION

In 1967, 29 producers reported production of about 2.7 million tons of ferroalloys, a slight decrease compared with that of 1966. Although production remained at about the same level, shipments of ferroalloys decreased almost 10 percent, reflecting the decrease in steel production.

Ferroalloys were produced in 17 States. Ohio and Pennsylvania accounted for more than half of the total tonnage. Production was also reported from Alabama, Florida, Idaho, Iowa, Kentucky, Montana, New York, New Jersey, Oregon, South Carolina, Tennessee, Texas, Virginia, Washington, and West Virginia.

Most of the ferroalloys were produced in electric furnaces. Although ferromanganese and silvery pig iron were produced in both electric and blast furnaces, blast furnaces produced a greater tonnage. Minor ferroalloys were produced by aluminothermic methods.

Ferroalloy production by Union Carbide Corp. was curtailed by strikes at four of its six electric furnace plants in 1966 and early 1967. The plants at Ashtabula and Marietta, Ohio, and Portland, Oreg., were struck late in August and the Alloy, W. Va., plant was closed early in July. Labor problems were resolved by February 1967 with new 2- to 3-year contracts. Plants were operated by supervisory personnel during the contract negotiation period. Despite the labor troubles, Union Carbide reported that customers were supplied at normal rates.

[1] Commodity specialist, Division of Mineral Studies.

As part of a 3-year modernization program, Union Carbide Corp. placed in operation a new, rotating hearth electric furnace at its Alloy, W. Va., plant. The annual capacity was estimated at 26,400 tons of ferrochromium-silicon, but the capacity will vary with product mix and grade.

A new 34,000-kilovolt-ampere rotating hearth furnace at the Ohio Ferro Alloys Corp. plant at Powhatan Point, Ohio, was placed on stream in 1966, bringing to four the number of furnaces for the production of silicon metal and high-silicon alloys. At the Philo, Ohio, plant, a 60,000-kilovolt-ampere rotating hearth furnace was under construction.

Pittsburgh Metallurgical Co., a division of Air Reduction Co., Inc., became the Airco Alloys Division in 1967; the name was later changed to Airco Alloys and Carbide Division. A new furnace planned for the firm's Charleston, S. C., plant was scheduled for completion in 1968.

Interlake Steel Corp. added to its ferroalloy production capacity with the installation of a sixth furnace in 1966 and a seventh in 1967.

Kawecki Chemical Co. started up a plant at Wenatchee, Wash., that was said to be the world's largest aluminum-base, master alloy facility. The concern planned to produce its regular line of grain-refining alloys, as well as new alloy addition agents such as manganese-aluminum, chromium-aluminum, and silicon-aluminum.

Table 2.—Ferroalloys produced and shipped from furnaces in the United States

Alloy	1966				1967			
	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]								
Blast furnace	651,987	78.7	651,678	$89,285	667,655	78.0	609,182	$82,408
Electric furnace [2]	r 295,223	r 78.2	334,040	56,569	273,272	78.4	261,599	45,954
Total	r 947,210	r 78.5	985,718	145,854	940,927	78.2	870,781	128,362
Silicomanganese	253,134	65.9	281,925	41,120	245,798	65.9	239,726	38,196
Ferrosilicon	575,689	52,2	547,567	93,318	673,535	56.6	603,415	102,010
Silvery iron	255,064	14.6	246,240	19,154	219,868	15.1	210,342	16,439
Chromium alloys:								
Ferrochromium [3]	309,786	r 67.3	309,110	86,033	323,431	67.6	299,333	81,978
Other chromium alloys [4]	134,039	r 39.0	106,686	22,332	122,706	42.5	92,890	23,010
Total	443,825	58.8	415,796	108,365	446,137	60.7	392,223	104,988
Ferrotitanium	5,526	28.4	4,854	3,838	3,116	25.2	3,704	2,417
Ferrophosphorus	131,533	24.4	125,053	6,360	123,510	24.5	106,987	6,091
Ferrocolumbium and ferrotantalum columbium	3,341	54.8	3,229	8,353	1,792	54.7	1,720	6,678
Other [5]	98,461	37.7	87,584	77,188	94,822	36.0	78,824	59,407
Grand total	r 2,713,783	57.5	2,697,966	503,550	2,749,505	59.5	2,507,722	464,588

r Revised.
[1] Includes briquets.
[2] Includes fused-salt electrolytic.
[3] Includes low- and high-carbon ferrochromium and chromium briquets.
[4] Includes ferrochrome silicon, exothermic chromium additives, and other chromium alloys.
[5] Includes Alsifer, ferroboron, ferronickel, ferromolybdenum, ferrotungsten, ferrovanadium, siminal spiegeleisen, zirconium-ferrosilicon, ferrosilicon-zirconium, and other miscellaneous ferroalloys.

Table 3.—Producers of ferroalloys in the United States in 1967

Producer	Plant location	Product [1]	Type of furnace
Agrico Chemical Co	Pierce, Fla	FeP	Electric.
Air Reduction Co., Inc., Airco Alloys Division. [2]	Calvert City, Ky	[3] FeCr, FeMn, FeSi, SiMn, FeCrSi.	Do.
Do	Charleston, S.C		
Do	Niagara Falls, N.Y		
Bethlehem Steel Co	Bethlehem, Pa	FeMn	Blast.
Calumet & Hecla Inc	Selma, Ala	FeSi	Electric.
Chromium Mining and Smelting Co.	Woodstock, Tenn	FeMn, SiMn, FeSi, FeCr, FeCrSi.	Do.
Climax Molybdenum Co	Langeloth, Pa	FeMo	Aluminothermic.
FMC Corp, Mineral Products Division.	Pocatello, Idaho	FeP	Electric.
Foote Mineral Co [4]	Cambridge, Ohio	FeB, FeCb, FeTi, FeV, other [5].	Do.
Do	Graham, W.Va	FeCr, FeCrSi, FeMn, FeSi, SiMn, other [5].	Do.
Do	Vancoram, Ohio	FeCr, FeCrSi, FeMn, FeSi, FeV, SiMn, FeCb, other [5].	Do.
Do	Keokuk, Idaho	FeSi, silvery iron	Do.
Do	Wenatchee, Wash	FeSi	Do.
The Hanna Furnace Corp	Buffalo, N.Y	Silvery iron	Blast.
Hooker Chemical Corp	Columbia, Tenn	FeP	Electric.
Interlake Steel Corp	Beverly, Ohio	FeCr, FeSi, SiMn	Do.
Jackson Iron & Steel Co	Jackson, Ohio	Silvery iron	Blast.
Kawecki Chemical Co	Easton, Pa	FeCb	Aluminothermic.
E J Lavino & Co	Lynchburg, Va	FeMn	Blast.
Do	Sheridan, Pa	do	Do.
Manganese Chemicals Corp	Kingwood, W.Va	FeMn	Electric.
Mobil Chemical Co. Industrial Chemicals Division.	Charleston, S.C	FeP	Do.
Do	Mt. Pleasant, Tenn	do	Do.
Do	Nichols, Fla	do	Do.
Molybdenum Corporation of America.	Washington, Pa	FeMo	Electric and aluminothermic.
Monsanto Co	Columbia, Tenn	FeP	Electric.
Do	Soda Springs, Idaho	do	Do.
National Lead Co	Niagara Falls, N.Y	FeCbTi, FeTi, other [5]	Do.
The New Jersey Zinc Co	Palmerton, Pa	Spln	Do.
Ohio Ferro-Alloy Corp	Brilliant, Ohio	FeCr, FeSi, Si, FeCrSi	Do.
Do	Philo, Ohio	FeB, FeMn, FeSi, SiMn, Si	Do.
Do	Powhatan, Ohio	FeSi, Si	Do.
Do	Tacoma, Wash	FeCr, FeSi	Do.
Reading Alloys	Robesonia, Pa	FeB, FeCb, FeV, NiCb, FeMo.	Aluminothermic.
Shieldalloy Corp	Newfield, N.J	FeV, FeTi, FeB, FeMo, FeCb, FeCbTa, other [5].	Do.
Stauffer Chemical Co	Mt Pleasant, Tenn	FeP	Electric.
Do	Silver Bow, Mont	do	Do.
Do	Tarpon Springs, Fla	do	Do.
Tennessee Valley Authority	Muscle Shoals, Ala	FeP	Do.
Tenn-Tex Alloy Chemical Corp.	Houston, Tex	FeMn, SiMn	Do.
Union Carbide Corp, Mining & Metals Division.	Alloy, W.Va [3]	FeB, FeCr, FeCrSi, FeCb, FeSi, FeMn, FeTi, FeW, FeV, SiMn, other [5].	Do.
Do	Ashtabula, Ohio		
Do	Marietta, Ohio		
Do	Niagara Falls, N.Y		
Do	Portland, Oreg		
Do	Rockwood, Tenn		
Do	Sheffield, Ala		
United States Steel Corp	Birmingham, Ala	FeMn	Blast.
Do	Duquesne, Pa	do	Do.
Do	Clairton, Pa	do	Do.
Woodward Iron Co	Woodward, Ala	FeSi	Electric.

[1] FeB, ferroboron; FeCbTi, ferrocarbontitanium; FeCr, ferrochromium; FeCrSi, ferrochromium-silicon; FeCb, ferrocolumbium; FeCbTa, ferrocolumbium-tantalum; FeMn, ferromanganese; FeMo, ferromolybdenum; FeNi, ferronickel; FeP, ferrophosphorus; FeSi, ferrosilicon; FeTi, ferrotitanium; FeW, ferrotungsten; FeV, ferrovanadium; NiCb, nickel columbium; Si, silicon metal; SiMn, silicomanganese; Spln, spiegeleisen.

[2] Formerly Pittsburgh Metallurgical Co.

[3] Not designated by plant.

[4] Formerly Keokuk Electro-Metals Co. and Vanadium Corporation of America.

[5] Includes Alsifer, simanal, zirconium alloys, ferrosilicon boron, aluminum silicon alloys, and miscellaneous ferroalloys.

CONSUMPTION

Consumption of ferroalloys as additives and contained alloying elements decreased significantly compared with the 1966 figures, owing primarily to the 5-percent decrease in total steel production. A change in the format of consumption data placed ferrochromium (including other ferrochromium alloys and chromium metal) in the additive table owing to lack of reporting of chromium content by respondents.

Approximately 70 percent of the total ferroalloy demand was consumed by the steel industry, and 15 percent by foundries. The remainder was consumed in a wide range of uses including that unspecified by respondents.

Table 4.—Consumption by end uses of ferroalloys as additives in the United States in 1967

(Short tons)

Alloy	Stainless steels	Other alloy steels [1]	Carbon steels	Tool steels	Gray and malleable iron castings	Other uses [2]	Total
Ferromanganese [3]	10,249	172,966	710,908	3,722	26,962	135,810	1,060,617
Silicomanganese	9,791	24,800	105,468	865	1,921	17,060	159,905
Silicon alloys [4]	18,159	84,213	145,925	4,624	309,324	143,718	705,963
Ferrotitanium	414	590	1,629	3	16	521	3,173
Ferrophosphorus	18	2,271	9,506	------	730	21,030	33,555
Ferroboron	6	48	212	------	8	40	314
Ferrochromium [5]	247,330	63,928	9,059	5,730	5,474	36,148	367,669
Total	285,967	348,816	982,707	14,944	344,435	354,327	2,331,196

[1] Includes steel mill rolls.
[2] Includes unspecified.
[3] Includes spiegeleisen, manganese metal, and briquets.
[4] Includes silicon metal and silvery iron.
[5] Includes other chromium ferroalloys and chromium metal.

Table 5.—Consumption by end uses of ferroalloys as alloying elements in the United States in 1967

(Short tons of contained elements)

	Stainless steels	Other alloy steel [1]	Carbon steels	High speed steels	Other tool steels [2]	Gray and malleable iron castings	High temperature alloys	Other uses [3]	Total
Ferromolybdenum [4]	941	774	154	441	130	1,300	383	1,044	5,167
Ferrotungsten	(5)	[6] 231	-----	397	84	5	56	69	842
Ferrovanadium [7]	35	2,117	823	421	236	33	47	1,263	4,975
Ferrocolumbium	200	699	246	3	1	-----	267	150	1,566
Ferrotantalum-columbium	18	1	-----	-----	---	-----	1	9	29
Total	1,194	3,822	1,223	1,262	451	1,338	754	2,535	12,579

[1] Includes steel mill rolls.
[2] Includes hot-work and die-steels.
[3] Includes unspecified.
[4] Includes calcium molybdate and molybdenum silicide.
[5] Included with "other alloy steels."
[6] Includes stainless steels, steel mill rolls, and other alloy steels.
[7] Includes other vanadium-carbon-iron-ferroalloys, and quantitites used in other tool steels not specified, and high-speed.

STOCKS

Producer ferroalloy stocks increased substantially, owing to a decrease in steel production. The largest increase was in the high-volume products, namely, manganese, chromium, and silicon ferroalloys. Consumer ferroalloy stocks increased 4 percent, owing principally to a substantial increase in stocks of manganese ferroalloys.

In addition to producer and consumer stocks, large inventories of ferroalloys were stored in various Government stockpile programs.

Table 6.—Stocks of ferroalloys held by producers and consumers in the United States, December 31

(Short tons)

Alloy	Producer		Consumer	
	1966, gross weight	1967, gross weight	1966, gross weight	1967, gross weight
Manganese ferroalloys [1]	123,982	215,427	154,321	177,532
Silicon alloys [2]	88,482	145,175	81,910	65,805
Ferrochromium [3]	40,496	123,754	37,375	37,154
Ferrotitanium	1,517	1,303	741	664
Ferrophosphorus	50,091	61,365	5,401	8,707
Ferroboron	154	201	75	51
Total	304,722	547,225	279,823	289,913
	1966, contained element	1967, contained element	1966, contained element	1967, contained element
Ferromolybdenum [4]	W	W	1,491	5,137
Ferrotungsten	W	W	242	1,259
Ferrovanadium	W	409	1,693	1,190
Ferrocolumbium	280	260	400	341
Ferrotantalum-columbium	W	W	7	11
Total	848	1,020	3,833	7,938

W Withheld to avoid disclosing individual company confidential data.
[1] Includes ferromanganese, silicomanganese, spiegeleisen, manganese metal and briquets.
[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 calcium molybdate and molybdenum silicide.

PRICES

Ferroalloy prices fluctuate according to supply and demand, import price, technologic change, and ore price. Quoted prices for the high-volume ferroalloys, such as standard ferromanganese and low- and high-carbon ferrochromium, remained unchanged in 1966 and 1967. However, chromium alloy producers selectively increased the price of some products early in 1967. Likewise, there was some price movement for particular manganese products in both years.

During 1967, alloy producers made several alterations in size groupings of the various ferroalloys. By eliminating premium prices for certain sizes, those alloys affected were sold at a reduced cost.

The quoted prices for low-carbon ferrotitanium (25 to 40 percent Ti) and ferrotungsten remained unchanged during 1966 and 1967, at $1.35 and $3 nominal per pound, respectively. Ferromolybdenum was priced at $2.04 per pound in 1966 and $2.11 per pound in 1967.

FOREIGN TRADE

Foreign trade in ferroalloys dropped sharply in 1967 after showing increases each year since 1962. However, the value of ferroalloy exports increased to the highest level on record despite a reduction in quantity of shipments. The largest increase compared with those of 1966 showed in exports of ferrochromium, ferrosilicon, and ferroalloys, not elsewhere classified. Shipments of ferrochromium returned to normal as labor problems of the major producer were settled. Ferrosilicon shipments more than doubled those of 1966, but were only 34 percent of those of the record year of 1961. Canada, Mexico, and West Germany were the main recipients of ferroalloy shipments.

Imports for consumption of ferroalloys, in both quantity and value, decreased sharply compared with those of 1966. Settlement of labor problems of the major electric furnace producer and reduced activity of government barter programs accounted for the decline. The largest decreases occurred in high-carbon ferrochromium, high-carbon ferromanganese, and ferronickel, while significant decreases occurred for chromium metal and low-carbon ferrochromium. Only low-carbon ferromanganese and molybdenum products increased in value. The United States remained a net importer for most ferroalloys in 1967.

Table 7.—U.S. exports of ferroalloys

Alloys	1965		1966		1967	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Ferrocerium and alloys	27	$221	31	$209	71	$303
Ferrochromium	12,002	3,021	7,647	1,870	13,453	3,479
Ferromanganese	3,273	727	545	228	1,861	760
Ferromolybdenum	1,115	4,983	1,100	4,085	767	2,436
Ferrophosphorus	79,910	2,914	62,942	2,975	22,901	847
Ferrosilicon	4,585	1,755	5,812	2,004	11,774	3,228
Ferrovanadium	220	747	482	2,209	351	1,398
Ferroalloys n.e.c	8,444	3,173	7,301	2,381	7,976	5,757
Total	109,576	17,541	85,860	15,961	59,154	18,208

Table 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1966			1967		
	Gross weight (short tons)	Content (short tons)	Value (thousands)	Gross weight (short tons)	Content (short tons)	Value (thousands)
Chromium metal	2,487	(1)	$3,739	1,246	(1)	$1,889
Ferrocerium and other cerium alloys	7	(1)	65	(2)	(1)	(2)
Ferrochrome and ferrochromium—						
Containing 3 percent or more carbon	23,883	15,850	3,336	8,513	5,646	1,350
Containing less than 3 percent carbon	74,111	50,399	18,740	48,969	32,827	12,408
Ferromanganese—						
Containing not over 1 percent carbon	4,614	3,750	1,254	5,106	4,497	2,102
Containing over 1 and less than 4 percent carbon	23,203	18,554	4,540	21,669	17,817	4,298
Containing not less than 4 percent carbon	224,155	172,259	23,661	189,004	145,234	19,708
Ferromolybdenum, molybdenum metal, compounds, alloys and scrap (molybdenum content)	347	188	1,394	1,175	690	2,485
Ferronickel	11,898	(1)	4,519	2,600	(1)	1,110
Ferrophosphorus	130	(1)	9	-------	-------	------
Ferrosilicon	30,405	13,133	4,610	30,333	15,337	4,456
Ferrosilicon chromium	2,252	(1)	324	-------	-------	------
Ferrosilicon manganese (manganese content)	35,771	24,046	4,168	34,936	23,416	4,106
Ferrotitanium and ferrosilicon titanium	30	(1)	21	153	(1)	85
Ferrotungsten and ferrosilicon tungsten	236	190	696	-------	-------	------
Ferrovanadium	10	(1)	40	8	(1)	37
Ferrozirconium	469	(1)	185	726	(1)	260
Manganese metal	2,020	(1)	837	2,337	(1)	919
Tungsten alloys (unwrought) and scrap (tungsten content)	39	12	57	(2)	(2)	2
Tungsten metal (lump, grains, or powder) and tungsten carbide (tungsten content)	(1)	26	170	(1)	5	63
Tungstic acid and other alloys of tungsten not specifically provided for (tungsten content)	161	100	354	31	22	260
Ferroalloys, not elsewhere classified	781	(1)	2,352	509	(1)	1,143

[1] Not recorded.
[2] Less than ½ unit.

WORLD REVIEW

Australia.—The Tasmanian Electro Metallurgical Co. Pty. Ltd. (Temco), a subsidiary of Broken Hill Pty. Ltd., doubled its production capacity for high-carbon ferromanganese to cope with new supplies of manganese ore from Groote Eylandt, Northern Australia. In October 1966 a second rotating-hearth furnace, rated at 16,000 kilovolt-amperes went on stream at the plant in Bell Bay, Tasmania. Production was boosted to 75,000 tons per year, and since domestic steel requirements were 40,000 tons per year, Australia changed from a net importer of ferroalloys to a net exporter.

Brazil.—The Companhia de Ferro Ligas da Bahia, a ferrochrome producer, became associated with a new enterprise, Termo-Ligas Metalurgicas S. A. The new company was to undertake the production of ferromolybdenum, ferrotungsten, ferrovanadium, ferrocolumbium, ferrotitanium, and metallic chromium and manganese in northeastern Brazil.

Canada.—In June 1966, Union Carbide Canada Ltd. acquired a majority interest in two companies: Smelter Power Corporation, which has a hydroelectric generating plant at Chicoutimi, Quebec, and Chicoutimi Silicon Ltd., which will supply ferrosilicon to worldwide markets.

Masterloy Products Ltd., a subsidiary of Geo-Met Reactors Ltd., opened a new 10 ton per day thermic plant in Ottawa to produce ferrocolumbium, ferromolybdenum, ferrotungsten, ferrovanadium, and other alloys.

Dominican Republic.—Falconbridge Dominicana, a subsidiary of Falconbridge Nickel Mines, Ltd., Canada, continued to ship experimental quantities of ferronickel to its Canadian plant. The concern operated two pilot plants during the year and planned to construct a full-scale plant by 1971. The planned production capacity was projected at 50,000 tons of nickel annually.

France.—A merger of the French ferroalloy producers, Ugine, Kuhlmann, and Sté. Produits Azotes (SPA), agreed to in June 1966, will form the second largest chemical concern in France. Ugine is dominant in ferrochrome and refined ferromanganese production, SPA is a large producer of ferrosilicon, and Kuhlmann produces ferrochrome, ferromolybdenum, ferrocolumbium, ferrotungsten, and ferrovanadium.

Greece.—The new ferronickel plant of Société Minière et Metallurgique de Larymna Larco S. A. began operating in April 1966. The quality of the initial product exceeded the expectation of the owners, Sté. Le Nickel and the Hellenic Chemical Products & Fertilizer Co. Annual production capacity of ferronickel will be 4,000 tons; the annual value of ferronickel exports is expected to be $12 million.

India.—In 1966, Mysore Iron and Steel Works Ltd. switched one ferrosilicon furnace to the production of refined, low-carbon ferromanganese. The company also considered exporting ferrosilicon since production capacity was greater than domestic consumption. A second ferrosilicon producer, Indian Metals and Ferro Alloys Ltd., initiated operation of a new ferrosilicon plant in May 1967.

Japan.—To further the rationalization of the ferroalloy industry, a committee, composed of government officials, industry representatives, banking officials, and interested trading companies, was established to discuss ways to effectively restructure the industry through regroupings and mergers. Because of Government disapproval, the ferroalloy industry decided not to continue with the "antirecession" cartel, formed in 1965 to regulate production and sales. Some 25 companies were members of the cartel, which expired at the end of September 1966.

Mexico.—Metalver, S.A., affiliated with Tubosde Acero de Mexico, S. A., opened a 24,000-ton-per-year ferroalloy plant to produce ferrosilicon, ferromanganese, and other ferroalloys.

Norway.—Aktieselskabet Hafstund Smelteverket planned to install a new 30,000-kilovolt-ampere ferrosilicon furnace at its plant near Sarpsborg. The new furnace was expected to double the concern's capacity.

South Africa.—A new plant was under construction for production of ferrotitanium, ferrocolumbium, ferromolybdenum, ferrovanadium, ferrotantalum, and nickel magnesium. A new company, Thermo-metallurgical Corporation, (Pty) Ltd. (Thermocor) will start production of these alloys in South Africa in early 1968.

TECHNOLOGY

The major technological trend in the ferroalloy industry during the past 2 years has been toward larger furnace size, improved material handling, and new techniques in solidifying molten alloys.

Furnaces rated at 25,000 to 60,000 kilovolt-amperes were either placed on-stream or under construction. The larger, higher powered furnaces were expected to reduce unit costs for power, labor, and overhead.

Airco Alloys Division, Air Reduction Co., Inc., announced, without details, a revolutionary casting technique that was expected to reduce by 10 percent alloy additive costs in steelmaking. Union Carbide Corp developed an alloy casting process that consists of casting ferroalloys in successive layers of fixed thickness.[2] Sizing is simplified because the layers of solidified alloy separate easily. The denser product that results reduces the generation of fines during shipment.

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[2] Forgeng, William D. and John W. Farrell. (assigned to Union Carbide Corp., New York). Casting Process for Ferroalloys. U.S. Pat. 3,323,899, June 6, 1967.

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Fluorspar and Cryolite

By William R. Barton[1]

FLUORSPAR

Imports again supplied about 75 percent of U.S. fluorspar needs. The three leading sources for imports were Mexico, Spain, and Italy, with lesser quantities originating in Canada, Colombia, France, Japan, the United Kingdom, and the Republic of South Africa. Record U.S. demand was paced by the requirements for use in the manufacture of hydrofluoric acid and as a slag modifier in the steel industry.

No exploration contracts for fluorspar projects were executed by the Office of Minerals Exploration during 1967. At yearend, the Government stockpile contained 1,141,000 tons of acid grade, and 412,000 tons of metallurgical grade, fluorspar.

Table 1.—Salient fluorspar statistics

	1963	1964	1965	1966	1967
United States:					
Production:					
Crude:					
Mine production----short tons--	586,158	620,474	772,765	737,411	838,631
Material milled or washed short tons--	586,400	624,745	825,867	796,418	914,616
Beneficiated material recovered short tons--	188,200	202,300	236,800	250,200	284,300
Finished (shipments)---------do----	199,948	217,137	240,932	253,068	295,643
Value-------------thousands--	$9,001	$9,723	$10,889	$10,841	$13,164
Exports------------------short tons--	1,202	3,702	9,385	5,732	10,345
Value-----------------thousands--	$157	$158	$315	$301	$517
Imported for consumption---short tons--	559,653	687,933	816,546	878,546	911,870
Value-----------------thousands--	$14,192	$16,882	$19,958	$21,968	$24,485
Consumption--------------short tons--	736,350	831,561	930,127	1,065,124	1,091,158
Stocks Dec. 31:					
Domestic mines:					
Crude------------------do----	299,197	299,109	274,011	207,338	126,716
Finished----------------do----	14,954	10,174	19,664	26,589	22,522
Consumer plants-----------do----	181,934	203,014	235,657	254,726	303,718
World: Production-------------------do----	2,369,490	2,717,105	3,046,990	3,129,205	3,150,488

DOMESTIC PRODUCTION

The Illinois-Kentucky area, consisting of Hardin and Pope Counties, Ill., and Crittenden, Livingston, and Caldwell Counties, Ky., continued as the traditional producer of most domestic fluorspar in 1967. Mining in this area usually depended on the recovery and sale of byproduct lead and zinc concentrates. About 60 percent of the ore value was in recovered fluorspar with the remainder in lead and zinc sulfides. Relatively small tonnages of ore and concentrates were shipped from mines in Arizona, Colorado, Montana, Nevada, and Utah, which were not dependent on the recovery of byproducts.

There was increasing demand for consolidated fluorspar flotation concentrates in the form of briquet or pellets. They were made especially for use in basic-oxygen-furnaces by the Ozark-Mahoning Mining Co. briquetting plant at Rosiclare, Ill., and the pelletizing plant of Minerva Co., Fluorspar Division, at Eldorado, Ill. The Mercier Brick Co., Detroit, Mich., pelletized imported acid-grade fluorspar.

[1] Commodity specialist, Division of Mineral Studies.

Table 2.—Shipments of finished fluorspar, by States

State	1966			1967		
	Short tons	Value		Short tons	Value	
		Total	Average per ton		Total	Average per ton
Arizona	-------	------------	--------	10,000	$280,000	$28.00
Illinois	176,175	$8,001,803	$45.42	210,207	9,858,743	46,90
Kentucky	28,725	1,360,870	47.38	32,952	1,686,064	51.17
Other States [1]	48,168	1,478,132	30.69	42,484	1,338,934	31.52
Total	253,068	10,841,000	42.84	295,643	13,164,000	44.53

[1] Includes Colorado, Montana, New Mexico (1967 only), Nevada, and Utah to avoid disclosing individual company confidential data.

New operations in the Illinois-Kentucky district included the Clement fluorspar mine of Calvert City Chemical Co., at Carrsville, Ky., and the Ozark-Mahoning Mining Co.'s Barnett Shaft and the new 500-foot shaft at the Minerva Co.'s Gaskins mine; both in Pope County, Ill. Henry Van Sickle and Associates reopened the Pygmy mine at Mexico, Crittenden County, Ky. Mines that closed down in 1967 included the open-pit operation of Marion Chemical Co. at Marion, Ky.; the Nancy Hanks mine of Kentucky Fluorspar Co. near Salem, Kentucky; and the mining operations of Alcoa at Rosiclare, Ill. Minerva Co. "robbed" the pillars and then abandoned its depleted Crystal mine, near Cave-in-Rock, Ill.

Table 3.—Fluorspar shipped from mines in the United States, by grades and industries

Grade and industry	1966				1967			
	Quantity		Value		Quantity		Value	
	Short tons	Percent of total	Total	Average per ton	Short tons	Percent of total	Total	Average per ton
Ground and flotation concentrates:								
Hydrofluoric acid	112,967	52.9	$5,406,403	$47.86	135,622	54.5	$6,684,414	$49.29
Glass	29,748	13.9	1,301,418	43.75	31,797	12.8	1,471,936	46.29
Ceramic and enamel	5,918	2.8	247,407	41.80	4,924	2.0	232,255	47.17
Nonferrous	5,043	2.4	224,925	44.60	3,831	1.5	178,472	46.59
Ferrous	52,294	24.5	2,286,545	43.72	68,879	27.6	3,139,607	45.58
Miscellaneous [1]	7,410	3.5	318,512	42.98	3,995	1.6	184,159	46.10
Total	213,380	100.0	9,785,000	45.86	249,048	100.0	11,891,000	47.75
Fluxing gravel and foundry lumps:								
Nonferrous	5	-----	205	41.00	17	-----	833	49.00
Ferrous	28,826	72.6	896,379	31.10	38,093	81.8	1,132,902	29.74
Miscellaneous	10,857	27.4	159,011	14.65	8,485	18.2	139,163	16.40
Total	39,688	100.0	1,056,000	27.00	46,595	100.0	1,273,000	27.32

[1] Includes exports.

Table 4.—Fluorspar (domestic and foreign) consumed and in stock in the United States, by grades and industries

(Short tons)

Grade and industry	1966 Consumption	1966 Stocks at consumer plants Dec. 31	1967 Consumption	1967 Stocks at consumer plants Dec. 31
Acid grade:				
Hydrofluoric acid	572,727	60,632	588,275	108,722
Glass	6,692	760	7,067	796
Enamel	279	48	211	31
Welding rod coatings	3,173	275	3,512	181
Special flux }				
Ferroalloys }	1,875	938	2,163	801
Primary aluminum }				
Total	584,746	62,653	601,228	110,531
Ceramic grade:				
Glass	22,647	2,537	20,979	2,580
Enamel	5,395	731	4,842	554
Welding rod coatings [1]	3,947	160	3,350	121
Nonferrous	217	53	205	122
Special flux }				
Ferroalloys }	7,227	1,733	7,465	1,256
Total	39,433	5,214	36,841	4,633
Metallurgical grade:				
Glass	586	62	564	54
Enamel	---	---	---	---
Nonferrous [2]	11,208	3,246	8,709	2,316
Special flux }				
Ferroalloys }	1,389	2,829	1,001	3,481
Primary magnesium }				
Iron foundry	22,490	2,527	20,881	2,010
Open-hearth steel	150,310 }		132,205 }	
Basic oxygen furnace steel	198,476 }	178,195	238,625 }	180,693
Electric-furnace steel	56,486 }		51,104 }	
Total	440,945	186,859	453,089	188,554
All grades:				
Hydrofluoric acid	572,727	60,632	588,275	108,722
Glass	29,925	3,359	28,610	3,430
Enamel	5,674	779	5,053	585
Welding rod coatings	7,120	435	6,862	302
Nonferrous	11,425	3,299	8,914	2,438
Special flux	5,650	1,592	5,656	1,275
Ferroalloys	2,321	379	2,264	331
Primary aluminum }	2,520	3,529	2,709	3,932
Primary magnesium }				
Iron foundry	22,490	2,527	20,881	2,010
Open-hearth steel	150,310 }		132,205 }	
Basic oxygen furnace steel	198,476 }	178,195	238,625 }	180,693
Electric-furnace steel	56,486 }		51,104 }	
Total	1,065,124	254,726	1,091,158	303,718

[1] Includes metallurgical grade to avoid disclosing individual company confidential data.
[2] Includes a small amount of acid grade to avoid disclosing individual company operations.

CONSUMPTION AND USES

Consumption of all grades of fluorspar reached a record level of about 1.1 million tons, the result of a continuing increase since 1962. In that year 652,888 tons was consumed, of which 57 percent was acid grade, 6 percent was ceramic grade, and 37 percent was metallurgical grade. Since 1962, the greatest increase in use was in metallurgical grade, because of the increased use of the basic-oxygen-process for making steel. About 12 pounds of fluorspar are required per ton of steel produced. Increased use of all grades of fluorspar is expected to continue, but quantities used in making open-hearth steel may decrease because of the more extensive use of the basic-oxygen-process.

Several new fluorocarbon finishes were being prepared to provide nonstick, abrasion-resistant coatings for paper, textile equipment, and various tools. The finishes were reported to bake at lower temperatures, show better hardness and abrasion resistance, and provide better single coatings than those previously available. However, the top operating temperature, 350° to 400° F, was lower than that previously available on similar surfaces. Teflon and fluorinated elastomers were used to make suits to protect rocket fuelers against liquid fluorine and other fuels and oxidizers.[2]

The 50,000 ton-per-year expansion for the Alcoa Plant at Badin, N.C., which was to be in operation by mid-1967, may require about 2,500 tons of fluorspar annually.[3]

According to the Public Health Service, Americans in 5,445 communities now drink fluoridated water. More than 62 million consumers live in the 3,145 communities where water is artificially fluoridated, and 10 million more live in communities where the water contains sufficient natural fluorides.[4]

[2] Chemical Engineering. Fluorine Won't Faze Rocket Fuelers Any Longer. v. 74, No. 12, June 5, 1957, p. 66.
[3] News Sentinel (Knoxville, Tenn.) Mar. 13, 1966. p. 1.
[4] Chemical & Engineering News. Fluoride Drinkers Increase. v. 45, No. 34, Aug. 14, 1967, p. 86.

Table 5.—Fluorspar (domestic and foreign) consumed in the United States, by States

(Short tons)

State	1966	1967	State	1966	1967
Alabama, Georgia, and North Carolina	12,605	12,674	Kentucky	56,271	64,390
Arkansas, Kansas, Louisiana, Mississippi, and Oklahoma	140,459	137,204	Maryland	19,187	31,101
California	45,412	51,165	Massachusetts	355	403
Arizona [1], Colorado, and Utah	28,361	23,996	Michigan	73,846	65,674
Connecticut	1,148	870	Missouri	2,732	2,715
Delaware and New Jersey	89,270	99,380	New York and Vermont	24,603	31,340
Florida, Rhode Island, and Virginia	1,439	1,431	Ohio	101,088	111,106
Illinois	56,772	60,521	Oregon and Washington	1,571	1,655
Indiana	42,473	43,145	Pennsylvania	98,336	89,252
Iowa, Minnesota, Nebraska, and Wisconsin	3,713	3,020	Tennessee	2,413	2,385
			Texas	221,286	215,326
			West Virginia	41,784	42,405
			Total	1,065,124	1,091,158

[1] 1967 only.

Table 6.—Stocks of fluorspar at mines or shipping points in the United States, by States, Dec. 31

(Short tons)

State	1966		1967	
	Crude	Finished	Crude	Finished
Illinois	179,642	21,284	98,031	16,797
Kentucky	1,283		W	
Other States [1]	26,413	5,305	28,685	5,725
Total	207,338	26,589	126,716	22,522

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Colorado, Montana, and Nevada to avoid disclosing individual company confidential data.

PRICES

Metals Week reported the following yearend 1967 prices for principal fluorspar grades:

	Per short ton
Domestic: f.o.b. Illinois and Kentucky:	
Metallurgical-grade, 72½ percent, effective CaF_2	$41.50
Acid-grade concentrates, dry basis, 97 percent CaF_2, carloads	51.00
Less than carloads	55.00
Bags, extra	4.00
Pellets 70 percent effective CaF_2	44.00
Ceramic-grade, 95 to 96 percent CaF_2	49.00
European:	
Acid-grade, duty paid, dry basis	44.50–45.50
Mexican:	
Metallurgical-grade, 72½ percent, effective CaF_2:	
Border, all rail, duty paid	32.00–33.00
Brownsville, Tex., barge, duty paid	34.00–35.00
Tampico, Mexico, vessel cargo lots	25.00
Acid-grade, 97 percent, Eagle Pass, Tex. bulk	40.00–45.00

FOREIGN TRADE

Mexico supplied 72 percent of total U.S. consumption; 60 percent of the acid-grade imports and 95 percent of the metallurgical-grade imports. The United States also imported significant quantities from Spain and Italy.

The duty on fluorspar remained unchanged. Acid-grade fluorspar containing more than 97 percent CaF_2 was subject to a duty of $1.875 per short ton, and metallurgical-grade containing less than 97 percent CaF_2 had a duty of $7.50 per short ton. The value per ton of imported fluorspar from Spain rose from an average value of $34.44 in 1966 to $37.80 in 1967, and that from Italy, for the corresponding period, increased from $28.48 to $32.57.

Table 7.—U.S. exports of fluorspar

Year	Short tons	Value (thousands)
1965	9,385	$315
1966	5,732	301
1967	10,345	517

Table 8.—U.S. imports for consumption of fluorspar, by countries and customs districts

Country and customs district	1966				1967			
	Containing more than 97 percent calcium fluoride		Containing not more than 97 percent calcium fluoride		Containing more than 97 percent calcium fluoride		Containing not more than 97 percent calcium fluoride	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Canada:								
Buffalo, N.Y.	-------	------	6,330	$134	-------	------	3,552	$72
Detroit, Mich.	-------	------	20	(1)	-------	------	60	2
El Paso, Tex.	465	$10	-------	------	-------	------	-------	------
Seattle, Wash.	12	1	-------	------	-------	------	-------	------
Total	477	11	6,350	134	-------	------	3,612	74
Colombia: Laredo, Tex.	-------	------	-------	------	229	$7	-------	------
France: New York City	-------	------	-------	------	22	1	-------	------
Greenland: El Paso, Tex.	-------	------	503	10	-------	------	-------	------
Italy:								
Detroit, Mich.	5,408	148	-------	------	4,287	153	-------	------
Galveston, Tex.	6,419	245	-------	------	11,297	363	-------	------
New Orleans, La.	21,768	585	-------	------	22,793	731	-------	------
Philadelphia, Pa.	19,045	521	-------	------	24,067	787	-------	------
Total	52,640	1,499	-------	------	62,444	2,034	-------	------
Japan: Detroit, Mich.	-------	------	47	1	-------	------	27	1
Mexico:								
Baltimore, Md.	-------	------	-------	------	333	11	18,603	387
Boston, Mass.	-------	------	107	2	-------	------	-------	------
Buffalo, N.Y.	-------	------	11,977	260	-------	------	31,951	708
Cleveland, Ohio	-------	------	24,648	542	-------	------	26,525	658
Detroit, Mich.	26	1	21,123	487	-------	------	27,929	599
El Paso, Tex.	60,711	1,518	69,524	1,387	78,349	1,964	77,857	1,557
Galveston, Tex.	-------	------	-------	------	354	11	-------	------
Houston, Tex.	241	5	-------	------	176	4	-------	------
Laredo, Tex.	253,924	6,616	77,664	1,105	235,543	6,259	73,977	1,113
Los Angeles, Calif.	-------	------	-------	------	177	4	-------	------
Miami, Fla.	277	7	-------	------	-------	------	-------	------
Mobile, Ala.	-------	------	9,139	165	-------	------	3,461	88
New Orleans, La.	37,163	1,038	96,883	2,362	42,368	1,287	29,651	855
New York City	-------	------	-------	------	261	8	-------	------
Norfolk, Va.	-------	------	1,928	35	-------	------	1,054	21
Philadelphia, Pa.	4,144	105	11,237	229	-------	------	10,860	251
St. Louis, Mo.	382	8	-------	------	-------	------	-------	------
San Diego, Calif.	-------	------	93	2	282	9	-------	------
Total	356,868	9,298	324,323	6,576	357,843	9,557	301,868	6,237
South Africa, Republic of:								
Baltimore, Md.	-------	------	13,730	234	-------	------	12,696	238
Philadelphia, Pa.	-------	------	3,752	78	-------	------	-------	------
Total	-------	------	17,482	312	-------	------	12,696	238
Spain:								
Cleveland, Ohio	19,292	740	-------	------	26,255	969	-------	------
Detroit, Mich.	4,837	120	-------	------	9,463	282	-------	------
Galveston, Tex.	6,306	202	-------	------	26,591	857	-------	------
New York City	-------	------	-------	------	3	7	-------	------
Norfolk, Va.	-------	------	-------	------	3,784	133	-------	------
Philadelphia, Pa.	89,324	3,062	-------	------	86,330	3,514	-------	------
Total	119,759	4,124	-------	------	152,426	5,762	-------	------
Sweden: Laredo, Tex.	-------	------	44	1	-------	------	-------	------
United Kingdom:								
Cleveland, Ohio	-------	------	-------	------	5,716	170	-------	------
New Orleans, La.	-------	------	-------	------	14,688	387	-------	------
San Juan, Puerto Rica	53	2	-------	------	299	17	-------	------
Total	53	2	-------	------	20,703	574		
Grand total	529,797	14,934	348,749	7,034	593,667	17,935	318,203	6,550

[1] Less than ½ unit.

WORLD REVIEW

Canada.—Fluorspar has been produced from several deposits in Newfoundland, Nova Scotia, Ontario, and British Columbia, but the most important mine is that operated by Newfoundland Fluorspar Ltd. St. Lawrence, Newfoundland, where underground mining provides feed for a 900-tons per day mill. The other producer in Canada is Pacific Silica Ltd., Oliver, British Columbia, where fluorspar is a byproduct at a silica quarry. Newfoundland Fluorspar, a wholly owned subsidiary of Aluminum Company of Canada, ships a heavy-media concentrate to Arvida, Quebec, where it is upgraded and used to make artificial cryolite for the aluminum plant at Arvida. The St. Lawrence deposits have produced almost 2 million tons of ore, and shipments to Arvida have been consistent since 1940.

Approximately 1,400 tons of fluorspar was produced on Cape Breton Island between 1940 and 1949. Recent drilling on the Island reportedly disclosed more than 2 million tons containing an average of 48.5 percent barite and 14.5 percent fluorspar. Surface exposure and drilling has indicated a large medium-grade deposit amenable to low-cost mining on Birch Island, British Columbia. A base metals deposit near Fredericton, New Brunswick, contains some fluorspar that might be recovered as a byproduct.[5]

India.—Fluorspar deposits at Ambadungar in Gujarat, India, were being developed by a State-owned company, Gujarat Mineral Development Corp. According to the Geological Survey of India the deposits contain minable reserves of 11.6 million tons averaging 30 percent CaF_2.[6]

Mexico.—Asarco Mexicana, S.A., the Mexican affiliate of American Smelting and Refining Company, was constructing the world's largest fluorspar flotation mill at Parral in southern Chihuahua. The capacity will be 85,000 tons of acid-grade concentrate, from a large stock of 15 percent CaF_2 tailings that have accumulated as a result of many years of mining lead-zinc ores.

Mozambique.—A new firm, Fluorspar Intermines of Mozambique, has been established to explore and exploit large flurospare deposits west of the Zambesi River near Canxixe in Manica e Solfala District, and near Chioco in Tete District.[7]

South Africa, Republic of.—Attention was being given to fluorspar reserves in the Republic of South Africa and in the Territory of South-West Africa. Published data indicate that there may be over 300 million tons of fluorspar ore of all grades. This estimate, however, probably refers to a noneconomical, low-grade ore, averaging 10 to 15 percent CaF_2. Known economic reserves are considered to be about 30 to 34 million tons averaging 44 percent CaF_2.[8] Other sources estimate reserves of 14.4 to 30 million tons of probable ore averaging 44 to 46 percent CaF_2.

Transvaal Mining and Finance Co., a subsidiary of General Mining & Finance Corp. Ltd., recently began producing 500 short tons of fluorspar per month at the Vischgat mine in Transvaal Province. Sufficient metallurgical-grade ore had been developed to permit opening the mine. The company's mill at the Buffalo mine, also in Transvaal, had operating difficulties in 1966 and produced only 11,094 tons of acid-grade fluorspar, of which 8,464 tons was sold. Reserves at the Buffalo mine were reportedly 5 million tons, averaging 22 percent CaF_2.[9]

Tunisia.—Production of fluorspar from the Djebel Quest and Djebel Staa mines in Tunisia was being supplemented by material produced at the reopened Hamman Zriba mine, which had been closed for 10 years. Tunisian deposits were reported to be the richest in the Mediterranean area.[10]

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[5] Northern Miner (Toronto). Fluorspar Demand on the Increase: Appreciable Gains. No. 41, Jan. 5, 1967, p. 18.
Reeves, J. E. Fluorspar. 1966 Mineral Review Preprint, Mineral Processing Div., Mines Branch, Dept. Energy, Mines, and Resources (Ottawa, Canada), No. 19, 1967, 5 pp.

[6] Bureau of Mines. Mineral Trade Notes. v. 64, No. 4, April 1967, pp. 11–12.

[7] Bureau of Mines. Mineral Trade Notes. v. 64, No. 12, December 1967, pp. 15–16.

[8] South African Digest. Fluorspar Mining Vital New Development. v. 14, No. 2, Jan. 13, 1967, pp. 8–9. South African Mining & Engineering Journal. Outlook for the Fluorspar Industry. v. 78, Pt. 1, No. 3867, Mar. 17, 1967, pp. 601, 623.

[9] Metal Bulletin (London). No. 5192, Apr. 25, 1967, p. 15.

[10] Bureau of Mines. Mineral Trade Notes. v. 64, No. 1, January 1967, p. 10.

Table 9.—World production of fluorspar, by countries [1] [2]

(Short tons)

Country	1963	1964	1965	1966	1967 p
North America:					
Canada e	85,000	96,000	112,000	r 79,000	88,000
Mexico	530,893	708,644	810,618	799,602	785,114
United States (shipments)	199,948	217,137	240,932	253,068	295,643
South America: Argentina	10,761	12,703	12,883	10,472	NA
Europe:					
France (marketable)	160,307	215,119	215,573	r 237,476	e 243,000
Germany:					
East e	r 77,000	r 77,000	r 88,000	r 88,000	NA
West (marketable)	115,272	98,960	91,402	r 93,195	e 95,000
Italy	148,407	137,449	162,990	r 215,193	e 224,000
Spain (marketable)	169,094	164,995	r 243,248	r 230,315	267,509
Sweden (sales)	3,253				
United Kingdom [3]	r 96,342	r 114,199	r 128,750	r 138,891	NA
U.S.S.R. e	300,000	330,000	385,000	385,000	420,000
Africa:					
Morocco	7,000	7,242	3,307	e 3,300	
Rhodesia, Southern	343	77	e 165	NA	NA
South Africa, Republic of	57,761	66,431	72,517	90,266	e 108,000
South-West Africa, Territory of	480				NA
Tunisia			e r 3,300	r 2,894	e 4,400
Asia:					
China, mainland e	220,000	220,000	240,000	r 280,000	280,000
India	780	429	607	1,178	1,385
Japan	23,037	21,078	18,205	r 15,472	12,866
Korea:					
North e	33,000	33,000	33,000	33,000	33,000
South	43,855	62,167	43,174	35,283	62,796
Mongolia	54,000	e r 63,000	e r 83,000	e r 83,000	e 83,000
Thailand	32,221	70,039	57,132	52,941	146,775
Turkey	719	1,436	1,187	1,659	NA
Oceania: Australia	17				
Total [4]	r 2,369,490	r 2,717,105	r 3,046,990	r 3,129,205	3,150,488

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Fluorspar is also produced in Brazil and Bulgaria; data are not available.
[2] Compiled mostly from data available May 1968.
[3] Excludes recovery from lead and zinc mine dumps.
[4] Total is of listed figures only; no undisclosed data included.

Table 10.—International fluorspar trade in 1966

(Short tons)

Producing country	Exports	Principal destination
Bulgaria	[1] 1,511	All to West Europe.
China, mainland	[1] 226,967	Japan 107,288; East Europe 75,187; West Europe 44,492.
France	97,441	West Europe 96,516; Asia 897.
Germany:		
East	[1] 25,191	East Europe 19,327; West Europe 5,864.
West	12,370	West Europe 12,123; East Europe 143.
Italy	60,931	United States 51,782; West Europe 7,903; Australia 1,000.
Japan	300	Asia 244; Australia 56.
Korea:		
North	[1] 7,319	East Europe 5,787; Japan 1,532.
South	43,230	Japan 39,673; Taiwan 2,050; Philippines 701.
Mexico	819,230	United States 690,290; Canada 127,427; South America 1,513.
Mongolia	[1] 49,714	All to East Europe.
South Africa, Republic of	94,240	Japan 42,683; West Europe 19,338; United States 18,007; Australia 6,299.
Spain	143,711	United States 110,849; West Europe 27,456; Asia 4,564.
Thailand	81,219	Japan 76,035; India 4,763; Australia 332.
United States	5,732	Canada 5,356; Africa 283; Asia 41; West Europe 23.

[1] From import detail of customs returns of destination countries.

TECHNOLOGY

The usefulness of fluorine compounds as lubricants was promoted by coating metals, including nickel-base alloys, with calcium fluoride and a suitable binder such as the oxide of cobalt, barium, or boron. When fused to the surface, the solid-film coating withstood temperatures of 1,900° F in oxygen or inert atmospheres, at atmospheric to high-vacuum pressures. Wright-Patterson Air Force Base developed special lubricants for orbiting satellites using a perfluorocarbon polymer base and a fluorinated ethylene-propylene copolymer. Cost of the lubricant, said to be effective from 10° to 400° F depending on pressure, was believed to be $25 to $100 per pound. A fluorocarbon powder with a low coefficient of friction was reported to be useful between 400° and 500° F.[11]

Continuous effective lubrication of ball bearings operating in a vacuum was provided by interspersing polytetrafluoroethylene balls with the steel balls. In a typical assembly every fifth steel ball was replaced with a plastic one and the slight wear on the polytetrafluoroethylene ball provided a solid lubricant for the others. Life was estimated at thousands of hours when the assembly was operated at temperatures of 250° to 800° F. Glass fiber or powdered metals could be incorporated in the plastic for increased strength if the bearings were to be operated under heavy loads.[12]

A newly developed class of fluorinated compounds has potential applications as dielectric fluids, high-temperature lubricants, hydraulic fluids for pumps, agents for treating corrosive liquids and gases, water and oil repellants, and heat transfer media. Details of the manufacture were not released, but the compounds were prepared by the photochemical combination between oxygen and perfluoroolefins, usually hexafluoroethylene.[13]

The manufacture of hydrofluoric acid, an intermediate for making fluoride chemicals for the aluminum, aerosol, refrigerant, and plastics industries, usually requires high grade, finely ground, and rather closely sized fluorspar concentrate. A process, in which the chemical and physical properties of raw materials may be less critical, was developed for the production of hydrofluoric acid from pellets. The pellets were formed by combining stoichiometric proportions of sulfuric acid and ground fluorspar with crushed anhydrite at a temperature below 50° C. The anhydrite ranged from 85 to 260 percent by weight of the calcium fluoride. The pellets were fed into a reactor and heated to 150° to 300° C to obtain gaseous hydrofluoric acid. The anhydrite imparted sufficient strength so that the shapes were not destroyed during furnance treatment.[14]

Fluorine was being tested as an oxidizer for rocket fuels. Liquid fluorine was used with a fuel mixture of monoethylhydrazine and hydrazine. Gaseous fluorine and liquid hydrogen were used to provide a high-temperature ignition source in the M–1 high-energy rocket engine.[15]

A mixture of sodium chloride, sodium fluoride, and potassium aluminum tetrafluoride proved to be the most effective electrolyte in recovering tungsten from tungsten oxide in a process developed by the Bureau of Mines. The power requirement was low and the temperature of the electrolytic bath was 800° C compared with the 1,000° C temperature now required in the commercial method.[16]

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[11] Chemical Week. Greases To Provide One-Shot Permanent Lubes. v. 99, No. 1, July 2, 1966, p. 41.
Industrial & Engineering Chemistry. New Chemicals and Materials: Lubricants. v. 58, No. 9, September 1966, p. 68.
Iron Age. Space Spawns Super-Lubes. v. 198, No. 3, July 21, 1966, p. 95.

[12] Materials in Design Engineering. Dry Lubricants for Vacuum Environment. v. 63, No. 6, June 1966, pp. 139–140.

[13] Chemical & Engineering News. Montecatini Edison Develops Liquid Fluorinated Compounds. v. 45, No. 27, June 26, 1967, pp. 12–13.

[14] Parinot, G. (assigned to Societe d'Electro 'Chimie, d'Electro-Metallurgie et des Acieries Electriques d'Ugine, Paris, France.) Process for Production of Hydrogen Fluoride from Sulfuric Acid, Fluorspar and Anhydrite. U.S. Pat. 3,300,279, Jan. 24, 1967.

[15] Chemical & Engineering News. Liquid Rocket. v. 44, No. 33, Aug. 15, 1966, p. 101.
———. A Fluorine Ignition System Is Being Used in the M–1 High-Energy Rocket Engine. v. 44, No. 37, Sept. 5, 1966, p. 49.

[16] Gomes, John M., Kenji Uchida, and Don H. Baker, Jr. Electrowinning Tungsten in Halide and Phosphate Electrolytes. BuMines Rept. of Inv. 6742, 1966, 9 pp.

CRYOLITE

Natural cryolite was imported from Greenland by Pennsalt Chemicals Corp., Philadelphia, Pa., and concentrated at its Natrona, Pa. plant.

Synthetic cryolite was produced by Kaiser Aluminum & Chemical Corp. at Chalmette, La., and by Reynolds Metals Co. at Bauxite, Ark. Cryolite was reclaimed from scrap pot linings by Aluminum Company of America at Point Comfort, Tex.; by Kaiser Aluminum & Chemical Corp. at Chalmette, La., and Spokane, Wash.; and by Reynolds Metals Co. at Listerhill, Ala., Longview, Wash., Corpus Christi, Tex., Troutsdale, Oreg., and Patterson, Ark.

General Chemical Div., Allied Chemical Corp., announced that it would soon start up facilities to produce artifical cryolite and aluminum fluoride at New Orleans, La.

PRICES

Cryolite quotations reported by the Oil, Paint and Drug Reporter, December 25, 1967, were as follows: Natural, industrial, in bags, carlots at works, 100 pounds, $13; and in bags, less than carlots, at works, 100 pounds, $14.25. The prices were unchanged from the previous year.

FOREIGN TRADE

Exports of synthetic cryolite were not separately classified in 1967. The import statistics shown in table 11 do not distinguish between natural and synthetic cryolite, but it is believed that virtually all shipments from countries other than Greenland were synthetic cryolite.

Table 11.—U.S. imports for consumption of cryolite

Year and country	Short tons	Value (thousands)
1964	24,264	$1,765
1965	24,011	2,009
1966:		
Denmark	2,352	107
France	6,622	1,154
Germany, West	66	23
Greenland [1]	16,693	728
Guinea	917	147
Italy	4,961	1,025
Switzerland	44	15
Total	31,655	3,199
1967:		
Canada	2,689	453
France	7,558	1,449
Germany:		
East	679	115
West	1,486	303
Greenland [1]	19,953	1,032
Italy	3,954	766
Total	36,319	4,118

[1] Crude natural cryolite.

Gem Stones

By Benjamin Petkof [1]

Domestic gem stone production was estimated during 1967 at $2.4 million, unchanged from 1966. Gem stone collection continued to be essentially a recreational activity of individual collectors and hobbyists.

DOMESTIC PRODUCTION

Production estimates indicated that 38 States produced gem material in 1967. The leading producing States were Oregon, California, Idaho, Arizona, Texas, Wyoming, Colorado, Montana, and Nevada with each State producing material valued over $100,000. These States provided 77 percent of total production.

CONSUMPTION

Consumption of gem diamond, both rough and cut, reached $387 million, only a small increase from $374 million in 1966. Value of imported synthetic and imitation gem stones including imitation pearl reached $11.5 million, compared with $10.0 million in 1966; natural and cultured pearls declined 19 percent from 1966.

Apparent consumption of gem stones (domestic production plus imports minus exports and reexports) was $304 million, compared with $289 million in 1966.

PRICES

During the year, price ranges for cut and polished, unmounted gem diamond were 0.25 carat, $80 to $375; 0.50 carat, $200 to $800; 1 carat, $500 to $2,500; 2 carat, $1,800 to $7,000.

FOREIGN TRADE

Exports of precious and semiprecious gem stone were valued at $6.5 million, compared with $64.1 million in 1966. Diamond, over one-half carat in weight, cut but unset, made up the bulk of the exports.

Reexports of all varieties of gem stone reached $72.0 million, a decline of $3.2 million from those of 1966. The major portion of reexports consisted of rough or uncut gem quality diamond.

Ruby and sapphires valued at $5.7 million were imported from 27 countries. Thailand, India, and Ceylon supplied about 70 percent of the total.

Imports of emerald rose in quantity but declined in value. India supplied 38 percent of all imports.

India and Japan were the major sources of imported natural pearl. However, Japan remained the largest supplier of cultured pearls.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—U.S. imports for consumption of precious and semiprecious stones, exclusive of industrial diamond

(Thousand carats and thousand dollars)

Stones	1966		1967	
	Quantity	Value	Quantity	Value
Diamond:				
Rough or uncut, suitable for cutting into gem stones carats	2,032	$208,039	2,506	$212,902
Cut but unset, suitable for jewelry do	1,452	165,737	1,455	174,570
Emeralds: Cut but unset do	r 218	r 5,994	242	5,518
Rubies and sapphires: Cut but unset, suitable for jewelry	NA	7,163	NA	5,685
Marcasites: Real and imitation, dutiable	NA	5	NA	3
Pearls and parts, not strung or set:				
Natural	NA	733	NA	576
Cultured or cultivated	NA	21,236	NA	17,140
Imitation	NA	506	NA	374
Other precious or semiprecious stones:				
Rough or uncut	NA	2,483	NA	4,900
Cut but unset	NA	4,972	NA	6,539
Other n.s.p.f.	NA	320	NA	270
Imitation:				
Cut but unset, synthetic number	2,699	1,178	3,042	1,382
Other	NA	8,341	NA	9,786
Total	NA	r 426,707	NA	439,645

r Revised. NA Not available.

Table 2.—U.S. imports for consumption of diamond (exclusive of industrial diamond), by countries

(Thousand carats and thousand dollars)

	1965				1966				1967			
	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
Argentina	-----	-------	-----	-------	-----	-------	-----	-------	4	$241	-----	-------
Belgium-Luxembourg	75	$7,597	680	$73,923	72	$9,520	787	$94,353	47	6,111	775	$96,676
Brazil	4	293	1	97	4	425	-----	-------	21	1,009	2	169
British West Africa	-----	-------	-----	-------	2	325	-----	-------	2	380		
Canada	7	1,138	([1])	44	10	1,663	([1])	16	5	847	([1])	64
Central African Republic	144	8,365	-----	-------	187	9,835	-----	-------	183	9,002	-----	-------
Cyprus	-----	-------	-----	-------	-----	-------	-----	-------	2	281	([1])	33
France	2	70	16	1,665	3	211	18	1,902	1	101	17	2,085
Germany, West	-----	-------	19	1,370	([1])	1	17	1,441	2	227	11	1,039
Ghana	3	146	([1])	16	20	464	-----	-------	5	68	-----	-------
Guinea	2	205	-----	-------	1	66	-----	-------	-----	-------	-----	-------
Guyana	19	742	-----	5	25	995	([1])	8	31	1,370	-----	-------
India	-----	-------	2	342	-----	-------	8	720	-----	-------	14	1,239
Ireland	4	71	([1])	3	56	2,248	2	101	132	571	3	240
Israel	57	3,310	473	42,134	36	3,096	525	51,446	46	4,079	533	55,033
Japan	([1])	8	1	142	([1])	6	1	78	([1])	14	2	150
Liberia	7	674	-----	-------	16	1,831	-----	-------	26	3,946	-----	-------
Netherlands	34	4,094	21	2,835	49	8,825	21	3,013	39	8,566	14	2,065
Sierra Leone	44	2,818	-----	-------	161	7,705	([1])	53	180	5,921	3	307
South Africa, Republic of	159	15,330	27	6,166	121	13,023	28	7,001	333	39,852	32	7,766
Southern Africa, n.e.c.	-----	-------	-----	-------	-----	-------	-----	-------	2	101	([1])	31
Switzerland	104	9,879	1	633	69	8,504	1	422	7	1,524	([1])	174
U.S.S.R.	-----	-------	11	1,410	-----	-------	29	3,391	([1])	17	39	5,918
United Kingdom	1,142	113,481	6	857	1,106	131,809	10	1,354	1,339	122,000	10	1,395
Venezuela	54	1,950	-----	-------	66	2,525	-----	-------	64	2,347	-----	-------
Western Africa, n.e.c.	35	4,903	-----	-------	21	3,446	-----	-------	35	4,260	([1])	6
Western Portuguese Africa, n.e.c.	2	124	-----	-------	7	1,445	-----	-------	-----	-------	-----	-------
Other countries	3	259	1	186	([1])	71	5	438	([1])	67	([1])	180
Total	1,901	175,457	1,259	131,828	2,032	208,039	1,452	165,737	2,506	212,902	1,455	174,570

[1] Less than ½ unit.

WORLD REVIEW

Brazil.—The diamond mining industry has been undergoing a change from hand mining method to the application of large hydraulic dredges for large-scale recovery. A dredge has been placed in operation on the Jequitinhonha River by Meneraçao Tijucana S.A., Dragagem de Ouro S.A., and Pacific Tin Corporation which moves material at the rate of 400 cubic yards per hour in 12-cubic-foot buckets. Test drilling has shown that the diamond recovery rate averaged 0.01 carat per cubic yard of diamondiferous gravel. Eighty percent of the material recovered is of gem grade.

The Mining Department of the Federal Government began prospecting and evaluating the Tocantins River area for available diamond by the interpretation of aerial photographs and coring operations. This area has previously been worked by crude hand methods.[2]

Table 3.—World production of gem diamond, by countries [1]

(Thousand carats)

Country	1963	1964	1965	1966	1967 p
Africa:					
Angola	759	804	878	964	e 1,000
Central African Republic	121	221	268	270	260
Congo (Kinshasa)	296	295	14	15	263
Congo (Brazzaville) e [2] [3]	341	316	318	r 300	300
Ghana	r 4	r 378	r 25	282	254
Guinea e	[2] 22	21	21	21	20
Ivory Coast	63	120	119	110	105
Liberia [2]	240	298	277	343	353
Sierra Leone	555	585	658	629	e 600
South-West Africa, Territory of	1,076	1,387	1,491	1,583	e 1,700
Tanzania	276	338	414	r 474	494
South Africa, Republic of:					
Premier	522	556	610	625	NA
De Beers group [4]	921	928	985	1,429	NA
Other pipe mines	16	18	123	131	NA
Alluvial	338	288	230	300	NA
Total South Africa	r 1,797	1,790	1,948	2,485	e 2,100
Total Africa	r 5,550	r 6,553	r 6,431	r 7,476	7,449
Other areas:					
Brazil e	175	175	175	150	160
Guyana	60	60	45	37	38
India	1	2	r 3	2	6
Indonesia	NA	NA	1	2	2
U.S.S.R. e	r 600	r 800	r 1,000	r 1,200	1,400
Venezuela	r 38	r 57	r 52	42	38
World total [5]	r 6,424	r 7,647	r 7,707	r 8,909	9,093

e Estimate. r Revised. p Preliminary. NA Not available.
[1] Compiled mostly from data available April 1968.
[2] Exports.
[3] Probable origin, Republic of the Congo.
[4] Includes some alluvial from De Beers properties.
[5] Totals are of listed figures only; no undisclosed data included.

Canada.—A recent paper postulates that the source of the diamond previously found in the glacial deposits of Ohio and Wisconsin was kimberlite deposits in the James Bay area.[3]

Lesotho.—The Government and The Rio Tinto-Zinc Corp. Ltd. announced an agreement for diamond prospecting and eventually mining at the Lesotho State Diamond deposit at Letseng-la-Terai in northeastern Lesotho. The agreement provided for a 2– to 3–year prospecting period to determine if large-scale mining operations are justified.[4] A large pale-brown stone weighing 601 carats was recovered.

[2] Linder, P. H. Modern Dredges Successful in Recovering Brazilian Diamond. Lapidary J.; v. 21, No. 2, May 1967, pp. 298–305.
[3] Northern Miner (Toronto, Canada). Diamond-Type Rocks in James Bay Area No. 1, Mar. 30, 1967, p. 15.
[4] U.S. Embassy, Maseru, Lesotho. Department of State, Airgram A–83, Oct. 27, 1967, pp. 1–2.

Sierra Leone.—In terms of value diamond was the major mineral product of Sierra Leone.

Sierra Leone Selection Trust Ltd. (SLST) and the Government renegotiated the SLST leases, providing for an increase in the income and diamond profits tax paid by the company. SLST also agreed to release certain locations in Kono and Tongo for licensed alluvial mining, to allow licensed diggers to recover diamond from its mine tailings, to begin a program of rehabilitating mined-out areas, and to study prospecting potential for more diamond.[5]

South Africa, Republic of.—The Finsch diamond mine was formally opened on February 24, 1967. The ore reserves were estimated at 110 million tons down to the open pit mining limit of 900 feet; at a planned production rate of 17,000 loads (16 cubic feet per load) per day, minimum life would be 25 years. The recovery rate was 38 carats per 100 loads.[6] About 75 percent of the diamond recovered was industrial grade. The average overall recovery ratio is 1 to six million. The Finsch is the first new pipe mine since the Premier mine was opened in 1903.[7]

Tanzania.—Williamson Diamonds, Ltd. and two subsidiary companies, New Alamasi and Kahama Mines, Ltd., supplied most of the diamond production and exports. The Government has 50 percent interest in this group. The company mined 3,285,038 tons of ore which yielded 923,423 carats at the Mwadui mine. Ore production at the New Alamasi totaled 411,512 tons of ore which contained 23,176 carats. The ore body was mined out at the Kahama Mines Ltd., and treatment of the stockpile began. Completion is expected in 4 years. Williamson Diamond continued to look for diamond north of Kahama during 1967, but nothing of value was found.[8]

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[5] Bureau of Mines. Mineral Trade Notes. v. 64, No. 6, June 1967, p. 5.

[6] U.S. Embassy, Johannesburg, Republic of South Africa. Department of State, Airgram A–351, Mar. 28, 1967, p. 1.

[7] World Mining. What's Going On in World Mining. v. 3, No. 4, April 1967, p. 41.

[8] Bureau of Mines. Mineral Trade Notes. v. 65, No. 1, January 1968, p. 7.

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Gold

By J. Patrick Ryan [1]

A sharp decrease in domestic gold output, attributed mainly to the copper strike, record industrial consumption, and a heavy outflow from the monetary stock following devaluation of the pound Sterling, featured the domestic gold situation in 1967.

World production of gold decreased for the first time in recent years, principally because of falloff in output in South Africa coupled with production declines in Canada and the United States.

For the second successive year, all of the non-Communist newly mined gold valued at $1,400 million went into private holdings for use in industry and the arts, investment, and speculation. The International Gold Pool had to again supply gold to satisfy private demand and stabilize the gold price just under $35.20 per ounce. Monetary reserves of non-Communist central banks and governments declined to about $41,600 million, the lowest level since 1962.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient gold statistics

	1963	1964	1965	1966	1967
United States:					
Mine production____thousand troy ounces__	1,454	1,456	1,705	1,803	1,584
Value____thousands__	$50,889	$50,971	$59,682	$63,119	$55,447
Ore (dry and siliceous) produced:					
Gold ore____thousand short tons__	2,459	2,631	3,113	3,447	3,076
Gold-silver ore____do____	223	224	206	248	157
Silver ore____do____	556	542	752	669	617
Percentage derived from—					
Dry and siliceous ores____	51	54	54	58	69
Base-metal ores____	36	37	40	37	27
Placers____	13	9	6	5	4
Refinery production [1]____thousand troy ounces__	1,469	1,469	1,675	1,802	1,526
Exports____do____	5,820	12,078	36,717	13,067	28,720
Imports, general____do____	1,281	1,169	2,905	1,200	930
Stocks Dec. 31: Monetary [2]____millions__	$15,596	$15,471	$13,806	$13,235	$12,065
Consumption in industry and the arts thousand troy ounces__	2,920	4,801	5,276	6,062	6,294
Price: Average per troy ounce [3]____	$35.00	$35.00	$35.00	$35.00	$35.00
World:					
Production____thousand troy ounces__	43,147	44,840	46,222	46,567	45,610
Official reserves [4]____millions__	$42,310	$43,060	$43,300	$43,205	$41,600

[1] From domestic ores.
[2] Includes gold in Exchange Stabilization Fund.
[3] Price under authority of Gold Reserve Act of Jan. 31, 1934.
[4] Held by free world central banks and governments.

Legislation and Government Programs.—Several bills were introduced in the 1st session of the 90th Congress to aid the domestic gold mining industry. The Senate Subcommittee on Minerals, Materials, and Fuels, on February 2, held public hearings on bills S. 49 and S. 6151 which would compensate domestic gold miners for the increase in production costs since 1939. The purpose of the subsidy was to provide incentive for reopening some mines and increasing the overall production of gold. In the House of Representatives the Subcommittee on Mines and Mining, on May 22 to 23 and June 2, held hearings on similar bills, H.R. 742, H.R. 3274, H.R. 5418, and related bills, H.R. 8803 and H. R. 9899. H.R. 3274 and similar bills provided for payments to operating mines ranging from 6 to 10 percent of the value of the bullion produced with an escalator clause tied to the Consumer Price Index. For inactive mines payments would be at the rate of 125 percent of bullion produced. H.R. 8803 and similar bills provide for grants-in-aid to States paying gold-mining subsidies at the rate of 90 percent of the amount paid. Executive agencies opposed enactment of the proposed legislation. No action on the legislation was taken by the full membership of the House and Senate.

Bills to permit free marketing of gold (H.R. 3276) and to eliminate the gold backing of Federal Reserve notes (H.R. 6428, S. 1983) were introduced and referred to the respective Committees on Banking and Currency, and the Senate Committee on Finance. Bills to provide tax incentives to encourage gold mining (H.R. 9900 and H.R. 10098) also were introduced and referred to the Committee on Ways and Means but no further action was taken on these bills. Another bill (S. 2727) was introduced to prohibit the use of gold for settlement of international balances with France while that Government is in arrears in the payment of its obligations to the United States.

Four contracts for gold exploration aggregating $144,240 were executed during the year under the financial assistance program administered by the Office of Minerals Exploration, U.S. Geological Survey. The Government share of the exploration cost was $86,355. The U.S. Department of the Interior in September announced an increase in the Government financial assistance from 50 to 75 percent of the allowable costs of exploring for gold, silver, and certain other minerals in short supply.

The following project contracts were active or in force at yearend:

Operator	*Location*	*Total cost*
High Sierra Mining Co	Sierra County, Calif	$25,350
W. S. Moore Co	Rio Grande County, Colo	81,680
Ruby Silver Mines, Inc	Jefferson County, Mont	132,800
Frank O. Richardson	San Juan County, Colo	57,300
Continental Quicksilver	Owyhee County, Idaho	61,360
Sidney Mining Co	do	40,208
Golden State Mining Co	Sierra County, Calif	42,100
Douglas W. Sumner and James Andrulli	Palmer District, Alaska	6,000
Dickey Exploration Co	Sierra County, Calif	81,300
Louie Clark, Et al	Wilkes County, Ga	22,500
Frank R. Ramsey	Baker County, Oreg	34,440
Total		$585,038

Creation of a new form of international monetary reserve called "special drawing rights" or S.D.R.'s was authorized by the governing board of the International Monetary Fund at its annual meeting in Rio de Janeiro in September 1967. The S.D.R.'s are designed to supplement and lessen dependence on gold and dollars in balance-of-payments transactions. A detailed plan for adopting the S.D.R.'s is being drawn up for ultimate ratification by I.M.F. member countries.

Under the U.S. Department of the Interior's Heavy Metals Program, established in 1966 to stimulate domestic production of gold and other heavy metals in short supply, the Bureau of Mines and the Geological Survey investigated several large potentially productive gold deposits. Bureau research on developing methods of reliably evaluating low-grade deposits and on improving extraction technology needed to economically exploit such deposits has indicated that additional quantities of gold may be produced through the application of new and better technology. The Survey, using advanced techniques of exploration and analysis, identified target areas geologically favorable for gold exploration.

The Bureau of Mines completed a 3-year engineering and economic appraisal of 1,300 known gold deposits in the United States which disclosed a production potential of more than 400 million ounces of gold of which 9 million ounces or 2 percent was producible under present economic and technologic conditions.[2]

DOMESTIC PRODUCTION

Mine production of recoverable gold in the United States dropped 12 percent to 1.6 million ounces, mainly because of the effects of strikes against major copper mining and smelting companies which since mid-July cut off most of the gold produced as a byproduct of base metals. Lower gold output was recorded in all States compared with that in 1966. In Nevada, production at the Carlin mine continued to rise but did not fully offset the falloff in byproduct gold output. Gold production from placer operations in Alaska and California and from lode gold mines in South Dakota and Washington declined as well as the output of byproduct gold from base metal ores in Arizona, Colorado, Montana, and Utah. Two mines, Homestake and Carlin, contributed nearly two-thirds of the total U.S. gold production. At least four gold mining operations, including the Gold King, Getchell, and Chicken Creek, ceased operations in 1967 leaving only three significant lode and two placer mines still operating.

American Exploration and Mining Co. announced that exploration of a gold deposit near Cortez, Nev., had indicated about 3 million tons of open-pit ore containing 0.3 ounce of gold per ton.

Homestake Mining Co. reported that 1.9 million tons of ore was treated in 1967 at its Homestake mine in Lead, S. Dak., from which 601,783 ounces of gold and 121,258 ounces of silver valued at $21.2 million was recovered. Although ore milled and gold output dropped slightly, the recovered value increased to $11.18 per ton compared with $10.64 in 1966. Metallurgical recovery dropped slightly to 95.2 percent. Production costs were about $31.50 per ounce, down moderately from the 1966 level. Measured ore reserves at yearend totaled 13.3 million tons averaging 0.319 ounce ($11.12) of gold per ton, a net decrease of 1.9 million tons for the year.[3]

The Carlin Gold Mining Co. reported that gold production at its Carlin mine, near Carlin, Nev., increased to 337,000 ounces compared with 261,000 ounces in 1966, the first full year of operation. Tons of ore milled decreased appreciably but average grade increased from 0.33 to 0.48 ounce of gold per ton. Ore reserves at yearend were 7.3 million tons compared with 8.4 million tons in 1966. The company installed mercury retorts to treat gold precipitates for recovery of byproduct mercury, which occurs in minute quantities in the ore.

At the Mayflower mine in the Park City district, Utah, operated by Hecla Mining Co., gold output increased 5 percent to nearly 65,000 ounces. Average grade of ore produced was 0.57 ounce of gold per ton, 4.7 ounces of silver per ton, 4.5 percent lead, 4.0 percent zinc, and 0.9 percent copper. Estimated ore reserves decreased to 331,000 tons at yearend compared with 385,000 tons at the beginning of the year.[4]

United States Smelting, Refining and Mining Co. operated two dredges in Alaska under normal conditions—one at Chicken Creek and one at Hogatza. Gold production was down 31 percent to 10,221 ounces. However, dredging operations at Chicken Creek became economically unfeasible and were discontinued. The company planned to continue dredging operations at Hogatza.[5]

The 25 leading gold producers contributing nearly all of the domestic output included 5 lode gold mines, 1 gold-silver mine, 3 placer mines, 12 copper mines, 2 copper-lead-zinc mines, and 2 lead-zinc mines.

Approximately 3,000 persons were employed in the gold mining industry in 1967.

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[2] Bureau of Mines Field Staff. Production Potential of Known Gold Deposits in the United States. Inf. Circ. 8331, 1967, pp. 1, 5.

[3] Homestake Mining Co. 90th Annual Report. Dec. 31, 1967, p.5.

[4] Hecla Mining Co. 70th Annual Report. Dec. 31, 1967, pp. 10, 13.

[5] United States Smelting, Refining and Mining Co. Annual Report. 1967, p.13.

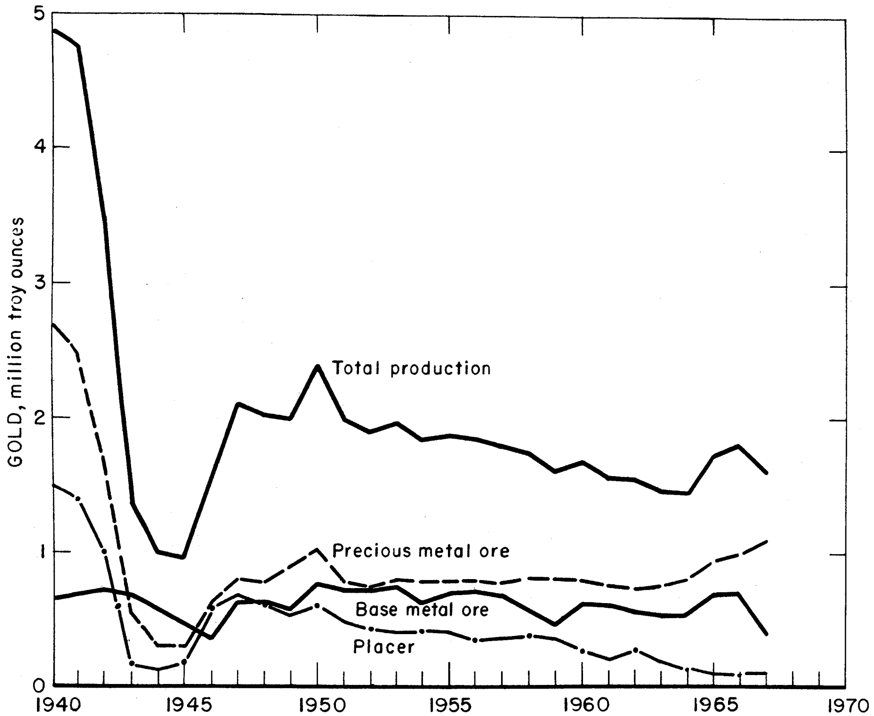

Figure 1.—Gold production in the United States.

CONSUMPTION AND USES

Domestic consumption of gold in fabricating various industrial and artistic products increased about 4 percent to about 6.3 million ounces, a record high for the fourth consecutive year.

Data compiled by the Office of Gold and Silver Operations, U.S. Department of the Treasury, indicate that about 70 percent of the gold sold or conveyed to manufacturers was used for jewelry, decorative, and dental products; the remainder was used chiefly in electrical and electronic components and other industrial products, including defense and aerospace equipment.

In the past 5 years consumption of gold has increased 80 percent. Gold has become increasingly important in subminiature and microminiature circuitry for computers and sophisticated electronic installations. Glass container manufacturers and pack agers are using increasing amounts of decorative gold to augment sales.

A study of the environmental effects upon connectors has confirmed that gold, usually in electroplated form, is the best general purpose material now available for contacts in corrosive environments such as those containing high levels of chlorine and ozone, sulfur dioxide, aldehyde or hydrogen sulfide.

The increasing application of gold in communications, electronics, and aerospace is based mainly on such outstanding properties as high electrical conductivity, high light and heat reflectivity, and superior malleability and corrosion resistance. In the telephone industry gold is commonly used for coating contact points in electromechanical switchgear and other components of the instrument. In computers gold alloys are used for cladding metal tapes. The use of gold and other precious metal alloys in electroplated printed circuits for many industrial applications continued to grow. Gold-alloy contacts in many types of household appliances and in voltage regulators for the automotive industry give higher performance and longer life.

A new magnet alloy containing 6 percent gold was developed at Bell Telephone Laboratories for use in computer memories. The gold enables the magnet's coercive force to be controlled by heat-treatment during production to any desired value within a range of 10 to 20 oersteds.

Westinghouse Electric Corp. developed a new process using gold and titanium films which increases substantially the reliability of integrated circuits. Essentially, the new technique is a three-step process which "seals" the integrated circuit more effectively against its environment, against chemical instability, and against certain internal electrical changes.

A gold grid was used in a high-speed electronic tester to determine the water vapor transmission rate through a variety of thin materials. As a sensor, the thin gold grid was embossed on a piece of transparent plastic and covered with a humidity-sensitive film. The electrical resistance of the gold grid varies inversely with the humidity. The device reduces the required testing time from days to minutes and requires a minimum of skill to operate.

Gold plating helped to achieve low power loss and light weight requirements in an electrothermal attitude control thruster for a nuclear detection satellite. The highly reflective plated surface on structural components reduces thermal radiation loss.

Tiny gold whiskers, only one-tenth the diameter of a human hair and about 0.010 inch long, vibrating like tuning forks, now make it possible to "tune" integrated circuits to a narrow band of frequencies and reject all others. This selectivity is a basic requirement of radio equipment and other electronic devices. These new transistors with vibrating whiskers have covered frequencies from about 10 to 100 kilocycles per second.

An efficient spray-process gold called the "Enplate" Lockspray-Gold Process, developed by Lockheed Missiles and Space Co., reduced fabrication costs and increased in-flight temperature control efficiency of the Gemini spacecraft. The gold film is applied by simultaneously spraying on two water base solutions, one containing gold in solution and the other a chemical reducing agent. The solutions react to form tiny gold crystals which adhere to the substrate to form a protective coating. The firm reported that a 0.000004-inch thick spray-on coating would reflect more than 60 percent of the sun's heat energy admitted through a glass window, thus reducing air conditioning costs and providing "special" decorative appearance. Apart from its usefulness in the space program, the process is finding applications in the production of such articles as one-way mirrors, electronics equipment, instrumentation, automatic data processing equipment, and in commercial architecture.

Gold-nickel alloys containing 82 percent gold and 15 percent nickel were used to secure leakproof joints in lightweight tubular systems for aerospace vehicles. The technique developed by Aeroquip Corp., uses induction heating to produce the brazing temperatures required. NASA engineers reported that this technique produced a highly reliable, lightweight tubing joint, solving many problems in joining light tubing.

A gold brazing alloy, 82Au18Ni, used for ceramic-to-metal joints in electronic tubes also was used in the form of custom-made brazing rings by Aeroquip Corp. for joints in various tubular fittings of the Gemini capsule. The gold-nickel alloy has good wetting characteristics and flowability and produces exceptionally strong joints with high resistance to oxidation and corrosion. The alloy was specified for the Apollo and other space vehicles.

Gold transfer tape for coating refractory nonconductors was developed by Vitta Corp. The new tape consists of a gold layer incorporating glass-flux materials. The gold layer is attached temporarily to a plastic carrier film with a special adhesive. During the subsequent firing procedure, the organic binders decompose and a uniform and firmly bonded gold layer remains on the refractory material.

A thin layer of gold on high-strength steel was found to protect the steel from hydrogen embrittlement during cadmium plating. The coating can eliminate the costly baking process normally required to remove the hydrogen from metal used in fabricating aircraft parts.

In fabricating a new planar triode tube, Machlett Laboratories used a thin coating of 24K gold on all exposed surfaces as well as on the fine tungsten wire mesh inside the tube. The outside coating permits soldering to circuit units. The microscopically thin coating on the grid which operates at temperatures above 1,500°F, suppresses electron emission.

Platinum sheathed gold seeds less than 0.1 inch in length were used in the radioactive treatment of cancer. The radioactive gold is totally encapsulated in pure platinum which screens certain harmful radiation products while permitting beneficial gamma rays to pass through and destroy malignant tissue.

Bright gold, a form of liquid gold developed for application over organic colors, may find increased use by cosmetic manufacturers in a wide range of decorative organic colors.

Gold-plating stainless steel liquid helium containers reduced losses of helium to less than 1.5 percent daily in 500-liter systems designed for air shipment.

A gold-plated titanium shield was developed to reflect fuel-element heat away from the Apollo spacecraft and help maintain the thermal balance inside the lunar module. The gold is plated over a diffusion barrier to impede the interdiffusion of gold and titanium and preserve the critical thermal rejection capability.

MONETARY STOCKS

The total U.S. gold stock, including gold in the Exchange Stabilization Fund, fell $1,170 million to $12,065 million at yearend, the lowest level since May 1937. Most of the gold outflow represented sales to foreign countries during the last 2 months following devaluaticn of the British pound. The 1967 gold loss was about twice that in 1966. The U.S. balance-of-payments deficit to which gold losses are closely related, measured on a liquidity basis, was $3,575 million, about $2,218 million more than in 1966.

The $12,065 million U.S. gold reserve represented 27.1 percent of the Federal Reserve note liability compared with $13,235 million or 31.5 percent at the end of 1966. About $10,600 million, representing the 25-percent statutory requirement, was held as backing for the Federal Reserve notes.[6]

Gold reserves of non-Communist central banks and governments and international banking institutions at yearend were estimated at $41,600 million compared with $43,205 million at yearend 1966. This was the second successive drop in official reserves in recent years, indicating that gold was being withdrawn from monetary reserves to supplement new production in meeting private demand.

The U.S. reserve of $12,065 million constituted about 29 percent of the total official non-Communist gold reserve compared with 31 percent a year ago. Gold reserves of other principal non-Communist countries at yearend, in million dollars, were as follows: France, $5,234; West Germany, $4,228; Switzerland, $3,089; Italy, $2,400; Netherlands, $1,711; Belgium, $1,480; United Kingdom, $1,291; and Canada, $1,015. The International Monetary Fund's gold reserve was $2,682 million.[7]

U.S. short-term liabilities to foreign interests payable in dollars, reported by banks in the United States, increased $3,285 million to $30,295 at yearend, reflecting the increase in the U.S. balance-of-payments deficit. These liabilities were potentially convertible into gold. More than one-half of the total liabilities were payable to West European countries.

[6] Federal Reserve Bulletin. V. 54, No. 5, May 1968, pp. A–69 to A–79.

[7] See work cited in footnote 6.

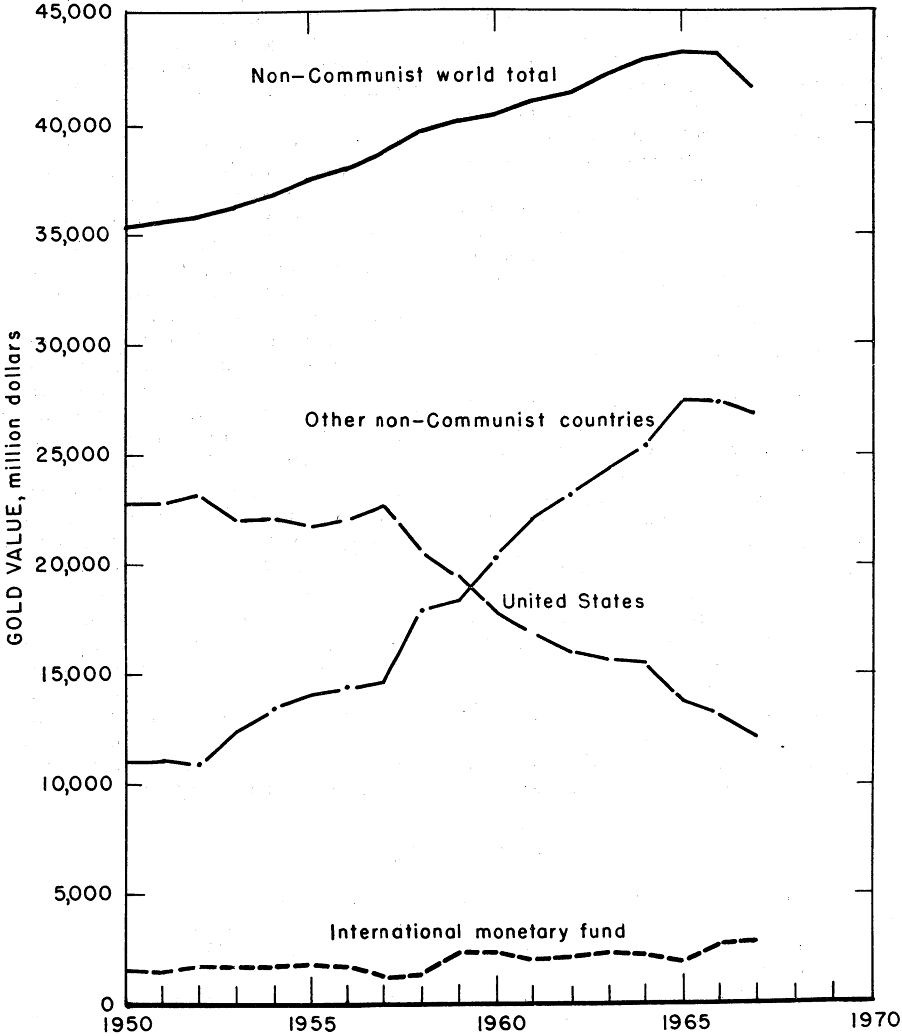

Figure 2.—Gold reserves of non-Communist central banks and Governments.

PRICES

Virtually all newly mined gold continued to be bought and sold either by refiners and dealers under license by the U.S. Department of the Treasury or by the Treasury itself through the Bureau of the Mint at the base price of $35 per ounce established by the Gold Reserve Act of 1934. The U.S. policy of purchasing all gold offered and redeeming dollars offered by foreign central banks and governments at $35 per ounce, establishes the official world price of gold.

Prices for bar gold fluctuated on the London gold market between $35.158 and $35.196 per ounce. In other gold markets of the world, price quotations were considerably higher than at London, reflecting local political conditions and unofficial exchange rates. Average prices at yearend in these markets were substantially higher than a year ago, ranging from $35.95 at Beirut; $36.50 at Paris; $42.50 at Hong Kong; to $57.50 at Bombay.

Devaluation of the pound Sterling on November 18 sparked an upsurge in gold speculation and hoarding against the threat of further international crisis and currency devaluations. The International Gold Pool was forced to supply gold to satisfy the private demand and maintain the price of gold near $35 per ounce. For the second consecutive year, no gold sales by the U.S.S.R. were reported.

Premiums on gold coins over their gold content increased substantially during the year. At yearend premiums quoted by a leading London bullion broker ranged from 25¼ percent on Mexican 50-peso centenarios to 153 percent on U.S. 5-dollar half eagles. Premiums on Queen Elizabeth sovereigns, U.S. 10-dollar eagles, 20-dollar double eagles, and 20-franc Napoleons were approximately 22, 62, 47, and 59 percent, respectively.

Government officials on several occasions reaffirmed the intention of the United States to maintain the price of gold at $35 per ounce and to continue the convertibility of the dollar into gold at that price.

Concerning the official price of gold, the U.S Department of the Treasury issued the following statement in January 1967 in response to press reports from Paris suggesting that study be given to raising the price of gold as one of the means of meeting international liquidity needs.

> "The price of gold is determined by its relationship to the United States dollar. This relationship has been fixed at $35 per ounce since 1934, and will remain there. Any suggestion that the price of gold be raised—either to meet needs for additional international liquidity or for any other reason—is completely unacceptable to the United States. Future international monetary arrangements must be based on this fact. This has been made clear to French financial authorities."

At the annual meeting of the International Monetary Fund in September 1967, Secretary Fowler stated with reference to the price of gold and convertibility:

> " . . . Nothing in the new arrangements on liquidity is designed to alter the present relationship between gold and the dollar. The United States' commitment to the convertibility of the dollar into gold at $35.00 an ounce remains firm. This has been, and will continue to be a central factor in the monetary system. . . ."

FOREIGN TRADE

The heavy outflow of gold in December, reflecting extraordinary heavy demand in the London market following devaluation of the pound Sterling, changed the net-import trade pattern of the first 11 months to a net-export situation for the year. For the 12-month period net exports (exports less imports) of 27.8 million ounces were the highest since 1965 and marked the seventh consecutive year that exports exceeded imports. Nearly all of the total gold exported went to the United Kingdom.

Tariff rates on gold in plated, semifabricated, and compound forms were lowered in accordance with Kennedy Round trade negotiations. The new rates effective January 1, 1968 are as follows:

TSUS[1] *No.*	*Item*	*Rate, Percent*[2]
605.46–605.47	Platinum-silver-plated gold.	29–45
605.60–605.66	Rolled semimanufactured gold.	18.5–36
418.80 & 427.28	Gold compounds	9

[1] Tariff Schedules of the United States.
[2] Ad valorem.

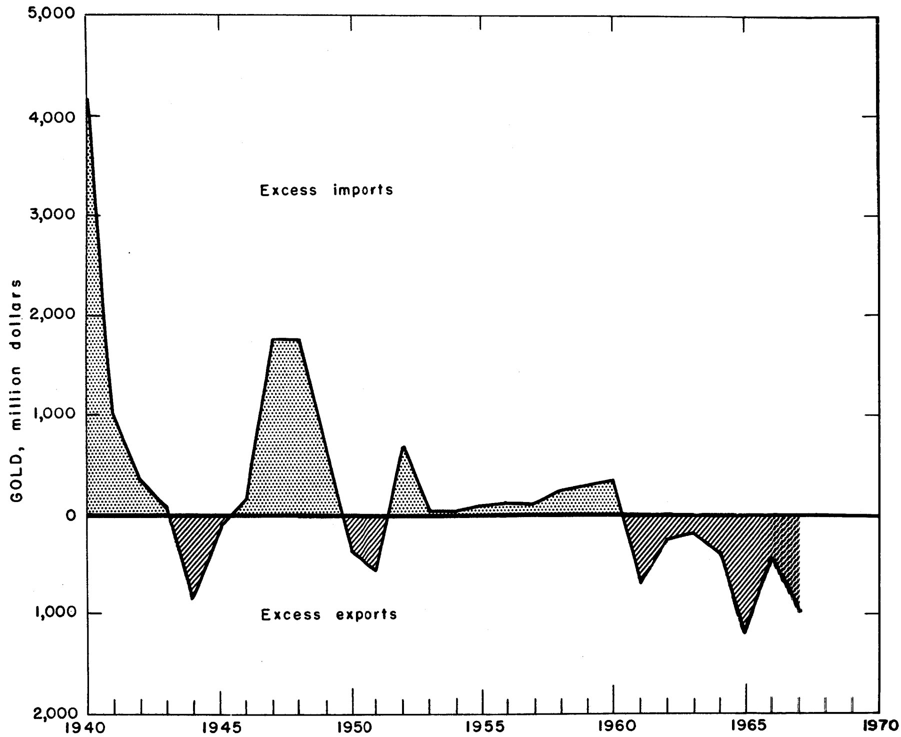

Figure 3.—Net exports or imports of gold.

WORLD REVIEW

World gold production after increasing for 13 consecutive years decreased about 2 percent to 45.6 million ounces valued at $1,596 million in 1967. Lower output in South Africa, the United States, Australia, and Canada was not fully offset by production gains in the U.S.S.R., Ghana, and the Philippines.

Non-Communist industrial consumption of gold, continuing the rising trend of recent years, was estimated at 18 million ounces, about 45 percent of production.

Australia.—Mine production of gold dropped 12 percent to 810,418 ounces. Western Australia, the major producing State, accounted for 72 percent of the total. Queensland and Northern Territory accounted for 12 and 9 percent, respectively, and other States the remaining 7 percent. About 80 percent of the total output came from gold ores; the remainder was recovered from copper and other base metal ores. Under the Gold Mining Assistance Act subsidy payments up to $8 per ounce were paid. The total subsidy paid in 1967 was $3.86 million. Gold mining income is exempt from income tax in Australia, Papua, and New Guinea. According to the 1966 census, a total of 179 gold mines employed 4,447 persons.

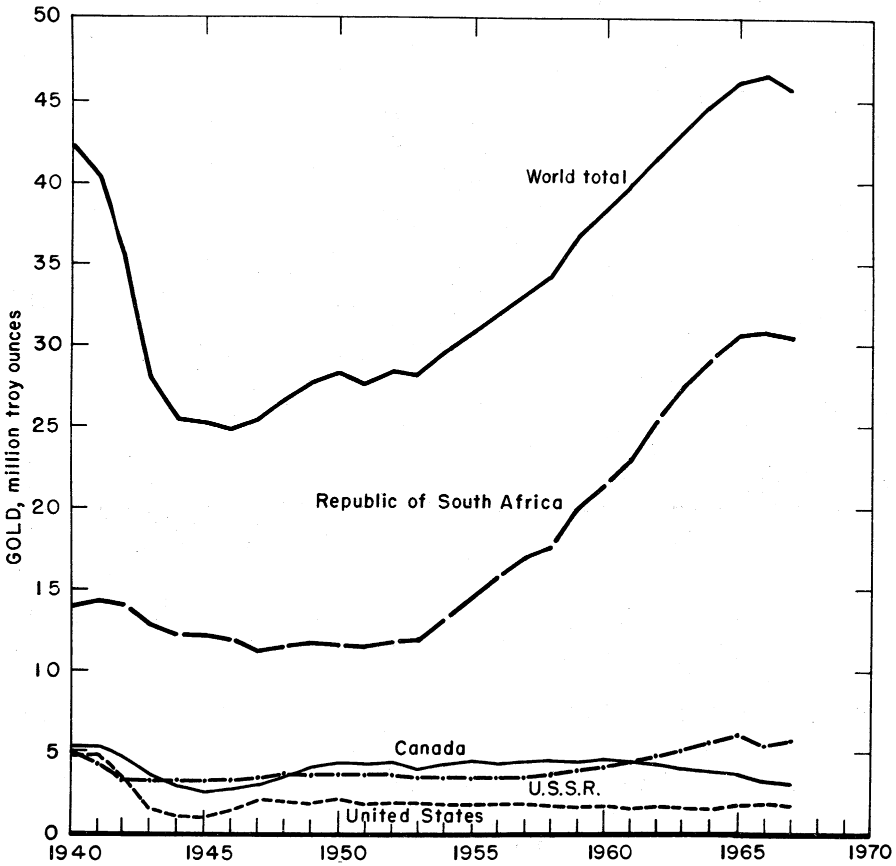

Figure 4.—World production of gold.

Canada.—Gold production continued to decline for the seventh consecutive year, dropping 10 percent to 3.0 million ounces valued at $115 million in 1967. Canada continued to rank as the third largest gold-producing country, exceeded only by South Africa and the Soviet Union. The average price per ounce paid by the Canadian mint in 1967 was Can$37.75, about the same as in the preceding 2 years.

Five lode gold mines with a combined annual production of 145,000 ounces closed or were scheduled to close in 1967 or early in 1968 as minable ore reserves were depleted. At yearend only 33 lode gold mines were operating. All but three of the lode gold mines operating in 1967 received cost-aid under provisions of the Emergency Gold Mining Assistance Act. The Act, due to expire at yearend 1967, was extended with the same provisions for an additional 3 years.

Geographic distribution of gold production in Canada follows:

Province or Territory	Troy ounces	
	1966	1967
Atlantic Provinces	27,321	26,911
Quebec	933,856	830,912
Ontario	1,640,069	1,500,149
Prairie Provinces	99,641	97,995
British Columbia	118,898	121,191
Yukon	42,061	14,216
Northwest Territories	412,059	370,625
Total	3,273,905	2,961,999

Source: Dominion Bureau of Statistics. V. 37, No. 12, 1967.

Placer gold output dropped sharply due to the termination late in 1966 of dredging operations by Yukon Consolidated Gold Corp. which had accounted for most of the placer gold production. Byproduct gold from base-metal mines constituted about 18 percent of the total gold recovered. Average employment in lode gold mines was about 10,300 persons.

Kerr-Addison Mines Ltd. reported a 6-percent increase in gold output, the first production gain since 1960. From 517,240 tons of ore milled, 199,245 ounces valued at Can$7.5 million were recovered. A slight decrease in tonnage milled was more than offset by an increase in the grade of ore treated which averaged 0.394 ounce ($13.78) per ton, compared with 0.357 ounce ($12.51) per ton in 1966. Operating costs increased $0.93 to $11.62 per ton, mainly because of the decrease in tons milled and the increased tonnage being mined by higher cost square-set and undercut-and-fill methods. Ore reserves at yearend declined to 3.75 million tons, averaging 0.45 ounce of gold per ton compared with 4.19 million tons averaging 0.43 ounce per ton per year earlier.[8]

Hollinger Consolidated Gold Mines Ltd. reported that the value of bullion production from the Hollinger and Ross mines declined from $8.0 million in 1966 to $5.7 million in 1967. Financial assistance under the Emergency Gold Mining Assistance Act (EGMA) totaled $1.5 million compared with $1.6 million in 1966. Operating loss before taxes, depreciation, and EGMA payments totaled $1.0 million for the combined operations. Ore milling and employment rates dropped to 1,500 tons and 550 persons, respectively, as salvage operations neared completion.[9]

Giant Yellowknife Mines Ltd., Canada's leading gold producer, reported a significant decline in tons of ore milled and gold produced. The company milled 331,922 tons, averaging 0.67 ounce ($23.45) per ton yielding 196,979 ounces of gold and 23,102 ounces of silver with a total value of $7.3 million. Percentage of gold recovery dropped slightly to 88.6. Operating costs were up $2.09 to $15.60 per ton. Reserves of developed ore at the Giant and contiguous mines at yearend were 2.04 million tons, averaging 0.70 ounce per ton compared with 2.52 million tons averaging 0.67 ounce per ton in 1966. The lower tonnage mined and treated during the year was principally due to a critical shortage of labor.[10]

Dome Mines Ltd. reported small gains in gold production at its Dome and Campbell Red Lake mines. At the Dome mine the company milled 708,800 tons yielding 179,347 ounces valued at $6.84 million. Dome mine ore reserves were estimated at 2.03 million tons averaging 0.27 ounce per ton compared with 2.21 million ounces of the same grade at the end of 1966. Financial aid was provided under the EGMA. Campbell Red Lake mines milled 261,408 tons of ore averaging 0.66 ounce of gold per ton yielding 173,451 ounces of gold valued at $6.65 million. Estimated ore reserves at Campbell at yearend totaled 1.28 million tons averaging 0.69 ounce per ton, an increase of 40,000 tons over last year. Metallurgical recovery was 92.8 percent. Operating costs were $10.46 per ton milled.

Colombia.—International Mining Corp. reported production from its dredging operations and its underground mine totaled 109,039 ounces, an increase of 6 percent from 1966. Three dredges in the Department of Choco operated normally and one in Narino had its first full year of production following extension of its digging ladder. About 16.5 million yards were dredged. Developed reserves at yearend were 173.2 million cubic yards averaging 17.2 cents per yard compared with 145.9 million yards averaging 15.7 cents per yard at the end of 1966. Underground reserves at the Frontino mine declined 21,000 ounces to 133,000 tons averaging 0.89

[8] Kerr-Addison Mines Ltd. Annual Report. 1967, 16 pp.
[9] Hollinger Consolidated Gold Mines Ltd. Annual Report. 1967, pp. 6, 18.
[10] Giant Yellowknife Mines Ltd. Annual Report. 1967, pp. 3–5.

ounce per ton, which was mainly due to curtailment of development following an earthquake which caused flooding of the lower levels.

Pato Consolidated Gold Dredging Ltd., controlled by International Mining Corp., reported a 2-percent drop in gold output to 88,465 ounces. The company dredged 26.6 million cubic yards, averaging 12.6 cents per yard compared with 28.1 million yards averaging 12.1 cents per yard in 1966. Five large bucket line dredges were operated in the Nechi River valley during the year. At yearend, total workable reserves, both fully developed and partially developed, were 284.7 million tons averaging 16.0 cents per cubic yard.

Ghana.—Gold production, reversing the declining trend of the preceding 3 years, increased 11 percent.

Ashanti Goldfields Corp. Ltd., the country's largest gold producer, reported gains in tons of ore treated and in gold recovered but a drop in average yield per ton. In the year ending September 30, 1967, about 545,300 tons of ore averaging 0.98 ounce per ton, was treated yielding 473,200 ounces of gold. Percentage recovery dropped slightly to about 89 percent. Ashanti's ore reserves dropped moderately to 3.42 million tons with an average grade of 1.03 ounces per ton. Approximately 4,800 persons were employed.[11]

South Africa, Republic of.—Output of gold from South African mines dropped slightly in 1967 after 15 consecutive years of rising production. Output was down 1 percent to 30.5 million ounces valued at $1,069 million. South Africa contributed 77 percent of the total non-Communist gold production in 1967. Working costs continued to rise and working profits declined.

All but one of the 49 gold producing mines that were members of the Transvaal and Orange Free State Chamber of Mines were primary gold mines, the other was essentially a uranium producer. Total ore milled was 77.5 million tons averaging 0.39 ounce per ton. Average working cost was $8.61 per ton and working profit was $5.39 per ton milled. Five mines, Rietfontein Consolidated, Van Dyk Consolidated, New Kleinfontein, Randfontein, and Daggafontein, ceased operations during the year.

Total payable ore reserves declined 6.9 million tons to 167.0 million tons but average grade increased slightly to 0.47 ounce per ton. The average number of employees in the gold mining industry in 1967 was 42,296 whites and 361,893 non-whites, a decline of 1,143 and 8,576, respectively.

Anglo American Corporation of South Africa Ltd. reported that its group of mines produced 12.11 million ounces of gold, about the same as in 1966, representing nearly 40 percent of South African gold production and nearly 30 percent of the world production, excluding Communist countries. Production from the seven Orange Free State mines of the group, although slightly lower than in 1966, again exceeded 8 million ounces, representing 66 percent of the group's output. Production increases at President Brand and Free State Saaiplaas partially offset lower output at Western Holdings, Welkom, Free State Geduld Mines Ltd., and Freddies. Gold production at the Transvaal mines of the group was virtually the same as in 1966. Higher output by Vaal Reefs, Western Reefs, and Western Deep Levels more than offset the decline in production at East Daggafontein and Daggafontein mines. Tons milled and yield per ton at Western Deep increased slightly to 3.1 million and 10.16 Pennyweight (dwt) (0.51 ounce). Ore reserves increased 0.3 million tons to 5.1 million tons but average grade dropped slightly to 561 inch-dwt, equivalent to 0.67 ounce per ton across a 42-inches stoping width. In addition, the ore reserve averaged 16.5 inch-pounds of uranium oxide. Vaal Reefs milled 2.3 million tons of ore yielding 9.71 dwt per ton (0.48 ounce), about the same as in 1966. Ore reserves dropped slightly to 6.6 million tons averaging 469 inch-dwt (about 0.56 ounce across 42 inches) and 32.5 inch-pounds of uranium oxide.

Free State Geduld Mines Ltd. milled 1.91 million tons yielding 20 dwt (1.00 ounce) per ton, a slight gain in tonnage but a slight drop in grade. The ore reserve was 5.1 million tons with an average yield of 1,170 inch-dwt (1.40 ounces) across 42 inches. At Welkom mine, 2.2 million tons was milled with an average yield of 6.72 dwt (0.33 ounce) per ton, about the same tonnage but a slightly lower grade. The yearend ore reserve was 5.5 million tons with an average grade of 260 inch-dwt (18 inch-ounces) compared with 5.3

[11] Ashanti Goldfields Corp. Ltd. 71st Annual Report, 1967, pp. 15–20.

million tons averaging 383 inch-dwt (19 inch-ounces) at the end of 1966.[12]

General Mining and Finance Corporation, Ltd., reported that Buffelsfontein, the largest of its group of gold mines, milled 2.7 million tons of ore averaging 0.46 ounce per ton at a unit working cost of $9.91 compared with 2.6 million tons yielding 0.45 ounce at a cost of $9.34 per ton in 1966. Ore reserves totaled 6.6 million tons averaging 0.51 ounce per ton across a stoping width of 54 inches. At Stilfontein 2.0 million tons was treated yielding 0.38 ounce per ton. Working costs per ton were $11.62, ore reserves totaled 3.7 million tons averaging 0.44 ounce per ton across 41.8 inches.[13]

Union Corp. Ltd. reported that the quantity of ore milled by its group of gold mines totaled 11.7 million tons which yielded 3.6 million ounces compared with 12.1 million tons and 3.8 million ounces in 1966. Ore reserves at yearend dropped 3.3 million to 30.1 million tons averaging 0.37 ounce ($13.12) per ton. At East Geduld, tons milled dropped to 979,000 but average yield per ton increased slightly to 0.21 ounce per ton ($7.42); working costs per ton remained virtually unchanged at $6.23. The ore reserve in the Main and Kimberley Reefs was 450,000 tons averaging 0.24 ounce per ton across 64 inches, and 450,000 tons averaging 0.21 ounce across 47 inches, respectively. Grootvlei Proprietary milled 2.5 million tons of ore yielding 0.095 ounce ($4.32) per ton at a unit cost of $5.00. Operations were gradually being curtailed as ore reserves continued to decline and working costs continued to rise. At yearend ore reserves in the Main Reef were 2.2 million ounces averaging 0.20 ounce per ton across 51 inches; on the Kimberley Reef the ore reserve was 1.6 million ounces averaging 0.23 ounce across 48 inches. St. Helena Mines reported virtually no change in tons milled and yield per ton at 2.4 million and 0.45 ounce, respectively. Unit working costs advanced 10 cents to $6.50 per ton. Ore reserves increased 400,000 tons to 9.5 million tons averaging 0.52 ounce per ton across 59 inches. Bracken Mines treated 1.1 million tons yielding 0.46 ounce ($16.10) at a working cost of $7.76, only a slight change from 1966 operating results. Development footage was reduced 7,000 feet to about 39,000 feet and about 9,000 feet was sampled of which 52 percent proved payable at an average of 360 inch-dwt. Ore reserves remained unchanged at 3.0 million tons but average grade was down slightly to 0.47 ounce per ton across 38 inches. At Winkelhaak, a record tonnage of 1.7 million tons was treated. Working costs were reduced 18 cents to $7.35 per ton but average yield declined slightly to 0.30 ounce per ton. Development footage was reduced 7,670 feet to 52,255 feet and 13,020 feet was sampled of which 49 percent proved payable at an average of 383 inch-dwt. The ore reserve at yearend remained unchanged at 5 million tons but average grade declined slightly to 0.30 ounce per ton across a 57-inch stoping width.[14]

Consolidated Gold Fields of South Africa Ltd. reported that its group of nine operating mines produced more than 5 million ounces of gold, equivalent to 17 percent of the total output of gold in South Africa. Average yield per ton of ore increased and working profit from gold increased nearly 5 percent. Four of the group's producing mines on the West Wits line—West Driefontein, Doornfontein, Libanon, and Venterpost—contributed more than 94 percent of the working profit. The increase in working costs was partially offset by increased productivity due to improved technology. Borehole exploration east and southeast of West Driefontein confirmed the area is underlain by gold-bearing reefs. Feasibility studies of the area were completed and financial and technical discussions initiated.

West Driefontein, the world's largest gold mine, produced 2.4 million ounces of gold, a new record output. Development and installation of production equipment was nearly completed at Kloof, the group's new mine on the West Wits line. Shaft sinking was retarded by water inflow and heavy ground; trial milling was scheduled to begin by yearend, and the target milling rate of 100,000 tons per month is expected to be reached in the second half of 1968. About 80 percent of the development footage sampled proved to be payable at an average grade of 741 inch-dwt.[15]

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[12] Anglo American Corporation of South Africa Ltd. 51st Annual Report. 1967, pp. 13, 14, 56, 59.

[13] General Mining and Finance Corporation, Ltd. Annual Report. 1967, p. 4.

[14] Union Corp. Ltd. Report and Accounts for the Year Ended 31 Dec. 1967. Pp. 25–31.

[15] Consolidated Gold Fields of South Africa Ltd. 80th Annual Report. 1967, pp. 21, 22.

U.S.S.R.—Although quantitative data are not published, available information indicates that gold production in the U.S.S.R., the second-ranking gold-producing country, continued to increase. Development of major auriferous deposits at Muruntau Mountain in Uzbekistan advanced in preparation for full-scale production. Also, large potentially productive gold-bearing deposits in Armenia were reported to be under development. At least two-thirds of the estimated U.S.S.R. gold production is believed to be from placer operations.

TECHNOLOGY

Under the U.S. Department of the Interior Heavy Metals Program to increase the domestic production of gold, the Geological Survey conducted a wide variety of field and laboratory studies of gold occurrences to improve capabilities for discovering concealed ore deposits and to develop more accurate and rapid analytical methods for detecting small amounts of gold. The Bureau of Mines conducted research on developing methods of reliably evaluating large currently submarginal but potentially productive deposits and on developing more efficient mining systems and extraction methods aimed at lowering exploration and production costs.

The Mining & Research laboratory of the South African Chamber of Mines reported progress in developing a rock cutter which can selectively mine narrow gold-bearing seams without the u e of explosives. Tests of a prototype machine by Luipaardsvei Estate & Gold Mining Co., Ltd., on the West Rand May, if successful, may lead to a continuous cycle of mining, diminished rock pressure at the face, reduced heat, and alleviation of ground support problems.

The new rock cutter consists essentially of two chisels with extremely hard tips which plane a ¾ inch slot above and below the reef to a depth of about 12 inches over a distance of about 10 feet. The reef is then displaced by wedging with a pneumatic breaker. After the reef is removed, the chisels are adjusted and cuts made in the hanging and footwalls to provide stoping width to take the machine forward for the next series of cuts and for cleaning and support installation.

Use of raise borers in South African gold mines sharply reduced the time and labor required in cutting ore passes and decreased operating hazards. A pilot drill hole bored between levels 300 feet apart was reamed to 4 feet in diameter, required for the ore pass.

The Bureau of Mines developed an organic reagent for leaching gold ores which contains a nitrile group that does not hydrolyze to form free cyanide. Laboratory tests using malanonitrile indicate that extraction of gold from a carbonaceous ore was substantially increased compared with extraction obtained with sodium cyanide, the standard extractant of the industry. Bureau reseach also indicates that carbonaceous ore may be rendered nonrefractory and gold extraction thereby increased by oxidation of absorptive components using such combinations as ozone—H_2SO_4, NaOCl, and Cl_2 or other oxidizing systems. The chemical oxidation technique may become the basis of a practical solution to the carbonaceous problem.

The Canadian Mines Branch investigation of the potential economic advantages of recovering gold from cyanide pulps by resin-in-pulp (RIP) techniques disclosed that appreciable savings over conventional cyanidation treatment costs could be achieved. The practical application for gold recovery will depend partly on the physical stability of the RIP resins and comparison of the cost of an ion-exchange plant with the cost of a conventional thickening, filtering, clarification, and zinc precipitation plant. Other potential RIP technique advantages include: High purity of gold bullion, recovery of base metals, and a clean effluent.

In the new highly automated mill of West Driefontein Gold Mines in the Republic of South Africa, rod and pebble mill input of new feed and moisture is regulated automatically by a gamma ray source which controls the cyclone spigot orifice. The automatic controls permit the entire grinding circuit, including five 9- by 12-foot rodmills and twenty 8- by 20-foot secondary pebble mills, to be operated by 12 men, 2 whites and 10 non-whites per shift.

An analytical technique for determining the presence of gold and silver in billionths of a gram quantities in geologic materials was developed by Geochemical Systems Company. Such sensitive analyses are achieved by combining solvent extraction techniques and atomic absorption spectroscopy. As little as 10 parts per billion of gold and 5 parts per billion of silver can be detected. The new analytical capabilities have greatly facilitated geochemical exploration for gold and silver.

A new technique of continuous selective plating of electronic components, developed by Burton Research Laboratories, was reported to effect substantial savings in gold requirements. The technique, called zone-controlled deposition, permits the selective application of gold or other precious metals in bands of any width and thickness on any area of strip without masking. If an integrated circuit is plated before it is stamped, gold savings can be as high as 85 to 90 percent. The proprietary process also is applicable to semiconductors, connectors, and other electronic components.

Enstrip AU–78, a metal stripper which removes gold from steel, nickel, copper, and copper alloys by immersion, was developed by Enthone, Inc., a subsidiary of American Smelting and Refining Company (Asarco). The AU–78 is particularly useful in stripping gold from parts such as printed circuit boards where both copper and nickel are exposed to the stripping solution. The solution will strip up to 1 troy ounce of gold per gallon of solution at a rate of ½ to 1 mill per hour.

A new high-speed process formulated for strip- and wire-plating of gold was developed by P.M.D. Chemicals, Ltd. The new process will deposit a high-purity bright gold electroplate of 23·8-carat purity with a hardness of 120 Vickers Harness Number (V.H.N.) to any desired thickness and will operate over a wide range of current density at near to 100 percent efficiency to give a deposition rate of 0.001 inch per minute or higher. A high concentration of gold in the solution (5 ounces per gallon) enables deposition at current densities up to 60 amperes per square foot for light deposits and up to 30 amperes per square foot for heavy deposits.

Table 2.—Mine production of recoverable gold in the United States, by months

(Troy ounces)

Month	1966	1967	Month	1966	1967
January	150,316	145,433	August	152,887	118,137
February	143,927	145,846	September	150,952	114,879
March	151,043	160,756	October	148,844	119,187
April	147,339	147,570	November	146,224	104,097
May	158,098	138,951	December	152,222	102,895
June	149,756	151,185			
July	151,812	135,251	Total	1,803,420	1,584,187

Table 3.—Twenty-five leading gold-producing mines in the United States in 1967, in order of output

Rank	Mine	State	County	Operator	Source of gold
1	Homestake	South Dakota	Lawrence	Homestake Mining Co	Gold ore.
2	Carlin	Nevada	Eureka	Carlin Gold Mining Co	Do.
3	Utah Copper	Utah	Salt Lake	Kennecott Copper Corp	Copper, gold-silver ores.
4	Knob Hill	Washington	Ferry	Knob Hill Mines, Inc	Gold ore.
5	Getchell	Nevada	Humboldt	The Goldfield Corp	Do.
6	Mayflower	Utah	Wasatch	Hecla Mining Co	Copper-lead-zinc ore.
7	Yuba Unit	California	Yuba	Yuba Consolidated Gold Fields	Placer.
8	New Cornelia	Arizona	Pima	Phelps Dodge Corp	Copper, gold-silver ores.
9	Copper Queen-Lavender Pit	do	Cochise	do	Copper ore.
10	Idarado	Colorado	Ouray and San Miguel	Idarado Mining Co	Copper-lead-zinc ore.
11	Iron King	Arizona	Yavapai	Shattuck Denn Mining Corp	Lead-zinc ore.
12	Copper Canyon	Nevada	Lander	Duval Corp	Copper ore.
13	San Manuel	Arizona	Pinal	Magma Copper Co	Do.
14	Veteran Pit	Nevada	White Pine	Kennecott Copper Corp	Do.
15	U.S. and Lark	Utah	Salt Lake	United States Smelting Refining and Mining Co	Lead-zinc ore.
16	Berkeley Pit	Montana	Silver Bow	The Anaconda Company	Copper ore.
17	Morenci	Arizona	Greenlee	Phelps Dodge Corp	Copper, gold-silver ores.
18	Liberty Pit	Nevada	White Pine	Kennecott Copper Corp	Copper ore.
19	Hogatza River	Alaska	Yukon River Region	United States Smelting Refining and Mining Co	Placer.
20	Magma	Arizona	Pinal	Magma Copper Co	Copper ore.
21	Chicken Creek	Alaska	Yukon River Region	United States Smelting Refining and Mining Co	Placer.
22	Gold King	Washington	Chelan	L-D Mines	Gold ore.
23	Chino	New Mexico	Grant	Kennecott Copper Corp	Copper ore.
24	85	do	Hidalgo	Diversified Mines, Inc	Gold-silver ore.
25	Blackbird	Idaho	Lemhi	Idaho Mining Co. and Machinery Center, Inc	Copper ore.

Table 4.—Mine production of recoverable gold in the United States, by States, 1965–67

(Troy ounces)

State	1965	1966	1967
Alaska	42,249	27,325	22,948
Arizona	150,566	142,528	80,844
California	62,885	64,764	40,570
Colorado	37,228	31,915	21,181
Idaho	5,078	5,056	4,838
Montana	22,772	25,009	9,786
Nevada	229,050	366,903	434,993
New Mexico	9,506	9,295	5,188
Oregon	499	281	186
Pennsylvania	[1] 90,674	[1] 85,000	[1] 73,337
South Dakota	628,259	606,467	601,785
Tennessee	122	141	181
Utah	426,299	438,736	288,350
Washington	(1)	(1)	(1)
Wyoming	3	----------	----------
Total	1,705,190	1,803,420	1,584,187

[1] Production of Pennsylvania and Washington combined to avoid disclosing individual company confidential data.

Table 5.—Production of gold in the United States, by States, and by source, 1967

(Troy ounces)

State	By type of mine production							Refinery production [1]
	Placer	Dry ore	Copper ore	Lead and zinc ores	Complex base metal ores	Other sources [2]	Total	
Alaska	22,948	---------	-------	-------	-------	-------	22,948	23,650
Arizona	2	110	66,933	4	13,007	788	80,844	82,300
California	39,008	1,291	1	71	85	114	40,570	40,000
Colorado	2,437	832	197	643	17,069	3	21,181	19,900
Idaho	26	772	1,880	1,435	711	14	4,838	3,540
Montana	141	592	8,304	387	11	351	9,786	15,000
Nevada	232	405,431	28,466	14	141	709	434,993	420,000
New Mexico	7	2,066	2,314	575	226	-------	5,188	4,000
South Dakota	2	601,783	-------	-------	-------	-------	601,785	615,500
Tennessee	------	---------	-------	-------	181	-------	181	210
Utah	1	660	213,122	5	74,077	485	288,350	260,000
Other States [3]	31	71,977	-------	7	-------	1,508	73,523	41,400
Total	64,835	1,085,514	321,217	3,141	105,508	3,972	1,584,187	1,525,500
Percent	4	69	20	(4)	7	(4)	100	100

[1] U.S. Bureau of the Mint.
[2] Gold recovered from mill and smelter cleanup, slags, tailings, and as a byproduct of magnetite-pyrite and tungsten ores.
[3] Includes Oregon, Pennsylvania, and Washington.
[4] Less than 0.5 percent.

Table 6.—Ore, old tailings, etc., yielding gold produced in the United States, and average recoverable content, in troy ounces of gold per ton in 1967

State	Gold		Gold-silver		Silver		Copper	
	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton
Arizona	474	0.061	74,516	0.006	421	0.019	53,666,497	0.001
California	2,125	.601	1,660	.052	----	----	8	.125
Colorado	2,520	.253	1,000	.190	150,421	(1)	2,109	.093
Idaho	254	.795	(2)	12.024	434,895	.001	60,808	.031
Montana	239	.197	3,641	.106	15,387	.033	9,014,687	.001
Nevada	1,084,702	.374	----	----	1,108	.047	6,422,123	.004
New Mexico	----	----	37,343	.055	----	----	4,446,944	.001
South Dakota	1,896,311	.317	----	----	----	----	----	----
Tennessee	----	----	----	----	----	----	----	----
Utah	----	----	39,060	.027	14,306	.006	20,864,443	.010
Other States [3]	88,995	.810	----	----	----	----	----	----
Total	3,075,620	.352	157,220	.027	616,538	.002	94,477,619	.003

State	Lead		Zinc		Lead-zinc, copper-zinc, and copper-lead-zinc		Total material	
	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounces of gold per ton	Short tons	Average ounce of gold per ton
Arizona	444	0.797	----	----	288,633	0.045	54,030,985	0.001
California	3,190	.022	----	----	7,860	.011	14,843	[4] .105
Colorado	1,297	.111	223,057	.002	792,093	.022	1,172,497	.016
Idaho	175,526	.008	21,728	.001	674,915	.001	1,368,126	.004
Montana	4,012	.086	35,443	.001	211	.052	9,073,620	.001
Nevada	252	.056	----	----	228,509	.001	7,736,694	.056
New Mexico	----	----	272,058	.002	43,929	.005	4,800,274	.001
South Dakota	----	----	----	----	----	----	1,896,311	.317
Tennessee	----	----	----	----	1,605,590	(1)	1,605,590	(1)
Utah	253	.020	16,176	(1)	570,959	.130	21,505,197	.013
Other States [3]	----	----	441,379	(1)	----	----	[5] 1,066,954	.069
Total	184,974	.013	1,009,841	.001	4,212,699	.025	104,271,091	.015

[1] Less than 0.0005.
[2] Less than ½ unit.
[3] Includes Oregon, Pennsylvania, and Washington.
[4] Includes byproduct gold from tungsten ore.
[5] Includes magnetite-pyrite ore from Pennsylvania.

Table 7.—Gold produced in the United States from ore and old tailings, etc., in 1967 by States and methods of recovery, in terms of recoverable metal

State	Total ore, old tailings, etc., treated (thousand short tons)[1]	Ore and old tailings to mills					Crude ore, old tailings, etc. to smelters	
		Thousand short tons	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Thousand short tons	Troy ounces
Arizona	72,556	72,262	2	----	1,920,399	75,548	294	5,292
California	15	11	379	94	3,896	233	4	856
Colorado	1,173	1,170	2,380	----	150,598	15,667	3	697
Idaho	1,773	1,707	163	----	200,919	4,613	66	36
Montana	9,092	9,044	----	----	235,189	8,362	48	1,283
Nevada	7,741	7,686	605	404,809	190,594	28,331	55	1,016
New Mexico	4,801	4,728	----	----	191,252	3,115	73	2,066
South Dakota	1,896	1,896	397,294	204,489	----	----	----	----
Tennessee	5,468	5,468	----	----	280,882	181	----	----
Utah	21,546	21,397	----	----	639,395	287,110	149	1,239
Other States [2]	2,149	2,149	13	322	450,515	73,010	(3)	147
Total	128,210	127,518	400,836	609,714	4,263,639	496,170	692	12,632

[1] Includes some nongold-bearing ores not separable.
[2] Includes Oregon, Pennsylvania, and Washington.
[3] Less than ½ unit.

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 from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting [1]	Placers
1963	437,264	218,212	30.1	15.0	42.2	12.7
1964	453,736	254,771	31.2	17.5	42.7	8.6
1965	460,271	392,171	27.0	23.0	44.2	5.8
1966	693,093	258,668	38.5	14.3	42.1	5.1
1967	400,836	609,714	25.3	38.5	32.1	4.1

[1] Crude ores and concentrates.

Table 9.—Gold production at placer mines in the United States, by methods of recovery

Method and year	Mines producing	Washing plants	Material treated (thousand cubic yards)	Gold recoverable: Thousand troy ounces	Value (thousands)	Average value per cubic yard
Bucketline dredging:						
1963	17	22	18,431	161	$5,651	$0.330
1964	13	13	14,382	103	3,604	.251
1965	9	11	13,685	83	2,889	.211
1966	9	11	13,384	75	2,631	.197
1967	10	10	5,448	48	1,690	.310
Dragline dredging:						
1963	11	11	266	2	70	.265
1964	19	13	195	2	68	.350
1965	10	11	[1] 632	[2] 2	57	.090
1966	9	9	[1] 227	[2] 2	70	.308
1967	4	4	[1] 55	[2] 1	21	[3] .981
Hydraulicking:						
1963	12	12	43	1	45	1.056
1964	11	11	30	(4)	10	.323
1965	6	6	4	(4)	3	.750
1966	4	4	41	(4)	9	.211
1967	4	5	7	1	27	[3] .478
Nonfloating washing plants:						
1963	50	67	[1] 638	[2] 14	499	.782
1964	55	49	[1] 585	[2] 14	489	.836
1965	48	64	[1] 501	[2] 11	391	.779
1966	41	59	[1] 548	[2] 13	456	.834
1967	41	57	[1] 797	[2] 13	472	[3] .449
Underground placer, small-scale hand methods, and suction dredge:						
1963	133	82	139	6	194	1.403
1964	87	56	49	6	212	4.292
1965	70	48	68	4	140	2.059
1966	57	23	26	2	56	2.159
1967	53	19	63	2	59	.925
Total placers:						
1963	223	194	19,517	184	6,459	.331
1964	185	142	15,241	125	4,383	.287
1965	143	140	14,890	100	3,480	.234
1966	120	106	14,226	92	3,222	.227
1967	112	95	6,370	65	2,269	[3] .332

[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

(Thousand troy ounces)

Year	Issued for industrial use	Returned from industrial use	Net industrial consumption
1963	4,252	1,332	2,920
1964	5,887	1,086	4,801
1965	6,551	1,275	5,276
1966	7,774	1,712	6,062
1967	NA	NA	6,294

NA Not available
Source: U.S. Bureau of the Mint.

Table 11.—U.S. exports of gold in 1967, by countries

Destination	Ore and base bullion		Refined bullion	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
Belgium-Luxembourg	34,358	$1,202	-----	-----
Canada	-----	-----	359	$13
Germany, West	18,967	664	-----	-----
Italy	-----	-----	65	2
United Kingdom	59,253	2,074	28,606,980	1,001,244
Total	112,578	3,940	28,607,404	1,001,259

Table 12.—U.S. imports of gold in 1967, by countries

Country	Ore and base bullion		Refined bullion	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
Argentina	2	(1)	-----	-----
Australia	18,029	$631	-----	-----
Austria	-----	-----	30	$1
Belgium-Luxembourg	24	1	20,040	701
Bolivia	8	(1)	-----	-----
Canada	27,095	948	27,370	962
Chile	22,211	778	-----	-----
Colombia	1,605	57	184,850	6,470
Ecuador	4,792	166	-----	-----
El Salvador	-----	-----	673	24
Germany, West	-----	-----	3,350	117
Guatemala	74	3	-----	-----
Honduras	2,810	98	54	2
Hong Kong	550	19	-----	-----
Japan	-----	-----	135,064	4,727
Mexico	2,637	92	-----	-----
Mozambique	449	16	-----	-----
Nicaragua	47,586	1,654	3,702	129
Norway	1,040	36	-----	-----
Peru	18,011	631	-----	-----
Philippines	56,677	1,989	286,087	10,013
South Africa, Republic of	15,723	550	-----	-----
Switzerland	-----	-----	2,815	98
Trinidad and Tobago	20	1	-----	-----
United Kingdom	39	1	46,452	1,632
Total	219,382	7,671	710,487	24,876

[1] Less than ½ unit.

Table 13.—Value of gold imported into and exported from the United States

(Thousand dollars)

Year	Imports	Exports
1965	$101,669	$1,285,097
1966	42,004	457,333
1967	32,547	1,005,199

Table 14.—World production of gold by countries [1] [2]

(Troy ounces)

Country [1]	1963	1964	1965	1966	1967 [p]
North America:					
Canada	4,003,127	[r] 3,835,454	[r] 3,606,031	3,273,905	2,961,999
Central America and West Indies:					
Costa Rica [e]	3,000	3,000	570	570	500
Haiti	6,778	8,090	[r] 6,719	5,071	NA
Honduras	[r] 3,070	[r] 3,401	[r] 4,090	[r] 4,274	5,924
Nicaragua	204,769	225,581	198,152	199,108	177,702
Mexico	[r] 237,947	209,976	[r] 215,795	[r] 213,609	181,491
United States [3]	1,454,010	1,456,308	1,705,190	1,803,420	1,584,187
South America:					
Argentina	313	303	84	[r] 55	NA
Bolivia	153,019	128,576	94,314	86,982	55,069
Brazil [4]	[r] 131,818	[r] 142,524	[r] 155,031	[r] 167,955	172,000
Chile	77,294	[r] 64,992	[r] 58,897	[r] 74,513	55,964
Colombia	324,514	364,991	319,362	[r] 280,823	258,186
Ecuador	21,041	17,681	11,512	10,901	NA
French Guiana	6,993	[r] 4,823	------------	632	NA
Guyana	[r] 2,848	2,111	2,077	3,045	2,379
Peru	101,018	92,503	105,183	94,978	95,559
Surinam	3,548	8,258	6,269	[r] 5,159	4,500
Venezuela	26,947	33,536	23,660	[r] 16,895	18,917
Europe: [1]					
Finland	20,416	22,055	18,037	15,465	[e] 14,000
France	53,627	54,303	57,389	[r] 60,164	[e] 6,400
Germany, West	2,048	2,402	1,865	[r] 1,071	[e] 1,100
Portugal	21,895	21,316	21,541	[r] 18,776	[e] 27,000
Spain	15,625	23,534	[r] 8,295	450	NA
Sweden	115,164	117,672	116,064	[e] 115,000	NA
U.S.S.R. [e] [5]	4,370,000	4,650,000	5,030,000	5,370,000	5,700,000
Yugoslavia	83,656	106,773	103,911	[r] 84,942	[e] 86,000
Africa:					
Angola	37	7	2	------------	------------
Botswana	142	10	------------	------------	------------
Cameroon	1,865	739	1,286	900	[e] 800
Central African Republic	96	75	23	48	------------
Congo (Brazzaville)	2,954	3,567	3,697	4,080	NA
Congo (Kinshasa)	214,574	188,693	90,408	158,632	153,520
Ethiopia	[e] 27,300	[e] 27,300	24,236	[r] 21,256	23,612
Gabon, Republic of	35,719	42,760	37,134	[r] 34,433	NA
Ghana	921,255	864,917	755,191	684,395	762,609
Kenya	10,193	12,480	11,420	11,988	33,366
Liberia [6]	1,960	1,824	1,701	4,351	5,111
Malagasy Republic	900	440	598	852	752
Mozambique	29	40	32	[r] 22	22
Nigeria	316	244	80	61	39
Rhodesia, Southern	566,277	575,386	544,100	[e] 550,000	NA
Rwanda	NA	NA	NA	[r] 106	3
South Africa, Republic of	27,431,956	29,111,524	30,553,874	30,879,700	30,532,880
South-West Africa, Territory of	3	32	14	------------	NA
Sudan	868	877	300	200	NA
Swaziland	2,092	2,078	1,619	308	------------
Tanzania	102,917	93,040	90,819	55,473	18,486
Uganda	48	24	36	3	NA
Upper Volta	44,786	32,665	32,504	16,075	------------
Zambia	4,960	5,033	5,196	[e] 5,000	[e] 5,000

See footnotes at end of table.

Table 14.— World production of gold by countries [1] [2]—Continued

(Troy ounces)

Country [1]	1963	1964	1965	1966	1967 p
Asia:					
Burma e	200	200	200	200	200
Cambodia	6,687	e 6,000	e 4,500	e r 4,000	NA
China, mainland e	60,000	60,000	60,000	60,000	50,000
India	138,409	148,504	130,628	120,244	97,256
Indonesia [4]	4,437	5,813	6,752	r 4,122	7,752
Japan [7]	262,142	253,300	264,842	r 256,395	252,769
Korea:					
North e	160,000	160,000	160,000	160,000	160,000
South [3]	90,095	75,791	62,836	60,765	63,337
Malaysia:					
Malaya	9,116	7,296	3,982	2,959	1,289
Sarawak	2,773	3,115	2,602	2,611	2,521
Philippines	376,006	425,770	r 437,474	r 453,546	500,417
Taiwan	31,710	17,660	32,148	41,805	32,414
Oceania:					
Australia	1,023,970	963,834	r 877,643	r 914,732	627,171
British Solomon Islands	240	101	310	NA	NA
Fiji	107,262	100,493	109,095	112,567	111,108
New Guinea	43,552	38,934	32,439	28,068	27,628
New Zealand	14,206	8,948	12,136	8,965	NA
Papua	47	43	55	38	43
Total	8 r 43,146,584	8 r 44,839,720	8 r 46,221,950	8 r 46,566,663	e 45,610,000

e Estimate. p Preliminary. r Revised. NA Not available, but estimate included in 1967 total.
[1] Gold is also produced in Bulgaria, Czechoslovakia, Rumania, and small quantities probably in East Germany, Hungary, and Thailand. Data for these countries are not available. Data are also lacking on clandestime activities.
[2] Compiled mostly from data available June 1968.
[3] Mine production.
[4] Officially reported production only.
[5] Qutput from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[6] Year ending August 31 of year stated.
[7] Refinery production for Japan was as follows: 1963, 432,572 ounces; 1964, 460,171 ounces; 1965, 519,170 ounces; 1966, 555,468 ounces; and 1967, 678,123 ounces.
[8] Total is of listed figures only; no undisclosed data included.

Table 15.—Republic of South Africa: Salient statistics of the gold-mining industry

	1965	1966	1967
Ore milled thousand tons	80,027	78,250	77,475
Gold recovered [1] thousand troy ounces	30,554	30,879	30,532
Gold recovered ounces per ton	.376	.389	.389
Working revenue (gold) [1] thousands	$1,087,717	$1,086,675	$1,075,337
Working revenue per ton milled [2]	$13.71	$14.14	$14.00
Working costs [2] thousands	$610,464	$630,861	$647,593
Working costs per ton [2]	$8.04	$8.43	$8.61
Working costs per ounce of gold [2]	$20.69	$21.11	$21.81
Total working profit from gold [1] thousands	$431,556	$428,841	$404,037
Estimated working profit per ounce from gold [2]	$6.93	$5.71	$5.36
Dividends paid thousands	$175,818	$174,076	$169,328

[1] Includes non-Chamber of Mines' producers.
[2] Excludes primary uranium producers.

Source: The Mining Journal (London).

Graphite

By Donald E. Eilertsen [1]

Domestic output of natural graphite was slightly smaller in 1967 than in 1966 while imports for consumption were near the largest, the amorphous type being the largest ever reported. Production data on synthetic graphite were obtained on a nationwide basis for the first time; the output in 1967 exceeded 208,000 short tons.

Legislation and Government Programs.—Government stocks of various natural graphites totaled 44,071 short tons at yearend 1967 compared with 45,071 tons at yearend 1966. This reduction resulted from the sale to the domestic consuming industry of 238 tons of Malagasy flake, 413 tons of Malagasy fines, and 349 tons of other graphite.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient natural graphite statistics

	1963	1964	1965	1966	1967
United States:					
Consumption [1] ____ short tons__	[2] 47,000	[2] 54,000	[2] 47,100	[2] 48,400	38,300
Value [1] ____ thousands__	[2] $6,111	[2] $7,026	[2] $6,390	[2] $6,629	$5,700
Exports ____ short tons__	900	2,000	3,200	3,200	3,600
Value ____ thousands__	$190	$333	$419	$428	$460
Imports for consumption [1] ____ short tons__	52,200	47,200	58,100	56,700	56,700
Value [1] ____ thousands__	$2,000	$1,943	$2,387	$2,545	$2,348
World: Production ____ short tons__	748,000	683,000	669,000	534,000	350,000

[1] Includes some artificial graphite.
[2] Includes some estimates.

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	15,331	----------	15,331
Total	26,131	----------	26,131
Malagasy crystalline fines:			
Objective	5,296	1,904	7,200
Excess	----------	4	4
Total	5,296	1,908	7,204
Ceylon amorphous lump:			
Objective	4,458	1,042	5,500
Excess	----------	386	386
Total	4,458	1,428	5,886
Other than Ceylon and Malagasy, crystalline:			
Objective	2,800	----------	2,800
Excess:			
Stockpile grade	2,009	----------	2,009
Nonstockpile grade	41	----------	41
Total inventory	4,850	----------	4,850

Source: Office of Emergency Planning. Statistical Supplemental Stockpile Report to the Congress. OEP-4, July–December 1967.

DOMESTIC PRODUCTION

The Southwestern Graphite Co., Burnet, Tex., continued to be the only producer of natural graphite for the sixth consecutive year. The output in 1967 was somewhat smaller than in 1966.

Production data on synthetic graphite were obtained on a nationwide basis for the first time in 1967. Synthetic graphite output (shipments of powder plus furnace production of shapes) totaled 208,107 short tons valued at almost $104.9 million, the largest production by far being graphite shapes. Six companies produced synthetic graphite principally from petroleum coke; although some graphite was derived from several other raw materials. The producers were as follows:

Company:	Location
The Carborundum Co	Hickman, Ky.
The Carborundum Co	Sanborn, N.Y.
The Dow Chemical Co	Midland, Mich.
Great Lakes Carbon Corp	Rosamond, Calif.
Great Lakes Carbon Corp	Morganton, N.C.
Great Lakes Carbon Corp	Niagara Falls, N.Y.
Speer Carbon Co	Niagara Falls, N.Y.
Stackpole Carbon Co	St. Marys, Pa.
Union Carbide Corp	Columbia, Tenn.
Union Carbide Corp	Niagara Falls, N.Y.

Chas. Pfizer Co., Inc., began to build a new plant at their Easton, Pa., facilities to produce pyrolytic graphite for missile and other uses.[2]

CONSUMPTION AND USES

Natural graphite consumption was substantially smaller in 1967 than in 1966 mostly due to revisions in reporting.

Synthetic graphite powder was used as carbon raiser in steelmaking, additive in nonferrous metallurgy, lubricants, and foundry facings. Synthetic graphite's largest uses were in the form of shapes, such as anodes, electrodes, crucibles and vessels, refractories, electric motor brushes, brush stock, cloth, fibers, and laminates.

[2] Steel. New Plant Will Produce Pyrolytic Graphite. V. 160, No. 16, Apr. 17, 1967, p. 90.

Table 3.—Consumption of natural graphite in the United States in 1967, by uses

Use	Crystalline		Amorphous [1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
Batteries	[2] 1,133	$241,483	W	W	1,133	$241,483
Bearings	[2] 139	60,817	W	W	139	60,817
Brake linings	421	133,918	395	$131,701	816	265,619
Carbon brushes	104	55,197	543	241,763	647	296,960
Crucibles, retorts, stoppers, sleeves, and nozzles	[2] 3,904	637,005	W	W	3,904	637,005
Foundry facings	1,768	312,815	6,743	656,756	8,511	969,571
Lubricants	278	108,577	2,350	314,937	2,628	423,514
Packings	224	79,178	244	98,877	468	178,055
Paints and polishes	25	6,263	204	23,647	229	29,910
Pencils	994	332,462	883	225,025	1,877	557,487
Refractories	W	W	[3] 6,643	640,532	6,643	640,532
Rubber	56	27,136	197	49,563	253	76,699
Steelmaking	783	113,737	5,986	475,071	6,769	588,808
Other [4]	933	290,439	3,366	443,144	4,299	733,583
Total	10,762	2,399,027	27,554	3,301,016	38,316	5,700,043

W Withheld to avoid disclosing individual company confidential data, included in total.
[1] Includes mixtures of natural and manufactured graphites.
[2] Includes some amorphous, the largest portion being crystalline.
[3] Includes some crystalline, the largest portion being amorphous.
[4] Includes adhesives, chemical equipment and processes, electronic products, gray iron castings, powdered-metal parts, small packages, specialties, and other uses not specified.

PRICES

Actual prices for natural graphite are negotiated between buyer and seller and cover a wide range of specifications.

Oil, Paint and Drug Reporter quoted the following prices for graphite, per pound, in bags, fiber drums, ex warehouse: Nos. 1 and 2 flake graphite containing 90 to 95 percent carbon at 29 to 32 cents; powdered crystalline graphite containing 88 to 90 percent carbon at 20 to 23.5 cents, 90 to 92 percent carbon at 22.5 to 25.5 cents, and 95 to 96 percent carbon at 29 to 32 cents; powdered amorphous graphite at 6.5 to 12 cents; and powdered amorphous graphite containing a minimum of 97 percent carbon at 30.5 to 33 cents.

Prices quoted by Metals Week for flake and crystalline graphite, f.o.b. source, bags, per short ton, were as follows: Malagasy Republic, $86 to $204; Norway, $85 to $145; West Germany, $112 to $610; and Ceylon, $76 to $223. Amorhpous, nonflake, crypto-crystalline, graphite per short ton, f.o.b. source (80 to 85 percent carbon) was quoted as follows: Mexico (bulk), $19 to $22; South Korea (bulk), $15; and Hong Kong (bags), $21.

FOREIGN TRADE

Exports of natural graphite were the largest on record, with Canada receiving almost 42 percent.

Imports of natural graphite ranked among the largest and those from Mexico were the largest ever reported from that country.

Table 4.—U.S. exports of natural graphite, by countries

Destination	Amorphous, crystalline flake, lump, or chip, and natural n.e.c.[1]			
	1966		1967	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Arabian peninsula states, n.e.c.	109	$5	-----	-----
Argentina	59	8	19	$2
Australia	28	3	97	10
Austria	6	1	-----	-----
Brazil	206	33	65	10
Canada	1,221	147	1,490	171
Chile	2	(2)	60	8
Colombia	66	9	16	3
Denmark	16	3	4	(2)
France	208	25	136	22
Germany, West	44	6	82	8
Greece	29	4	-----	-----
Guatemala	4	(2)	-----	-----
India	-----	-----	11	1
Israel	21	3	11	2
Italy	82	33	67	13
Japan	13	2	123	20
Leeward and Windward Islands	2	(2)	64	8
Libya	-----	-----	64	7
Mexico	335	42	403	50
Netherlands	109	14	205	25
Norway	29	2	7	1
Pakistan	7	1	-----	-----
Peru	13	2	-----	-----
Philippines	68	10	79	11
South Africa, Republic of	7	1	-----	-----
Spain	26	3	7	1
Sweden	31	4	15	2
Switzerland	8	1	28	4
Taiwan	12	2	25	3
United Kingdom	232	36	300	45
Venezuela	123	21	173	30
Viet-Nam, South	11	2	-----	-----
Other countries	34	5	18	3
Total	3,161	428	3,569	460

[1] Not elsewhere classified.
[2] Less than ½ unit.

Table 5.—U.S. imports for consumption of natural and artificial graphite, by countries

Year and country	Natural						Artificial		Total	
	Crystalline flake		Crystalline lump, chip, or dust		Other natural, crude and refined					
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1965	6,394	$669	87	$19	51,533	$1,688	42	$11	58,056	$2,387
1966:										
Austria	27	3	-----	-----	66	8	-----	-----	93	11
Canada	-----	-----	-----	-----	-----	-----	70	2	70	2
Ceylon	-----	-----	-----	-----	4,150	474	-----	-----	4,150	474
France	2	1	-----	-----	-----	-----	-----	-----	2	1
Germany, West	487	98	-----	-----	1,344	156	5	3	1,836	257
Greenland	-----	-----	-----	-----	107	2	-----	-----	107	2
Hong Kong	-----	-----	-----	-----	17	4	-----	-----	17	4
Korea, South	-----	-----	-----	-----	695	16	-----	-----	695	16
Malagasy Republic	5,886	599	-----	-----	28	2	-----	-----	5,914	601
Mexico	-----	-----	-----	-----	40,213	847	-----	-----	40,213	847
Norway	-----	-----	-----	-----	3,503	306	-----	-----	3,503	306
Switzerland	-----	-----	-----	-----	-----	-----	8	3	8	3
Turkey	81	11	-----	-----	-----	-----	-----	-----	81	11
United Kingdom	-----	-----	-----	-----	31	6	28	4	59	10
Total	6,483	712	-----	-----	50,154	1,821	111	12	56,748	2,545
1967:										
Austria	40	4	-----	-----	28	3	-----	-----	68	7
Canada	-----	-----	-----	-----	1	1	250	9	251	10
Ceylon	-----	-----	-----	-----	3,842	441	-----	-----	3,842	441
France	2	1	-----	-----	-----	-----	-----	-----	2	1
Germany, West	215	43	14	4	1,504	190	27	19	1,760	256
Korea, South	-----	-----	-----	-----	995	26	-----	-----	995	26
Malagasy Republic	4,451	457	-----	-----	28	3	-----	-----	4,479	460
Mexico	-----	-----	-----	-----	42,632	893	-----	-----	42,632	893
Norway	-----	-----	-----	-----	2,389	222	-----	-----	2,389	222
Sweden	-----	-----	-----	-----	110	9	-----	-----	110	9
Switzerland	-----	-----	-----	-----	-----	-----	10	5	10	5
Thailand	-----	-----	-----	-----	56	8	-----	-----	56	8
Turkey	55	6	-----	-----	-----	-----	-----	-----	55	6
United Kingdom	-----	-----	-----	-----	-----	-----	26	4	26	4
Total	4,763	511	14	4	51,585	1,796	313	37	56,675	2,348

WORLD REVIEW

India.—India's first synthetic graphite plant, Graphite India Ltd., Durgapur, West Bengel, was dedicated in January and expected to begin production within 2 months. The initial annual capacity was reported to be 6,000 metric tons and expandable to 30,000 tons. The plant is a joint enterprise of Great Lakes Carbon Corp. of New York City and Bangur Brothers Ltd., of Calcutta, and capitalized for $1,625,000, the Indian and United States firms each subscribing $325,000 and the general public of India $975,000. At full capacity, the new plant is expected to save $3.3 million annually in foreign exchange.[3]

South Africa, Republic of.—Graphite deposits in the Zoutpansberg District were reported to contain reserves of 40,000 tons of crystalline graphite at Dow 71MT mine, 100,000 tons of crystalline graphite at Gumbu mine, and at least 40,000 tons of amorphous graphite at the Mutale mine.[4]

Spain.—Plans were disclosed for constructing a $10 million graphite electrode plant at Pamplona by Union Carbide Iberica, S.A. The plant, to be completed in the latter part of 1968, will be fully integrated from raw material to finished product, and have an annual capacity of 10,000 tons.[5]

Sweden.—Union Carbide Norden AB was reportedly expanding its graphite products plant at Trollhattan to a capacity of 10,000 tons of graphite electrodes, anodes, and special products annually.[6]

[3] Bureau of Mines. Mineral Trade Notes. V. 64, No. 4, April 1967, p. 13.
[4] Bureau of Mines. Mineral Trade Notes. V. 64, No. 11, November 1967, p. 20.
[5] Chemical Week. Carbide * * * Will Build Spanish Graphite Electrode Plant. V. 100, No. 22, June 3, 1967, p. 44.
[6] Industrial Minerals (London). No. 1, October 1967, p. 20.

Table 6.—World production of natural graphite by countries [1]

(Short tons)

Country	1963	1964	1965	1966	1967 [p] [2]
North America:					
Mexico	[r] 20,176	33,441	44,548	[r] 42,717	NA
United States	W	W	W	W	W
South America:					
Argentina	306	245	[r] 202	154	NA
Brazil	[e] 1,650	[e] 1,270	1,292	[r] 1,408	NA
Europe:					
Austria	109,778	112,697	94,529	87,677	[e] 35,300
Germany, West	14,122	14,796	15,005	[r] 14,488	[e] 14,300
Italy	2,053	[r] 1,443	1,353	1,179	[e] 2,000
Norway	8,408	7,983	[r] 9,348	[r] 9,458	[e] 8,800
U.S.S.R.[e]	60,000	[r] 66,000	[r] 66,000	[r] 72,000	72,000
Africa:					
Malagasy Republic	21,214	14,521	18,756	[r] 18,040	[e] 17,600
South Africa, Republic of	671	1,042	447	1,161	[e] 660
South-West Africa	---------	276	396	400	NA
Asia:					
Ceylon (exports)	9,280	11,957	9,789	11,051	11,428
China (mainland)[e]	45,000	45,000	45,000	45,000	34,000
Hong Kong	891	795	---------	---------	21
Japan	3,305	2,700	2,482	[r] 2,428	NA
Korea:					
North [e]	77,000	77,000	77,000	83,000	83,000
South	374,428	291,515	283,315	144,338	70,417
Total [3]	[r] 748,282	[r] 682,681	[r] 669,462	[r] 534,499	349,526

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

[1] Graphite is known to be produced in Czechoslovakia and India, but production data are not available.

[2] Compiled from data available April 1968.

[3] Total is of listed figures only; no undisclosed data included.

Table 7.—Ceylon: Exports of graphite, by countries

(Short tons)

Destination	1966	1967
Australia	505	440
France	246	384
Germany, West	84	67
India	509	991
Japan	2,195	2,754
Pakistan	71	81
Poland	55	83
United Kingdom	2,274	2,512
United States	4,868	3,836
Other countries	244	280
Total	11,051	11,428

Table 8.—Malagasy Republic: Exports of graphite, by countries

(Short tons)

Destination	1965	1966
Australia	192	113
Belgium-Luxembourg	63	------
Canada	55	55
Denmark	27	------
France	3,339	2,808
Germany, West	2,066	1,609
India	185	96
Italy	818	1,003
Japan	1,088	1,127
Netherlands	66	242
Poland	50	99
South Africa, Republic of	66	------
Spain	257	229
United Kingdom	5,836	5,505
United States	5,638	5,550
Other countries	34	97
Total	19,780	18,533

TECHNOLOGY

A promising technique for rapid, small-scale production of artificial graphite products was described. Some of the features of this method were the determination of a satisfactory coke-pitch mixture ratio of (79:21), the simultaneous extrusion, baking and graphitizing of a 2-inch square rod at a speed of 1.75 inches per minute, and venting soot from the gas baking furnace to avoid shortout of an electrical heater.[7]

[7] Heitman, Joseph B. Rapid Process for the Manufacture of Carbon and Graphite Articles. Electrochem. Tech., v. 5, No. 5–6, May–June 1967, pp. 307–308.

Improvement in the quality of carbon and graphite materials for seals, bearings, and electric motor brushes continued. Better materials and improved mechanical designs have made carbon and graphite components last three to five times longer than in the past and have made them able to withstand much higher temperatures and pressures. The extent of this progress is revealed in a systematically arranged report with more than a hundred references.[8]

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[8] Paxton, R. Robert. Carbon and Graphite Materials for Seals, Bearings, and Brushes. Electrochem. Tech., v. 5, No. 5-6, May-June 1967, pp. 174-182.

Gypsum

By Paul L. Allsman [1]

Gypsum production continued to drop during 1967, but the decline was apparently leveling out. At the end of the year a new surge in the construction materials industries gave gypsum producers renewed confidence. A trend toward diversifiication into related industries was apparent as the industry attempted to lessen its dependence on construction activities. Research into new uses for gypsum established the industry in basic chemicals and fertilizer manufacture during 1967.

Domestic production of crude gypsum declined only 3 percent from 1966, while the quantity of imported crude gypsum declined 14 percent. Production of board products decreased only 1 percent during 1967, while total value of board products decreased 3 percent in 1966.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient gypsum statistics

(Thousand short tons and thousand dollars)

	1963	1964	1965	1966	1967
United States:					
Active mines and plants [1]	103	106	113	121	113
Crude:[2]					
Mined	10,388	10,684	10,033	9,647	9,393
Value	$38,138	$38,874	$37,375	$35,681	$34,383
Imports for consumption	5,490	6,258	5,911	5,479	4,722
Calcined:					
Produced	9,181	9,440	9,320	8,434	7,879
Value	$131,668	$135,877	$133,028	$119,747	$115,467
Products sold (value)	$414,090	$431,717	$419,620	$376,871	$362,268
Gypsum and gypsum products:					
Exports (value)	$1,431	$1,808	$2,032	$2,674	$2,918
Imports for consumption (value)	$12,357	$14,687	$13,328	$17,281	$11,353
World: Production	50,172	51,638	53,076	49,629	NA

NA Not available.
[1] Each mine, calcining plant, or combination mine and plant is counted as 1 establishment.
[2] Excludes byproduct gypsum.

DOMESTIC PRODUCTION

Of the 75 mines operated, 58 were open pit and 16 were underground; 1 was both. Eighty-four percent of the total output came from 41 mines operated by companies having calcining equipment. By State, the leading crude gypsum producers were Michigan, 15 percent; California and Iowa, 13 percent each; and Texas, 10 percent.

Domestic and imported gypsum was calcined at 76 plants that had 224 kettles and 77 other pieces of calcining equipment. A total output of 8.3 billion square feet of board products was reported in 1967 with a value of $302.6 million, compared with 8.4 billion square feet of board products with a value of $312.5 million in 1966.

New-capacity additions slowed in 1967 as the housing market declined for the third straight year and sales of gypsum building products slumped. Instead, the gypsum industry began to expand into other, related or closely **allied industries** such as wood-fiber building products, the home furnishings industry, and manufacture of chemicals. Mergers by several of the largest gypsum producers should diversify their product markets so that sales are not dependent on construction of new residential housing.

United States Gypsum Co. completed a new plant at Danville, Va., which produces hardboard, asphalt-coated sheathing, and other wood fiber products related to gypsum wallboard. The company also began production of mineralized, wool-fiber roof deck in a new plant in Columbia, S.C. The new manufacturing process was developed by United States Gypsum's Research and Engineering Department.

Georgia-Pacific Corp. bought the new Gypsum Products of America wallboard plant at Lovell, Wyo., which came on stream in midyear. The $3-million plant, which produces 54-inch wallboard, has a capacity of 75 million board feet of ½-

Table 2.—Crude gypsum mined in the United States, by States

(Thousand short tons and thousand dollars)

State	1966			1967		
	Active mines	Quantity	Value	Active mines	Quantity	Value
Arizona	5	75	$394	W	W	W
California	11	1,207	3,064	9	1,241	$3,150
Colorado	6	75	269	4	77	265
Iowa	5	1,285	5,577	5	1,219	5,186
Michigan	5	1,522	5,489	5	1,422	5,085
Nevada	3	594	2,023	3	409	1,412
New Mexico	4	146	545	5	155	588
New York	5	559	2,998	5	570	3,118
Oklahoma	8	785	2,212	8	804	2,266
South Dakota	1	17	68	1	12	49
Texas	8	899	3,258	7	984	3,419
Other States [1]	20	2,483	9,784	23	2,500	9,845
Total	81	9,647	35,681	75	9,393	34,383

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, and Washington, 1 mine each; Arkansas, Indiana, Kansas, Montana (1967), Ohio, Utah (1967), Virginia and Wyoning (1966), 2 mines each; Montana (1966), Utah (1966), Wyoming (1967), 3 mines each; and Arizona (1967), 4 mines.

Table 3.—Calcined gypsum produced in the United States, by States

(Thousand short tons and thousand dollars)

State	1966					1967				
	Active plants	Quantity	Value	Calcining equipment		Active plants	Quantity	Value	Calcining equipment	
				Kettles	Other [1]				Kettles	Other [1]
California	9	688	$8,640	21	15	7	584	$7,641	16	9
Georgia	3	404	8,007	15	-----	3	464	8,832	15	-----
Iowa	5	816	11,929	23	4	5	768	11,477	22	4
Louisiana	3	173	3,072	6	1	W	W	W	W	W
Michigan	4	426	6,820	10	1	4	362	5,929	10	1
New Jersey	W	W	W	W	W	4	347	4,056	9	4
New York	7	961	12,803	23	5	7	836	12,265	22	5
Ohio	W	W	W	W	W	3	334	4,960	9	1
Texas	7	670	9,376	28	3	7	723	10,519	27	3
Other States [2]	40	4,296	59,100	108	50	36	3,461	49,788	94	50
Total	78	8,434	119,747	234	79	76	7,879	115,467	224	77

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, 1; Arkansas, 1; Colorado, 1; Connecticut, 1; Delaware, 1; Florida, 3; Illinois, 1; Indiana, 3; Kansas, 2; Louisiana, 2 (1967); Maryland, 2; Massachusetts, 1; Montana, 1; Nevada, 3; New Hampshire, 1; New Jersey, 4 (1966); New Mexico, 2; Ohio, 3 (1966); Oklahoma, 2; Pennsylvania, 1; Utah, 2; Virginia, 2; Washington, 1; Wyoming, 1 (1966), 2 (1967).

inch gypsum board annually. Georgia-Pacific Corp. also announced plans for a new research and development facility for its Bestwall Gypsum Division in Tigard, Oreg., near the Company's new manufacturing and sales headquarters in Portland, Oreg. Two new buildings will house both applied and basic research, as well as product-and construction-systems testing.

Elcor Chemical Corp. announced plans for a $26 million plant in Culberson County, Tex., to produce 1,000 long tons of sulfur per day from gypsum. The new, secret process was pilot-plant-tested and reportedly will make the company the fourth largest domestic sulfur producer. Gypsum will be quarried locally at the Rock House facility.

Power Gas Corp. of America, a subsidiary of Davy-Ashmore Co. Ltd., awarded a contract for a $2 to $3 million plant at Hanford, Calif., to manufacture fertilizer from gypsum rather than elemental sulfur. The plant will produce 200 tons-per-day of ammonium sulfate and byproduct chalk. The company has a similar 420-ton-per-day plant in India.

In a move to diversify its product lines and lessen its dependence on the construction industry, National Gypsum Co. agreed tentatively to terms of a merger with Congoleum-Nairn Inc., a furniture and carpet manufacturer of Kearney, N.J. A new National Gypsum preferred stock was created; the value of the transaction was announced as $74 million. United States Gypsum Co. announced a merger with A.P. Green Refractories Co. of Mexico, Mo., thus broadening its line of construction materials. The value of a new preferred stock was set at $45 million. United States Gypsum Co. also received approval of a merger with Amsted Industries, a major manufacturer of a diversified line of railroad, water transmission, and machine tool components. Combined sales of the two companies amounted to more than $600 million in 1967.

CONSUMPTION AND USES

Development of new markets for gypsum products, notably the renovation of slums and tenement buildings with new, appealing board products, should greatly enhance wallboard sales in the major urban areas. In 1967, 1.3 million private, nonfarm housing was begun, 11 percent below the level of 1967 and 1966 despite the higher interest rates in 1965 and 1966. Wallboard consumption decreased only 1 percent from that of 1966.

More than 56 percent of the output of crude gypsum in California was sold uncalcined for agricultural purposes. Thirty-four percent of the total crude gypsum production was utilized uncalcined for cement, chemical, or sulfur manufacture.

Forecasts indicated that the coming year's nonresidential construction would be over $20 billion, and that the remodeling market would account for $16 billion. Predecorated wallboard, now available in a variety of colors and vinyl finishes, should appeal to home decorators and do-it-yourselfers, and give gypsum board manufacturers a fair share of this market. Consequently, gypsum producers were extremely optimistic about the future of the industry despite the mild slump in construction sales in 1967. Quality of construction is expected to improve, and consequent greater use of more expensive finish plasters and multiple layered wallboard is expected.

Gypsum construction is expected to assume more importance in public and hospital buildings, both scheduled for major increases. College construction, another appropriate area for gypsum construction, is also expected to show gains, as in the construction of commercial and manufacturing buildings. The sharp drop in residential construction was expected to level out in the long run, and most forecasters predicted that housing development would be on the increase in 1968.

Basic research and development of new products continued to lead the way toward many new applications of gypsum. The Gypsum Association published a manual on fire-resistive constructions, listing fire test information for residential, commercial, industrial, and institutional buildings.[2]

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[2] Gypsum Association. Design Data on Fire Resistance. 1967, 60 pp.

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	1966 Quantity	1966 Value	1967 Quantity	1967 Value
Uncalcined:				
Portland-cement retarder	3,372	$15,544	3,154	$14,704
Agricultural gypsum	1,240	5,195	1,280	5,466
Other uses [1]	81	705	77	712
Total	4,693	21,444	4,511	20,882
Calcined:				
Industrial:				
Plate-glass and terra-cotta plasters	46	706	33	498
Pottery plasters	50	1,220	50	1,246
Dental and orthopedic plasters	16	667	15	614
Industrial molding, art, and casting plasters	122	2,741	108	2,408
Other industrial uses [2]	88	3,605	87	3,522
Total	322	8,939	293	8,288
Building:				
Plasters:				
Base-coat	680	13,067	561	10,928
Veneer plaster (basecoat and finishes)	(4)	(4)	34	1,664
Mill-mixed basecoats (sanded and perlited)	391	10,396	328	8,485
To mixing plants	W	W	W	W
Gaging and molding	101	2,372	80	2,006
Prepared finishes	18	1,252	8	758
Roof deck	354	5,647	334	5,582
Keene's cement	20	847	16	462
Other [3]	15	404	12	583
Total	1,579	33,985	1,373	30,468
Prefabricated products [5]	[6] 7,832	312,503	[6] 7,647	302,630
Total	------	346,488	-------	333,098
Grand total, value	------	376,871	-------	362,268

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, unclassified building plasters, and quantity and value indicated by symbol W.
[4] Included in "Sanded and premixed perlite" and "Prepared finishes."
[5] Excludes tile.
[6] Includes weight of paper, metal, or other materials.

Table 5.—Prefabricated products sold or used in the United States, by products

Product	1966 Thousand square feet	1966 Thousand short tons [1]	1966 Value (thousands)	1967 Thousand square feet	1967 Thousand short tons [1]	1967 Value (thousands)
Lath:						
3/8 inch	953,317	702	$24,764	809,407	596	$21,330
1/2 inch	118,289	115	4,357	131,325	126	4,884
Other [2]	7,226	9	342	7,828	10	403
Total	1,078,832	826	29,463	948,560	732	26,617
Wallboard:						
1/4 inch	112,896	69	3,070	104,023	59	2,473
3/8 inch	1,504,604	1,127	50,800	1,354,634	1,012	45,035
1/2 inch	4,824,505	4,769	185,646	4,966,794	4,789	184,877
5/8 inch	626,060	780	34,360	654,821	793	34,771
1 inch [3]	16,230	29	1,225	8,648	17	763
Total	7,084,295	6,774	275,101	7,088,920	6,670	267,919
Sheathing	173,147	176	5,635	192,838	192	5,835
Laminated board	[4] 5,818	4	291	[4] 5,694	6	352
Formboard	49,474	52	2,013	44,645	47	1,907
Grand total [5]	8,391,566	7,832	312,503	8,280,657	7,647	302,630

[1] Includes weight of paper, metal, or other materials.
[2] Includes a small amount of 1/4-inch, 5/8-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 are withheld to avoid disclosing individual company confidential data.

PRICES

Prices (base rates) for truckload lots of gypsum products in 20 U.S. cities are published monthly in Engineering News-Record. Neat plaster averaged $32.99 per ton, and ranged from $26 in Boston and Minneapolis to $47.75 in Seattle. Gauging plaster sold for an average of $39.13 per ton, and ranged from $29 at Detroit to $52 at Cleveland. One-half-inch gypsum board averaged $61.35 per thousand square feet, and ranged from $44 at Detroit to $80 at Boston. Quotations for 3/8-inch board averaged $52.14 and ranged from $38 at Detroit to $63 at Pittsburgh. Three-eighths-inch gypsum lath averaged $42.29 and ranged from $29 in the Detroit market to $58.75 at Seattle. Tongue and groove sheathing averaged $57.08 and ranged from $40 in the Detroit area to $89 at Los Angeles.

Major gypsum companies announced price increases early in 1967 of about 5 percent. The increase was effective throughout the year in raising the average price for gypsum products 3 percent above the level of 1966.

FOREIGN TRADE

Imports of crude gypsum decreased 14 percent compared with those of 1966, as demand for gypsum products in the United States slackened. Imported gypsum was 33 percent of the total crude gypsum supply. Canada provided 81 percent of the total crude imports; Mexico, 14 percent; Jamaica, 3 percent; and Dominican Republic, 2 percent.

Table 6.—U.S. exports of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude, crushed or calcined: Quantity	Crude, crushed or calcined: Value	Other manufactures n.e.c., value	Total value
1965	28	$1,112	$920	$2,032
1966	38	1,458	1,216	2,674
1967	39	1,707	1,211	2,918

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			
1965	5,911	$11,848	1	$65	$1,055	$360	$13,328
1966	5,479	15,761	2	91	985	444	17,281
1967	4,722	9,723	490	86	855	689	11,353

[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	1966		1967	
	Quantity	Value	Quantity	Value
Canada	4,381	$8,966	3,827	$7,770
Brazil			(1)	9
Dominican Republic	67	216	87	282
France	------	----------	1	3
Italy	------	----------	(1)	2
Jamaica	172	528	145	505
Japan	(1)	(1)	--------	----------
Mexico	830	5,996	656	1,065
Netherlands Antilles	29	55	--------	----------
New Zealand	------	----------	6	87
Total	5,479	15,761	4,722	9,723

[1] Less than ½ unit.

WORLD REVIEW

Canada.—British-American Construction and Materials Ltd. (BACM) brought into production its new 700-ton-per-day gypsum mine at Amaranth, Manitoba. The mine will supply a 500-ton-yer-day BACM wallboard plant at Winnipeg, Manitoba, and a new BACM wallboard plant at Saskatoon, Saskatchewan. The mine was developed by a 10-foot-diameter, 550-foot sloping tunnel at an angle of 15°, to a depth of 140 feet. Initial cost was estimated at $350,000.

Greece.—Discovery of a gypsum deposit estimated to contain 1 billion tons was reported on the Island of Crete by Litton Industries. The deposit is easily minable and accessible to large-tonnage vessels through the Bay of Psira.

Jamaica.—Caribbean Cement Co. Ltd., of Kingston, Jamaica, announced formation of the Caribbean Gypsum Co., Ltd. Operation will be under all-Jamaican management.

United Kingdom.—Imperial Chemical Industries Ltd. added two specially constructed, articulated four-wheel Northfield-type, 20-ton trucks to its fleet at the anhydrite mine at Billingham, Durham. The units are specially designed for dusty operating conditions underground.

Table 9.—World production of gypsum, by countries [1] [2] [3]

(Thousand short tons)

Country [1]	1963	1964	1965	1966	1967 [p]
North America:					
Canada [4]	[r] 5,955	6,361	6,306	[r] 5,976	4,922
United States	10,388	10,684	10,033	9,647	9,393
Middle America:					
Cuba [e]	[r] 29	[r] 28	NA	NA	NA
Dominican Republic	39	121	99	100	NA
Guatemala	16	[r] 8	[r] 10	13	NA
Honduras	[r] 3	[r] 5	7	13	NA
Jamaica	256	215	234	244	NA
Mexico	1,210	1,284	1,192	1,269	NA
Nicaragua	3	6	6	10	NA
Trinidad	3	3	2	2	NA
South America:					
Argentina	216	170	259	[r] 253	NA
Brazil	116	93	80	[r] 88	NA
Chile	128	131	[r] 111	132	NA
Colombia	112	118	123	127	NA
Paraguay	([r])	1	2	3	NA
Peru	57	55	73	70	NA
Venezuela	[r] 72	[r] 82	[r] 95	[r] 95	NA
Europe:					
Austria [4]	644	626	681	856	[e] 834
Bulgaria	110	142	192	[e] 200	[e] 200
Czechoslovakia	333	387	[r] 365	[r] 392	NA
France [4]	4,639	5,415	5,526	[e] 5,500	NA
Germany:					
East [5]	284	295	287	[r] 289	NA
West (marketable)	1,255	1,409	1,433	[r] 1,451	1,433
Greece	[e] 105	[e] 90	[e] 110	130	NA
Ireland	225	255	[e] 240	[e] 240	NA
Italy	2,633	2,785	3,614	[e] 3,600	NA
Luxembourg	7	8	6	[e] 7	NA
Poland	645	[e] 838	[e] 840	[e] 840	NA
Portugal	66	72	89	124	NA
Spain	4,258	3,146	[r] 3,408	NA	NA
U.S.S.R.	4,673	4,633	4,788	[e] 4,900	[e] 5,000
United Kingdom [5]	4,558	5,056	4,922	4,804	[e] 4,950
Yugoslavia	152	171	184	[r] 186	187
Africa:					
Algeria [e]	195	195	195	195	190
Angola	16	11	11	[e] 11	[e] 11
Ethiopia	NA	[e] 4	[e] 3	[r] 6	[e] 6
Kenya	23	31	38	37	[e] 37
Libya	--------	([6])	2	3	[e] 3
Morocco [e]	[r] 45	55	[r] 80	[r] 90	100
Niger	--------	----------	2	[e] 2	[e] 2
South Africa, Republic of	207	265	335	327	[e] 328
Sudan	5	5	5	2	[e] 4
Tanzania	2	3	5	5	[e] 6
Tunisia	20	[e] 20	[e] 20	[e] [r] 25	[e] 28
United Arab Republic	500	372	[r] 505	506	[e] 280
Asia:					
Burma	[r] 9	[r] 10	([6])	[e] 2	[e] 2
China (mainland) [e]	550	650	650	650	550
Cyprus	110	50	[e] 67	50	[e] 51
India	1,313	973	[r] 1,279	1,425	NA
Iran [e] [7]	1,100	1,300	1,700	2,000	1,995
Iraq [e]	550	550	550	550	550
Israel [e] [8]	115	[r] 120	[r] 120	[r] 95	95
Japan	863	828	716	659	NA
Jordan	[e] 10	([r])	([r])	([r])	NA
Lebanon	--------	----------	----------	30	[e] 30
Mongolia [e]	17	22	22	22	22
Pakistan	[r] 218	[r] 215	[r] 165	[r] 125	NA
Philippines	34	45	30	[r] 17	NA
Saudi Arabia	[e] 40	[e] 33	25	28	[e] 28
Syrian Arab Republic	[e] 17	22	[e] 17	[e] 17	NA
Taiwan	29	19	31	9	NA
Thailand	26	46	12	44	NA
Turkey	198	[e] 220	[e] 240	[e] 240	[e] 240
Oceania: Australia	[r] 770	[r] 881	934	[r] 896	NA
Total [2]	[r] 50,172	[r] 51,638	[r] 53,076	[r] 49,629	NA

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

[1] Gypsum is also produced in Rumania and Switzerland, but production data are not available. Production in Bolivia and Ecuador is negligible.

[2] Total is of listed figures only; no undisclosed data included.

[3] Compiled from data available April 1968.

[4] Includes anhydrite.

[5] Crude production estimates based on calcined figures.

[6] Less than ½ unit.

[7] Year ended March 20 of year following that stated.

[8] Year ended March 31 of year following that stated.

TECHNOLOGY

Studies of gypsum deposits, chemistry, and reactions were continued in 1967 as several important papers were published. The gypsum deposits at Shoals, Ind. were described, detailing recent exploration for commercial extensions of the minable beds. Stratigraphy, depositional environment, and mining facilities of the district were included.[3]

A publication described Kaiser Gypsum Co's. new wallboard plant at Delanco, N.J., including flowsheets. The highly automated plant has an annual capacity of 180 million square feet of gypsum board products and 40,000 tons of plaster. Complete dust collection and television control systems are in use.[4]

The Bureau of Mines began pilot-plant experiments to recover elemental sulfur and byproducts sodium carbonate and calcium chloride from gypsum at the Salt Lake City Metallurgy Research Center. Planned research, using small tube, rotary-kiln, fluidized-bed reactors and continuous ion exchange, promises important new uses for gypsum in basic chemical manufacture.

The number of patents on gypsum products and manufacturing processes reached a high in 1967 as new research facilities came on stream. Several methods for improving the calcining process in gypsum manufacture were patented. One of the most important was a new type of kettle reactor containing an automatic flue system and ventilator.[5] Other improvements in calcining included the introduction of a two-stage apparatus for plaster production, a method for quality control of plaster, a technique for providing greater soakability and workability of plaster, and a process for controlling air entrainment in mixing gypsum, foam, and additives.[6]

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[3] French, Robert R. Geology and Mining of Gypsum in Southwestern Indiana. Indiana Acad. of Sci., v. 76, 1967, pp. 318–322.

[4] Taeler, David H. Gypsum Plant By-The-Numbers. Miner. Proc., v. 8, No. 1, January 1967, pp. 16–20.

[5] Conray, Joseph E., and J. Sharland Jorgensen (assigned to Georgia-Pacific Corp., Portland, Oreg.). Apparatus for Continuous Calcination of Gypsum. U.S. Pat. 3,307,915, Mar. 7, 1967.

[6] Chassevent, L. E., and N. Gouloune s (assigned to Lambert Frères and Cie., Paris). Method and Apparatus for Calcining Gypsum in Two Stages. U.S. Pat. 3,312,455, Apr. 4, 1967.

Gall, R. W. (assigned to Kaiser Gypsum Co., Oakland, Calif.). Method of Grinding and Introducing a Set-Control Agent Into a Gypsum Slurry. U.S. Pat. 3,314,613, Apr. 18, 1967.

Plemans, H. F., and M. D. S. Fields (assigned to National Gypsum Co., Buffalo, N.Y.). Process for Making Gypsum Board. U.S. Pat. 3,343,818, Sept. 26, 1967.

Shull, John D., Jr. (assigned to National Gypsum Co., Buffalo, N.Y.). Gypsum Product. U.S. Pat. 3,328,121, June 27, 1967.

Helium

By Edwin M. Thomasson [1]

Total consumption of grade A helium during 1967 in the United States decreased slightly to 907.2 million cubic feet [2] from the record 947.6 million cubic feet used in 1966. Of the grade A helium sold (and presumably used) during 1967, a total of 300.2 million cubic feet was produced and sold by the private helium industry, not connected in any way with the Federal helium program. Federal sales of grade A helium were 607.0 million cubic feet, as compared to the 808.6 million cubic feet in 1966. Most of this decline was attributed to decreased activity in the Nation's space program.

Under the helium conservation program, the Bureau of Mines purchased 3,618.7 million cubic feet or essentially the same volume as the 3,617.1 million cubic feet purchased in 1966.

The Bureau of Mines continued to sell helium at $35 per thousand cubic feet, the price established in 1961. Private helium plants operating independently of the Government's program sold helium at somewhat lower prices.

PRODUCTION [3]

Helium was produced at 13 helium extraction plants in the United States during 1967. These plants can be segregated into three categories: (1) Plants owned by the Federal Government and operated by the Bureau of Mines; (2) "conservation" plants, privately owned and operated, producing only crude helium (50 to 85 percent purity), which is purchased by the Bureau of Mines as part of the national helium conservation program; and (3) privately owned and operated plants producing grade A helium for independent sale to commercial (non-Federal) customers.

Production from all 13 plants during

[1] Staff engineer, Office of Assistant Director—Helium.

[2] All volumes of gases reported in this chapter are measured at 14.7 pounds per square inch absolute and 70° Fahrenheit.

[3] The following terms have these meanings: Grade A helium—helium having a purity of at least 99.995 percent (impurities of 50 parts per million or less). The principal impurity of grade A helium is neon. Crude helium—helium having a purity of from 50 to 85 percent by volume, the primary impurity being nitrogen. Crude helium may contain some hydrocarbons. Only the actual volume of the helium contained in the helium-nitrogen mixture is reported. For example, 100,000 cubic feet of such a mixture, containing 70 percent helium, is reported herein as 70,000 cubic feet of crude helium.

Table 1.—Ownership and location of helium extraction plants in the United States

Plant category [1]	Owner or operator	Location	Type of production
1	Bureau of Mines	Amarillo, Tex	Grade A helium.
1	do	Exell, Tex	Do.
1	do	Keyes, Okla	Do.
1	do	Shiprock, N. Mex	Do.
1	do	Otis, Kans. [2]	Crude helium only.
2	Cities Service Helex, Inc	Ulysses, Kans	Crude helium only.
2	National Helium Corp	Liberal, Kans	Do.
2	Northern Helex Co	Bushton, Kans	Do.
2	Phillips Petroleum Co	Dumas, Tex	Do.
2	do	Hansford Co., Tex	Do.
3	Kerr-McGee Corp	Navajo, Ariz	Grade A helium. [3]
3	Kansas Refined Helium Co	Otis, Kans	Do. [3]
3	Alamo Chemical Co	Greenwood, Kans	Do. [3]

[1] See text.
[2] Plant operated as part of the national helium conservation program. No sales from plant.
[3] Plant equipped to produce liquid helium.

1967 was 4,769.7 million cubic feet, a 5.4-percent increase over the 4,524.7 million cubic feet produced in 1966.

Table 2.—Helium production in the United States

(Million cubic feet)

Year	Production
1965	4,365.1
1966	4,524.7
1967	4,769.7

Bureau of Mines Plants.—The Bureau of Mines owns and operates five helium plants. Four of these plants produce grade A helium, while the fifth, located at Otis, Kans., produced only crude helium. The latter plant, operated as part of the helium conservation program, produced 37.4 million cubic feet of crude helium during 1967.

The other four plants produced a combined total of 714.8 million cubic feet during the year, a decrease of about 12 percent from the 812.4 million cubic feet produced in 1966. Each Bureau plant processed essentially all available natural gas and operated without difficulty throughout the year.

Table 3.—Production of grade A helium by Bureau of Mines plants

(Million cubic feet)

Plant location	Production	
	1966	1967
Amarillo, Tex	62.7	60.8
Exell, Tex	301.4	273.8
Keyes, Okla	352.4	309.0
Shiprock, N. Mex	95.9	71.2
Total	812.4	714.8

Conservation Plants.—The five helium conservation plants which produce only crude helium, are owned and operated by private companies. Output of these plants, however, is purchased under long-term contracts by the Bureau of Mines.

During 1967, the five conservation plants produced and delivered to the Bureau of Mines 3,618.7 million cubic feet of crude helium, essentially the same volume as the 3,617.1 million cubic feet delivered in 1966. Two of the plants produced 101.3 million cubic feet in excess of their contract requirements, of which 57.4 million cubic feet was stored by the Bureau of Mines in the Cliffside gasfield for the credit of the producers and 43.9 million cubic feet was sold to one of the privately owned plants where it was purified to grade A quality and presumably resold to non-Federal customers.

Table 4.—Helium purchased by the Bureau of Mines for conservation

(Million cubic feet)

Company and location of plant	Helium delivered				
	1963	1964	1965	1966	1967
Northern Helex Co., Bushton, Kans	208.1	493.9	585.1	565.5	654.9
Cities Service Helex, Inc., Ulysses, Kans	75.3	492.2	638.6	717.4	[1] 740.6
National Helium Corp., Liberal, Kans	457.5	1,184.4	1,310.2	[2] 1,303.7	[1] 1,245.6
Phillips Petroleum Co., Dumas, Tex	197.7	458.7	513.6	539.8	551.2
Phillips Petroleum Co., Hansford Co., Tex	481.7	563.9	502.1	490.7	426.4
Total	1,420.3	3,193.1	3,549.6	3,617.1	3,618.7

[1] Does not include net total of 57.2 million cubic feet stored for these companies, but not purchased by Bureau of Mines.
[2] Does not include 57.6 million cubic feet stored for this company, but not purchased by Bureau of Mines.

Private Plants.—The three private helium extraction plants, produce grade A helium for sale to commercial customers, and all have the capability of producing large volumes of liquid helium. The Kerr-McGee Corp. plant at Navajo, Ariz., commenced operations in 1961; the other two plants began sustained production during 1966.

The combined output of the three plants is estimated to be 300.2 million cubic feet in 1967, an increase of about 115 percent over the estimated 1966 production of 139.0 million cubic feet.

Shipments (sales) of grade A helium from Bureau of Mines plants in 1967 totaled 607.0 million cubic feet, a decrease of 201.6 million cubic feet or about 24

Table 5.—Helium in conservation storage

(Million cubic feet)

Year	Amount stored: From Bureau of Mines plants	Amount stored: From conservation plants [1]	Amount withdrawn from storage [2]	Amount in storage on Dec. 31
1962	[3] 522.2	2.4	------------	524.6
1963	165.0	1,420.3	------------	2,109.9
1964	131.0	3,193.1	0.7	5,433.3
1965	114.1	[4] 3,527.3	1.9	9,072.8
1966	71.1	[5] 3,586.4	10.1	[5] 12,720.2
1967	166.8	[6] 3,676.1	36.1	[6] 16,527.0

[1] Some crude helium purchased from conservation plants is purified for shipment to meet peak demands prior to conservation storage; consequently, the amounts shown are not necessarily identical to the amounts purchased by the bureau of Mines and shown in table 7.
[2] Withdrawn incidental to operation of Cliffside field.
[3] Stored during 1962 and previous years.
[4] Adjusted from data previously reported.
[5] Includes 50.2 million cubic feet stored for (1) 1 conservation company, and (2) 1 private company but not purchased by Bureau of Mines.
[6] Includes net 57.4 million cubic feet stored for 2 conservation companies but not purchased by Bureau of Mines.

percent from the 1966 sales of 808.6 million cubic feet. This decrease in Bureau of Mines sales was attributed to three factors: (1) Decreased activity in the Nation's space programs caused by the Apollo disaster at Cape Kennedy in January 1967; (2) the general cutback in all governmental programs not related to the Viet-Nam conflict; and (3) the growth of the private helium industry which in 1967 supplied virtually all grade A helium to the civilian market. Federal agencies are required by law to obtain their major helium requirements from the Bureau of Mines.

In delivering the 607.0 million cubic feet of helium to its customers, the four Bureau plants filled and dispatched 1,707 railway tank cars, 1,023 highway semitrailers, and 150,542 standard gas cylinders. The Bureau's plant at Otis, Kans., produces only crude helium and therefore made no shipments.

The Amarillo, Tex., plant is specially equipped to fill, process, load, and ship helium in standard gas cylinders (Interstate Commerce Commission 3A and 3AA cylinders), and all cylinder shipments originate there. All plants are equipped to load and ship both railway tank cars and highway semitrailers. Rail shipments were made from the Gallup, N. Mex., shipping terminal connected by pipeline to the Navajo plant at Shiprock, and highway semitrailers can be serviced at either the plant or the shipping terminal. All shipments from Bureau of Mines plants were as a compressed gas, and facilities permit filling shipping containers to a maximum pressure of 4,000 pounds per square inch at 70° Fahrenheit.

Redistribution of helium by private companies, under contracts with the General Services Administration, continued satisfactorily. 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. The purpose of these contracts is to make relatively small quantities of helium readily available to the agencies and to reduce freight charges on small quantities.

Table 6.—Shipments of grade A helium from Bureau of Mines plants, in 1967

(Million cubic feet)

Plant	Shipments: Federal agencies	Shipments: Non-Federal customers [1]	Total shipments
Amarillo, Tex	49.0	49.7	[2] 98.7
Exell, Tex	134.8	28.9	163.7
Keyes, Okla	167.2	106.2	273.4
Shiprock, N. Mex	67.6	3.6	71.2
Total	418.6	188.4	607.0

[1] A large part of this helium is redistributed by the Bureau's non-Federal customers to Federal agencies and their contractors; hence, these data are not indicative of actual helium use by the Bureau's non-Federal customers.
[2] The Amarillo and Exell plants are connected by a grade A helium pipeline, primarily serving the cylinder loading facility at the Amarillo plant. Thus, shipments from the Amarillo plant exceed plant production.

CONSUMPTION AND USE

Table 7.—Shipments of grade A helium from Bureau of Mines plants to various customers

(Million cubic feet)

Recipient	1966 Quantity	1966 Percent	1967 Quantity	1967 Percent
Federal agencies:				
Department of Defense	232.9	28.8	226.1	37.3
Atomic Energy Commission	52.9	6.5	39.3	6.5
National Aeronautics and Space Administration	214.7	26.6	147.0	24.2
Weather Bureau	5.8	.7	5.5	.9
Other	.6	.1	.7	.1
Total	506.9	62.7	418.6	69.0
Non-Federal customers [1]	301.7	37.3	188.4	31.0
Grand total	808.6	100.0	607.0	100.0

[1] 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.

As previously stated, private companies produced an estimated 300.2 million cubic feet of grade A helium during 1967. Substantially all of this volume of helium was sold as produced since the plants have little storage capacity. Thus, when combined with sales from Bureau of Mines plants, the total grade A helium delivered to customers and presumably used during 1967 was 907.2 million cubic feet. This is a decrease of 40.4 million cubic feet from the 947.6 million cubic feet delivered and used in 1966.

The Nation's space and missile program continued to be the largest user of helium. However, as indicated by the steadily rising sales to private (non-governmental) customers, industrial applications of helium are increasing substantially. Research applications contributed to the rapidly increasing consumption of helium.

Table 8.—Grade A helium used in the United States

(Million cubic feet)

Year	Quantity [1]	Year	Quantity [1]
1962	630	1965	757
1963	662	1966	948
1964	713	1967	907

[1] Includes helium produced and sold by privately owned helium extraction plants

RESOURCES

A continuing survey of the helium resources of the United States is conducted by the Bureau of Mines. Natural gas samples from fields and wells throughout the country are obtained and analyzed for helium content. During 1967, 424 samples from 20 States and four foreign countries were subjected to analysis. No significant new deposits of helium-bearing natural gas were identified during the year, although several new discoveries may be significant when further drilling permits a thorough evaluation.

U. S. helium reserves,[4] in helium-bearing natural gas are estimated to be approximately 195 billion cubic feet as of January 1, 1965. This estimate excluded the helium then stored in the Cliffside gasfield near Amarillo, Tex., as part of the national helium conservation program, but does include the helium contained in the remaining native natural gas in the Cliffside field.

Almost 90 percent of these reserves are located in five major helium-bearing natural gasfields: (1) The Hugoton field of Kansas, Oklahoma, and Texas, (2) the Panhandle field of Texas, (3) the Keyes field of Oklahoma, (4) the Greenwood field of Kansas and Colorado, and (5) the Cliffside field of Texas. All of these fields are within about 200 miles of Amarillo, Tex.

[4] As used herein, the term "helium reserves" means the volume of helium contained in helium-bearing natural gasfields (or groups of fields in close geographic proximity which can be developed as a single entity) containing at least 100 million cubic feet of helium and having a helium content of at least 0.3 volume-percent.

Other helium-bearing natural gas deposits are located in western Colorado, eastern Utah, northwestern New Mexico, Arizona, Wyoming, and Montana. In all, some 85 natural gasfields are known to contain reserves of helium.

FOREIGN TRADE

Helium is exported under licenses issued by the Office of Munitions Control, U.S. Department of State. Exports amount to less than 2 percent of the annual domestic consumption. It is believed that most exported helium is used in fundamental and applied research, in chromatography, and in various atomic energy applications.

WORLD REVIEW

In December 1963, a helium plant near Swift Current in Saskatchewan Province, Canada, commenced operation. The plant produces grade A helium from a small, nonflammable helium-bearing gas deposit. During 1967 the plant was enlarged to an annual capacity of approximately 36 million cubic feet. While some helium from the plant is marketed in Canada, most of it is exported to Japan and other Asian countries. The Canadian plant is the only facility in the free world, other than the United States, that extracts helium from natural gas.

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Iron Ore

By F. E. Brantley [1]

Additional reserves of iron ore continued to be proved throughout the world and were added to the surpluses which have resulted in a buyers' market for several years. Lower grade ores declined further in value, and in some areas of Europe mines remained open only through national subsidies. Pelletized ore was being established as a sizable segment of the international ore market, and production of metallized iron ore products was under consideration by several countries for exportation as well as internal consumption.

Distances between producing and consuming countries were effectively narrowed in terms of cost as ore carriers of increased capacity, and more efficient ore handling equipment were placed in service.

The world market for iron ore continued to expand in many areas. However, in the United States 1967 was a recession year for iron ore with production declining as the demand for steel weakened in the automotive and other industries. Production was down an estimated 30 percent in mainland China due to political unrest throughout the year.

Exploration activities continued in 1967. Expansions of facilities planned or in progress throughout the world prepared for continued growth of the industry to keep pace with expected increases in population and income.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient iron ore statistics

(Thousand long tons and thousand dollars)

	1963	1964	1965	1966	1967
United States:					
Iron ore (usable;[1] less than 5 percent Mn):					
Production [2]	73,599	84,836	87,439	90,147	84,179
Shipments [3]	73,564	84,300	84,073	90,041	82,415
Value [3]	$678,181	$802,331	$801,350	$854,134	$817,511
Average value at mines per ton	$9.22	$9.52	$9.53	$9.49	$9.92
Exports	6,812	6,963	7,085	7,779	5,943
Value	$76,340	$79,670	$80,418	$92,157	$71,585
Imports for consumption	33,263	42,408	45,103	46,259	44,627
Value	$323,158	$421,288	$443,788	$462,354	$444,079
Consumption	112,535	132,328	131,888	134,047	127,424
Stocks Dec. 31:					
At mines [3]	11,099	10,241	12,667	12,160	13,230
At consuming plants	54,971	54,189	53,799	54,658	55,221
At U.S. docks	5,347	3,741	2,494	2,707	2,987
Manganiferous iron ore (5 to 35 percent Mn):					
Shipments	485	213	333	246	289
World: Production	515,135	[2] 572,094	607,269	627,974	618,308

[1] Direct shipping ore, washed ore, concentrates, agglomerates, and byproduct pyrites cinder and agglomerates.
[2] Includes byproduct ore.
[3] Excludes byproduct ore.

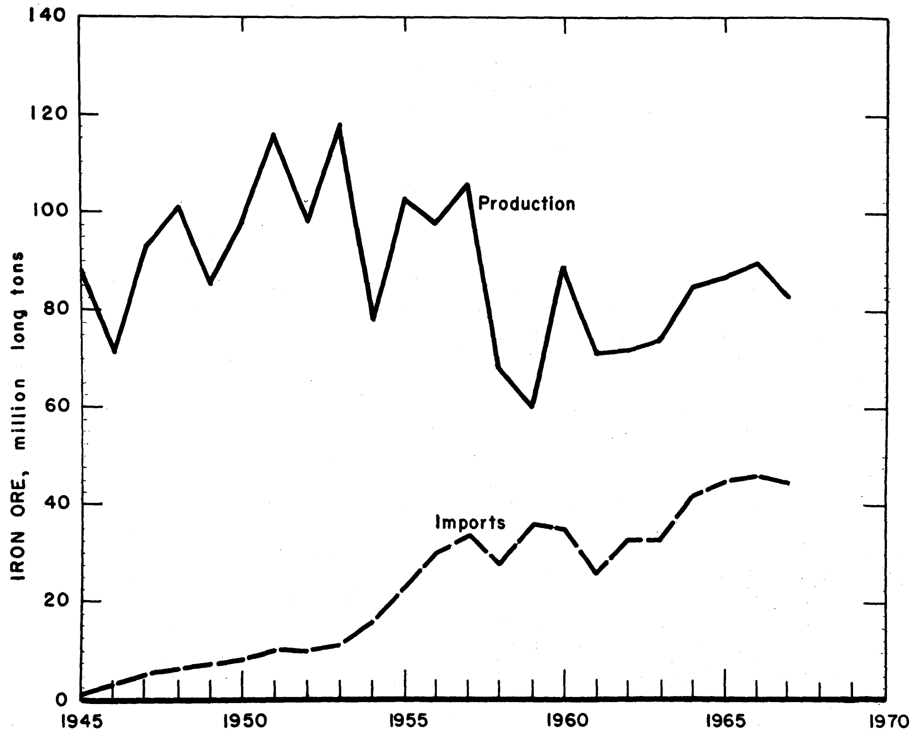

Figure 1.—United States iron ore production and imports for consumption.

EMPLOYMENT

Decreases of about 2 percent in the average number of employees and 10 percent in the number of operating mines occurred in 1966 as shown in table 2, although crude ore production increased 12 percent. This was due mostly to completion of pellet projects, to increased ore output at large-scale taconite operations, and also to the continued closing of uneconomical undergound mines and small open-pit operations. Taconite activity on the Mesabi range resulted in a 19-percent increase in employment in Minnesota. The highly efficient technologic methods used in mining and processing taconite helped raise production averages per man employed.

Preliminary employment data for 1967 is given in table 2-A. The trend in increased production of crude ore per man-hour due to the large scale taconite operations continued, although usable ore showed slight decreases. The decreases can be attributed in part to lower production per man during initial startup periods at new plants, and cutbacks in usable ore output due to lowered steel production without corresponding employment reductions in ore operations during the year.

The practice of mining companies maintaining a stable labor force by employing men all year even if they must be placed on jobs other than producing ore for part of the year has prevented a true measure of production based on labor. However, the increase in year-round production from the large-scale low-grade iron ore operations in recent years has helped to bring production and man-hour figures more into line.

DOMESTIC PRODUCTION

The amount of domestic crude ore mined in 1967 was slightly higher than in 1966. The Lake Superior district recorded a gain of 4 million tons due to increased taconite operations, while the remaining districts showed a decrease. Magnetite gained 8 percent and accounted for 58 percent of the total domestic ore; hematite and brown ore were down by 6 percent and 25 percent, respectively.

Crude domestic ore from all underground mines accounted for less than 8 percent of the total U.S. crude mined in 1967.

A significant number of mines were closed or were idle in 1967, including 16 in the Lake Superior district. Most of them were small operations, many of which had opened in 1965 to help meet a rising domestic iron demand.

Mines closed during the year included the Pioneer, Vermilion range, operated by U.S. Steel; Higgins No. 2, Mesabi range, operated by Pacific Isle Mining Co.; Armour No. 2, Cuyuna range, operated by Inland Steel Co.; Cliffs Shaft, Marquette range, operated by The Cleveland-Cliffs Iron Co.; and the Chateaugay, Lyon Mountain, New York, operated by Republic Steel Corp.

Underground iron ore mining in Minnesota ceased with the closing of the Pioneer and Armour No. 2 mines.

The demand for usable ore was off during the year and production was down about 7 percent from that of 1966. The average iron content of usable ore increased from 57 to 58 percent, however, as the output of high-grade pellets increased. A more selective production of higher grade ores was evident in the smaller, natural-ore operations.

On the Mesabi range, three large taconite projects began operations, United States Steel Corporation's Minntac complex at Mountain Iron, the Butler taconite plant near Cooley, and the National Steel pellet plant near Keewatin. The capacities of the three plants were to be 4.5, 2, and 2.4 million tons per year, respectively. In addition, the annual capacity of Erie Mining Company's Hoyt Lakes plant was expanded from 7.5 million to 10.3 million tons.

Capactiy of the Groveland pellet plant of The Hanna Mining Co. in Michigan was to be increased from 1.6 million to 2.1 million tons.

The Pilot Knob project in Missouri, a joint venture of Hanna Mining and Granite City Steel Co., was under construction. This plant was expected to be completed in 1968 and to produce pellets at a rate of about 1 million tons per year.

A depletion tax allowance bill passed and signed into law in Wisconsin resulted in a contract being awarded for construction of a taconite concentration and pellet plant at the Black River Falls mine of Jackson County Iron Co., a subsidiary of Inland Steel Co. The plant was scheduled for completion in 1969 with a capacity of 750,000 tons annually.

Total installed pellet capacity in the United States at the end of 1967 was estimated to be about 50 million tons.

In Minnesota deep-drilling of taconite formations south of the present mine sites on the Mesabi proved the continuation of the known beds and increased potential iron resources in this district. Cores from the drillings were added to the Federal Bureau of Mines core library at Minneapolis where total core storage passed the 1 million linear foot mark during the year.

The Geological Survey in publishing an aeromagnetic map of Southeastern Pennsylvania discussed magnetic anomalies which could contain extensive ore deposits.[2]

CONSUMPTION AND USES

The method of reporting iron ore consumption adopted in 1963 was continued in 1967. Concentrate used for agglomerate produced at mine sites is not reported as iron ore consumption. Its consumption is reported when the agglomerate produced is shipped to the furnace site and consumed. Concentrate and fines used for agglomerate production (mainly sinter) at blast furnaces and steel mills is reported as iron ore consumed. This method of reporting gives a valid balance between reported consumption and iron ore supply

[2] Bromery, R. W., and Andrew Griscom. Aeromagnetic and Generalized Geologic Map of Southeastern Pennsylvania. U.S. Geol. Survey, Geophysical Investigations Map GP-577, 1967.

(production plus imports less exports including adjustments for losses due to processing and transporting).

Iron ore consumed in making agglomerate 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 are excluded.

No production of nodules for furnace use was reported in 1967. Although pellet capacity was increasing rapidly it was not expected to replace sinter in the near future.

Miscellaneous use data shown in table 12 includes iron ore used in the manufacture of paint and coatings, cement, and ferrites, in ferroalloy furnaces, as aggregate in high-density concrete, and magnetite used in heavy-media coal and ore processing plants.

STOCKS

Iron ore stocks at mines, U.S. docks, and consuming plants totaled 71.2 million tons at yearend; 55.1 million tons was at U.S. furnace plants and 3.0 million tons at U.S. docks according to the American Iron Ore Association. Stocks were above average at mines and consuming plants due to a buildup begun early in 1967 as steel production dropped from 1966 production levels.

PRICES

Base prices for Lake Superior 51.5 percent iron ores remained unchanged during 1967. The quoted prices at rail of vessel, lower lake ports, per long tons were as follows: Mesabi nonBessemer, $10.55; Mesabi Bessemer, $10.70; Old Range non-Bessemer, $10.80; and Old Range Bessemer, $10.95. Corresponding base long ton unit values were $0.20485, $0.20777, $0.20971, and $0.21262, respectively. Lake Superior pellets were quoted at $0.252 per long ton unit; Marquette open-hearth lump, $12.60 per long ton; and Vermilion open-hearth lump, $13.15 per long ton.

Published minimum prices for selected foreign ores were as follows:

Venezuela–Orinoco No. 1 (58 percent iron), f.o.b. Puerto Ordaz, $7.88 per long ton.

Peru–f.o.b. San Juan, lump ore (62 percent iron), $8 per metric ton; fine ore (62 percent iron), $4.75 per metric ton.

Brazil–run-of-mine (68 to 69 percent iron), f.o.b. Atlantic port, $8.50 per long ton.

Goa–f.o.b. Mormugao Port, lump ore (58 percent iron), $5.45 per metric ton; fine ore (62 percent iron), $4.50 per metric ton. (Government minimums for Goa).

The average value of domestic usable ore per long ton f.o.b. mines, excluding byproduct ore, was $9.92, compared with $9.49 in 1966, and $9.53 in 1965. These values were compiled from producers' statements and approximate the commercial selling price less the cost of mine-to-market transportation.

TRANSPORTATION

The first long distance movement of iron ore by pipeline, the launching of a 100,000-ton ore carrier, and plans to construct 125,000-ton ore carriers were announced in 1967.

The Savage River Mines pipeline in Tasmania, installed in lieu of rail transportation to move iron concentrate approximately 53 miles from the mines to a pelletizing plant on the coast, operated successfully. The scheme involved moving the concentrate as a slurry of about 60 percent solids through a 9-inch inside-diameter pipeline, with a travel time of about 14 hours. Although lighter solids such as coal have been handled by pipelines, this marked the first use of a pipeline to move high-density solids such a distance.

Since an increase in ore carrier size reflects a decrease in cost per ton-mile for ocean movement of iron ore, vessels of increasing size have been planned as port facilities could be constructed to accommodate them. An agreement was announced in 1967 for the construction in Japan of two 125,000-ton capacity carriers for San Juan Carriers, Ltd., a wholly-owned subsidiary of Marcona Corp. They were scheduled for delivery in 1969 and 1970 to join a 100,000-ton ore carrier launched in 1967. Additional carriers of the same size were planned by other companies.

Also under consideration were 100,000-ton to 200,000-ton combination oil-iron ore carriers. These would reduce in-ballast time by transporting oil from the Persian Gulf to South American ports before loading ore for Japan. Further reductions in costs per ton-mile would thus be possible.

Japanese interests planned to start a triangular shipping plan in 1968 using a large ore carrier to transport African or South American ore to Japan; the carrier would then move to Australia and load ore for Western Europe before returning to Africa or South America and repeat the cycle.

Larger ore carriers in service on the Great Lakes were predicted in a few years with completion of the new 110-foot-wide Poe Lock at Sault Ste. Marie. U.S. Steel announced that a 45,000-ton vessel capable of unloading pellets at a rate of 10,000 tons per hour would be built for lake service.

The St. Lawrence Seaway authorities increased the maximum permissible vessel draft for Seaway transit from 25 feet 6 inches to 25 feet 9 inches, which meant an increased allowance of about 300 tons for large vessels. The decision was based on favorable water levels prevailing in the lakes.

A number of new or improved port facilities were under construction or planned around the world. A new port was to be constructed at Santa Cruz in the State of Guanabara, Brazil, and another was planned for the Republic of South Africa near the mouth of the Orange River. In Australia contracts for the construction of port facilities and deepening the channel at Port Hedland were awarded. In other ports handling iron ore, improvements being made were mainly for berthing the larger ore carriers, increasing storage facilities, and installation of equipment to increase loading or unloading time. On the Great Lakes, a $6 million taconite pellet handling and storage facility with a capacity of 2.2 million tons of pellets was dedicated near Superior, Wis., by the Great Northern Railway.

The Chicago & North Western Railway planned to construct a $12.3 million iron ore transfer and storage facility at Escanaba, Mich., for operation in 1969. The initial stockpile capacity for pellets would be 1.5 million tons, and increased later to 3 million tons.

Lake freight rates on iron ore were not increased in 1967. However, increases in dock charges were published late in the year along with general rail increases under tentative approval of the ICC. Interstate rates were raised 10 cents per ton between most of the established shipping points.

Dock charges per long ton on iron ore were changed as follows:

	Old	*New*
Rail of vessel to car	$ 0.22	$ 0.25
Rail of vessel to stockpile .	.49	.53
Dock stockpile to car	.31	.34
Storage per month	.01¼	.01½

FOREIGN TRADE

U.S. exports dropped about 24 percent from that of the previous year, with decreased shipments to Canada accounting for essentially all of the loss. Imports of ore declined about 4 percent.

The overall import trade pattern remained essentially unchanged from that of 1966. Imports from Norway, Canada and Venezuela registered modest gains of 0.4 million, 0.3 million and 0.2 million tons, respectively.

WORLD REVIEW

Australia remained the focal point of world iron ore news. Production was increasing rapidly, and exports were expected to be valued at over $200 million annually by 1971.

High-grade natural ores remained in over-supply, and high-grade fines found ready markets at reduced prices. The lower cost fines were in demand by many Japanese and European users as this material could be shipped to and agglomerated at the importing country's consuming plants to provide a high-grade furnace feed at a cost lower than similar material could be purchased for on the world market.

The United Nations assisted several countries in completing geological surveys of their land areas and in making aeromagnetic surveys.

NORTH AMERICA

Canada.—The recommendations of the Royal Commission on Taxation as presented in the Carter report regarding mining industry taxation resulted in concerned protests from Canadian-based iron-mining companies, and civic groups. The report called for the phasing out of existing tax incentives over a 5-year period and the immediate elimination of percentage depletion.

The part played by the favorable depletion allowances and the tax structure in general on the rapid development of Canadian mining ventures was underscored in an article by an executive of Pickands Mather & Co.[3]

A number of drilling programs were active on various iron properties, which generally raised known reserve figures in each instance.

British Columbia.—Westfrob Mines Ltd., a subsidiary of Falconbridge Nickel Mines, Ltd., officially opened, on June 19, its new Tasu operation on Moresby Island. The $40 million complex, which includes a townsite and deep seaport facilities, was to produce high grade iron concentrate from one deposit, and both iron and copper concentrates from another. Shipments were started to Japan on a 10-year contract with Mitsubishi Shoji Kaisha Ltd. of Japan which covered 400,000 tons of sinter concentrate and 550,000 tons of pellet concentrate per year.

Texada Mines, Ltd., an underground iron ore producer since 1952 was acquired by Kaiser Aluminum & Chemical Corp. The company had a long-term contract to ship about 500,000 tons of concentrates per year to Japan.

Newfoundland–Labrador–Quebec.—Negotiations to reopen the Bell Island mine in Newfoundland were unsuccessful, and future mining activity at this underground operation was not contemplated.

The Quebec-Labrador trough was estimated to have yielded in the past 13 years well over $1 billion in iron ore for export through the port of Sept-Iles. The economic impact of this foreign exchange has been the development of mines, a railroad, towns, and industry in what was previously a wilderness area. Efforts were underway to further increase annual production by interesting European steel companies in development of new iron ore deposits in the area.

The Iron Ore Company of Canada proceeded with a major expansion program to boost its pellet capacity at Labrador City from 5.5 to 10 million tons per year. Total cost approached $60 million with expenditures about evenly divided for the years 1966 and 1967.

Ontario.—The Steep Rock Iron Mines Ltd. began continuous operation of its new, 1.35 million ton annual capacity pellet plant near Atikokan. Ore reserves at the mines operated by Steep Rock were estimated at 337 million tons with an additional 273 million tons of low grade material available.

Falconbridge Nickel Mines, Ltd., planned a $50 million iron ore concentrating plant at its Sudbury nickel mine site. All iron would eventually be recovered from the pyrrhotite produced by the company.

The Algoma Steel Corp. Ltd. obtained two properties near Wawa, on long term lease from Sherritt Gordon Mines, Ltd. The company's ore division expected to begin production of 34-percent-iron ore from the open-pit siderite mines known as the Ruth and Lucy early in 1968. The

[3] McInnes, Robert. U.S. Mining Investments in Canada. Min. Cong. J., v. 53, No. 3, March 1967, pp. 34–37.

ore would be upgraded at Wawa to a 51-percent-iron product.

The International Nickel Company of Canada, Ltd., planned to enlarge its iron ore recovery plant in the Sudbury district as part of a $50 million expansion program. The company also formally opened a new $4 million laboratory near Toronto for research in extractive metallurgy.

The Steel Company of Canada Ltd.'s $60 million Griffith mine venture at Bruce Lake was scheduled for startup in early 1968. Under the management of Pickands Mather & Co., 1.5 million tons of pellets would be produced annually. Year-round shipments were planned from this taconite operation.

The Sherman Mine complex near Timagami, a joint venture involving Dominion Foundries & Steel Ltd. (90-percent interest) and the wholly-owned subsidiary of The Cleveland-Cliffs Iron Co., Tetapaga Mining Co. Ltd. (10 percent) was expected to begin production at the rate of about 1 million tons of pellets annually in 1968.

Mexico.—Plans to start exploitation of the Peña Colorado iron ore deposits in the State of Colima continued with the Federal Government adding its name to a consortium of four steel companies pledged to supply the capital. Activity has been limited to surveys and feasibility studies in the area, but additional work was expected to start in 1968.

Cerro de Mecado S.A., a subsidiary of Cía. Fundidora de Fierro y Acero de Monterrey, S.A. had a heavy-media beneficiation plant under construction at its Durango site which would upgrade the lower-grade conglomerate located near the base of the iron-rich mountain. Future plans included a pellet plant to handle fines resulting from the Durango operation.

A subsidiary of Hojalata y Lamina, S.A. (HyL), Las Encinas, S.A., completed surveys of, and prepared to open a new mine, San Pasquel. This mine adjoining the El Encino deposits in the State of Jalisco had been located by aerial survey and was estimated to contain 15 million tons of 55- to 67-percent ore. Iron ore fines produced at this operation were to be pelletized at a future date when a proposed plant could be installed, possibly at the junction of the company's 22 kilometer mine-to-railhead aerial tramway.

Tubos de Acero de Mexico S.A. (TASMA) started up its new 500 ton-per-day Vera Cruz plant using the HyL process to convert iron ore to sponge iron. HyL planned another installation at Puebla to supply a proposed steelworks with 85-percent-iron sponge similar to the product made at Monterrey and Vera Cruz.

SOUTH AMERICA

Argentina.—A study was released by the Dirección General de Fabricaciones Militares on the Sierra Grande iron ore deposits in the province of Río Negro. The report combined investigations made by a number of international firms and was used as the basis for soliciting offers to exploit the Sierra Grande deposit to provide sufficient ore for the country's requirements. Consumption of at least 5 million tons by 1974 was predicted. Brazil and Chile have supplied most of the ore imported in the past; only 10 to 15 percent of Argentina's needs have been produced internally. The proposed development called for an investment of approximately $50 million, including pelletizing facilities.

Government exploitation of the low grade Unchime and Santa Barbara iron ores in the province of Jujuy was begun, and there were plans to work other deposits in this province.

Brazil.—The Companhia Vale do Rio Doce (CVRD), principally government owned and controlled, continued as Brazil's largest ore mining and exporting company. Fine ore (minus one-half inch), accounted for about one-third of the exports which were estimated at 13 million tons for 1967. This was a significant change from former years, and the result of a lower price tag placed on the high-iron fines, which can be readily sintered or pelletized to form high grade furnace feed. A multi-million-ton order was signed to supply seven Japanese steelmakers with fines over a period of 12 years.

The U.S. Steel affiliate Companhia Meridional de Mineraçao filed applications to prospect potential iron ore deposits reported by the company's geologists some 300 miles south of the Amazon Delta in the State of Pará.

New port facilities at Santa Cruz, in Guanabara, were planned for the export of iron ore and import of coal. Authorization was given to obtain foreign financing, and completion was expected in about 2 to 3 years.

A record load of ore, 95,100 long tons, was shipped from the port of Tubarao bound to Japan aboard the *Ossig Silver*.

Chile.—Strikes slowed iron ore production to some extent although an overall gain was shown for the year. Future annual increases were indicated but were expected to be at a more moderate rate than in previous years. About 90 percent of the country's output was mined by three companies, Cía. Minera Santa Fe S.A., Cía. Acero del Pacífico S.A. (CAP), and Bethlehem-Chile Iron Mines Company. The latter held the largest producing mine, El Romeral. Bethlehem considered plans for increasing production to about 4.5 million tons per year, which would require new investment of approximately $20 million. If CAP accepted an offer by Bethlehem to join as a partner in the expansion, the annual production would be raised to 5 million tons and the investment to $25 million. CAP, backed by the Chilean Government, invited Bethlehem to participate in a new company to be organized for the exploration and development of iron ore and other minerals in Chile. Bethlehem's proposed share was 25 percent.

Santa Fe completed a project to determine its reserves in the El Laco deposit. The results showed proven reserves of 200 million tons, and estimated reserves of 400 million tons.

Exploration and metallurgical work was reported underway on the CerroNegro Norte magnetite deposit in the Copiapó district, and a large pelletizing plant was planned for future operation.

Cía. Minera Santa Bárbara completed a port construction program in February at Huasco to allow the docking of vessels as large as 67,000 tons capacity. This was followed by expanding the capacity to 100,000 tons, and the loading capacity to 3,500 tons per hour.

Peru.—Marcona Mining Co. entered into a new agreement with the Santa Corp. for exploitation of Marcona's iron ore deposits. This supplanted their 1960 contract and contained concessions which included royalty payments by Marcona in 1967 estimated at about $7 million. A new ore fines plant was built at San Nicolas to replace the San Juan plant, and pellet production capacity was raised to 3.5 million tons per year.

Peru's first blast furnace located at the SOGESA plant in Chimbote started operation in December. The furnace had a capacity of 200,000 tons of pig iron per year.

Venezuela.—Orinoco Mining Co., a subsidiary of U.S. Steel, authorized construction of a 1-million-ton annual capacity iron ore reduction plant to produce briquettes containing about 85 percent iron. The product would be used for domestic steel production and also offered for sale abroad. An option to obtain a 25-percent interest in the venture would be held by the Government. An iron ore reduction plant to utilize some of the country's excess natural gas had been under study by the Government for several years.

EUROPE

Czechoslovakia.—The last of the operating Krupp-Renn units was to be closed completely during the year due to the excessive cost of the product obtained compared with high grade imported ore. In the past, State-controlled mines have supplied about 10 to 12 percent of the country's iron ore needs, but this will be reduced to about 8 percent with the phasing out of the Krupp-Renn installation. Increased concentrate shipments from the Soviet Union were expected.

Finland.—Low world prices and high transportation costs were given as reasons for the scheduled closing of Vuoksenniska Oy's mines at Kolari and Jussarö. Crude ore from the mines averaged about 27 percent iron and was upgraded to 57.6 percent. Finland imported 638,000 tons of iron concentrates during 1967.

France.—Announcements of mine closings continued as underground mines producing low-grade phosphoric ores appeared to be slowly yielding to high-grade imports. Prolonged strikes initiated by miners in the Lorraine Basin caused a production drop in the first half of the year which amounted to a decrease of 18 percent from that produced in the first half of 1966. Iron ore mining and steel production were of major concern in France's future economic planning.

Germany, West.—As in France, the mining of domestic iron ore continued to decline, with the Salzgitter area blast furnaces almost the only ones consuming indigenous ores. Importing countries led by Sweden, Liberia, and Brazil supplied cheaper and higher quality ores than could be produced locally.

Norway.—The Government-owned concern, A/S Sydvaranger decided to install a pelletizing plant in order to bolster a falling market for their iron ore concentrate, which had steadily declined in value over the preceding 8-year period. The company, Norway's largest producer, reported its 1967 production of iron ore sold at an average of 8 percent below 1966 prices. A West German firm would build the complete 1.2 million ton per year plant under agreement with and from designs and specifications supplied by Allis-Chalmers Manufacturing Co. Operations were scheduled to start in 1969.

Portugal.—The Moncorvo ore deposits, about 80 miles east of the port of Leixoes, were studied by a group of European concession holders, including August Thyssen-Hütte. The latter reported flotation could be used in upgrading the 30- to 40-percent ore to a concentrate containing 65-percent iron and 6-percent-silica. Reserves exceeding 300 million tons have been shown by exploration. Further study was required before a decision concerning the economic feasibility of the extraction and transportation of the ore to users could be reached.

Spain.—Published reports that iron deposits estimated at about 300 million tons were discovered in the provinces of Badajoz, Seville, and Huelva were not confirmed by the Government. Government geologists had been surveying and drilling in these areas on lands reserved to the State.

The Government set 1972 as a target date for producing ore with 8-million-tons-iron content and intended to improve poorer ores by pelletizing and other beneficiation processes.

Sweden.—Several iron mines in central Sweden were forced to close during the year due to their inability to remain competitive. Reasons given were high transportation costs, inability to utilize cost-saving large-scale mining methods, and the low quality of the ores.

Luossavaara-Kiirunavaara AB (LKAB), which is State-owned, began work on a pelletizing plant at Svappavaara scheduled to have an annual output of 1.8 million tons.

Work was done on outlining two new ore bodies in the Kiruna district by LKAB, one of which was described as an extension of the main Kiirunavaara deposit and was said to contain about 250 million tons of ore.

Pilot production of cold-bonded pellets was started by the Grängesberg Co. at Strassa, and blast furnace trials of the product were scheduled to be carried out at the Oxelösund steelworks. Pellets costs were claimed to be greatly reduced from those of the hot pelletizing processes.

Grängesberg and LKAB announced that 1968 delivery prices of phosphatic ores to the United Kingdom, West Germany, and Belgium would be 3 to 4 percent lower than in 1967.

U.S.S.R.—The Five Year Plan entered its second year in 1967. It was characterized by continued large-scale expansions in iron mining and in beneficiation plants to accompany increased iron and steel production capacity. Priority of the ferrous industry over agriculture and chemicals seemed to reflect the general feeling of the present Presidium that the power of a nation still depends on its ability to produce steel. Although much was written in Soviet publications about failures in achieveing goals set for the ferrous branch of the State's economy, production increased at a high rate, with many new and expanded operations reported.

Some of the established mining bases were being expanded, and developments were planned for new areas. The State Plan which called for an output of 163 million tons of usable ore in 1967, with an average iron content of 57.6 percent apparently was exceeded. New production of agglomerates was scheduled at 2.8 million tons.

Mining of the high-grade Belozersk iron ore started during the year. Analysis of this ore was reported as 62 to 67 percent iron, 0.02 percent phosphorus, 0.01 percent sulfur, and 3.9 percent silica, making it the Soviet Union's highest grade natural ore.

The first long-term contract was signed

with Japanese steelmakers for Soviet iron ore. A $20 million contract was negotiated to supply 4.9 million tons of ore annually over a 5-year period beginning in 1968. The ore would move through a Black Sea port which was to be enlarged to accomodate Japan's larger ore carriers.

AFRICA

Algeria.—New markets for iron ore were obtained by Algeria, and initial contracts were made to supply 600,000 tons to the U.S.S.R., 500,000 tons to Rumania, and 100,000 tons to Hungary. The U.S.S.R. contract involved trade exchanges and a loan for the erection of the Annaba steel plant. The Rumania contract involved the exchange of four oil rigs. Deliveries to Great Britain and other traditional markets, although not terminated, were reduced considerably after nationalization of the Algerian iron mines in 1966.

A special technical committee set up jointly by Algeria and Spain was studying the possible development of the Tindouf Basin iron deposits. The key to commercial exploitation of the deposits was thought to be a route to the Atlantic through Spanish Sahara which would eliminate Algeria's long haul to the Mediterranean seacoast.

Angola.—The Ciuma mine in the southern district was scheduled to be closed, and the efforts of the Companhia Mineira do Lobito would thereafter be concentrated on operation of the Cassinga mines in the South Central section, where substantial iron ore production was achieved during the second half of 1967. An export potential of 5 million tons annually was expected in 1968. New mechanized ore-loading facilities at Saco de Giraul about 6 miles north of the port of Moçamedes, were opened, and large-scale shipments of the Cassinga ore were started. Shipments to Japan on a regular basis were scheduled.

Deposits of low-grade ore in the Cassala region east of Luanda, estimated at 500 million tons, were being studied for development by the Companhia do Manganese de Angola and the Klöckner steel firm of West Germany. A pelletizing plant was included in the plans for consideration.

Gabon.—Exploitation of the Belinga iron ore deposits, estimated to contain 1 billion tons of high-grade direct-shipping ore, continued to play a prominent part in the Gabonese plan for future economic development. Construction of a railroad to the seacoast was deemed feasible in a preliminary survey completed in 1965. A final engineering study, financed by the United Nations Special Fund, was underway and was to be completed in 1968. Plans called for construction of the railroad to be started in 1969.

Liberia.—Iron ore continued to be the country's primary export and source of revenue. In 1967 the Government's share of the income from this commodity amounted to about $10 million. Production of the ore has increased steadily in the past few years although prices declined from an average of $11.90 per metric ton (f.o.b.) in 1960 to $6.58 in 1967; this was largely due to world competition and recent cutbacks in European steel output.

Four companies operated in Liberia in 1967, Bong Mining Co., National Iron Ore Co., Ltd. (NIOC), Liberia Mining Co. Ltd. (LMC), and the Liberian American-Swedish Minerals Co. (LAMCO). Through contracts made by the Grängesberg Co. in Sweden, LAMCO was to supply Japan 4.5 million tons of Liberian ore during the period 1968–72 in addition to a 5.6-million-ton contract previously made for 1968–74. LAMCO completed a new washing plant and a pelletizing plant during the year and began trial operations. The new facilities when in full operation would add a large output of washed fines and lump ore as well as 2 million tons of pellets annually to the company's products.

An airborne magnetometer-scintillometer survey of Liberia was begun in 1967 under the auspices of the United Nations and the Liberian Geological Survey. Coverage of the entire country was planned with the results available in 1969.

Morocco.—The Government proceeded with nationalization of the country's largest iron ore producer, Compañía Española de Minas del Rif (CEMR). A joint commission from the Government and CEMR was activated to decide on procedures to be followed and compensation for the owners.

A plan to establish a steel plant at Nador, near the mines of the Rif, had been under consideration for a number of years and with the importance of the mines to the national economy was thought to figure largely in the Government's decision to take them over.

ASIA

India.—Production and exportation of iron ore failed to reach target figures set by the Government. Among the factors contributing to the difficulties were strikes, the Suez canal situation, and excess ore stocks at the country's steel plants. Keen international competition in both iron ore and steel also added to the failure. Ore exports did increase slightly in 1967 and reached a total of 13.9 million tons. Of this Goa supplied 6.8 million tons, 0.4 million tons less than in 1966. Production was estimated to be about 1 million tons below the 1966 output.

The conversion of fine ore to high grade pellets and exportation of fines were expected to help maintain India's position in the world iron ore market. Export duty on fine ore, approximately 65 cents per ton, was reduced by 20 percent during the year.

India's Minerals and Metals Trading Corp. (MMTC) negotiated the sale of 5.8 million tons of ore to Japan at $9.52 per ton, f.o.b., which was about $0.42 less than the agreed rate for the prior year. Contracts also were made to supply over 2 million tons of ore to five East European countries.

The Government-owned National Minerals Development Corp. (NMDC) studied proposals of Marcona Mining Co. and Japanese interests for joint development of magnetite deposits in the Kudremukh area of Mysore which contained proved reserves in the order of 1 billion tons. Although no contract was signed, preliminary plans called for the Aroli deposits to be exploited first; they would supply about 4 million tons per year for export. The development of port facilities at Mangalore to eventually admit entry of 100,000 ton carriers and the installation of rapid-loading equipment is to be done by the Government.

Reductions of $1.40 to $2 per ton in shipping costs of iron ore from Mormugao Port in Goa to Japan were estimated if the port were modernized to permit rapid dockside loading. The average 14-day delay for the carriers would be reduced to 4 or 5 days.

New deposits of iron ore were located in the Calicut district of Kerala. The extent of the reserves had not been proven by drilling, but estimates exceeded 100 million tons.

Plans were being pushed for the installation of new pelletizing operations in Goa, Orissa, and possibly Mysore.

Japan.—Japanese steelmakers sought ore and made contracts for future deliveries in many parts of the world. Australia shipped 8.3 million metric tons to Japan during the year and was expected within a short time to supply about 40 percent of the country's rapidly increasing import requirements, which in 1967 amounted to 56.4 million tons.

Japan's iron ore production including iron sands continued at slightly more than 2 million tons; byproduct ore added another 2 million tons, the two sources supplying about 7 percent of the country's steelmaking needs. Contracts were obtained during the year for ore from a number of sources including the U.S.S.R. At least a dozen countries were committed to furnishing various grades and types of iron ore for periods of time up to 21 years at prices which could only be obtained in a buyer's market such as continued to exist throughout 1967.

Some of the prices per metric ton contained in contracts or offers reported by the Japanese included 62-percent concentrate feed at $4.15, f.o.b. Black Sea ports from U.S.S.R.; 68-percent run-of-mine at $15.34, C&F from Brazil; 63-percent lump ore at $7.80, f.o.b. Chile; 64-percent lump ore at $9.37 and 64-percent fine ore at $7.68, f.o.b. Western Australia; 60-percent lump ore at $8.85, f.o.b. Malaysia; 63-percent fines at $4.55, f.o.b. Goa; 63-percent run-of-mine at $6.30, f.o.b. Liberia (for 1968); and 62-percent Benson Lake ore at $5.95, f.o.b. British Columbia. In some cases the prices reflect part of a package offer and may be valid only if accepted under all specified conditions.

Japanese interests studied proposals to participate or actually invested in several foreign iron ore projects including the Mekambo project in Gabon, the Philippine Iron Mines project in the Philippines, the Kudremukh project in southwest India, and three separate projects in Australia.

Malaysia.—Airborne magnetometer and ground surveys were being conducted in the State of Johore and in the north central section of West Malaysia. They were being carried out with the assistance of United Nations teams. The upgrading of some lower grade iron material was being considered in order to increase Malaysia's production.

Philippines.—A new company, Pellet Corp. of the Philippines (PCP), was formed by Kawasaki Steel Co. and Kawasaki Drydock Co. of Japan with the Philippine Iron Mines (PIM) to take over the pellet operations of PIM. The pellet output from the 0.75 million tons annual capacity plant was scheduled to go to Kawasaki Steel.

OCEANIA

Australia.—The Australian boom based on the iron ore industry continued with large-scale shipments being made for the first time from some areas and installations being rushed to completion in others. Exploration, surveying, and planning for the future growth of the iron ore industry and its associated activities continued throughout 1967.

The Department of National Development predicted that by 1971–72 the value of iron ore exports based on known contracts would reach $210 million a year. Planned and actual capital expenditures directly related to the establishment of the iron ore industry were estimated to be in excess of $600 million, $550 million of which was for Western Australia and the remainder for Northern Territory and Tasmania. A considerable amount of U.S. capital was included in the investments.

Northern Territory.—Operations of the Frances Creek Iron Mining Corp. Pty. Ltd. were opened officially during the year. Lump ore of 62-percent-iron content was to be supplied to Japan through the port of Darwin at a rate of about 0.5 million tons per year for 8 years. Contract price was $8.90 per long ton.

Sentinel Mining Co., a wholly-owned subsidiary of National Bulk Carriers, Inc., proceeded with survey work on concessions granted. Design study contracts were let for port plans and other facilities involved in the project, Prereduction studies were being made of the ore in the U.S., and offers of lump ore to Japan were being prepared.

Western Australia.—Seven major mining companies held signed agreements with the State Government for development of iron ore deposits, and exports had reached a rate of about 15 million tons annually by yearend.

Hamersley Iron Pty. Ltd. was the leading group in contracts for exporting ore, with about 125 million tons of lump ore, pellets, and fines contracted for during the period ending in 1981. Most was to go to Japan, with small short-term contracts calling for deliveries to Wales in the United Kingdom and to Belgium. Test shipments were made also to France, West Germany, and Italy.

The company's $50 million pelletizing plant started operation in 1967 and was expected to be at full capacity early in 1968. This plant would supply a 10-year Japanese pellet contract for 18 million tons scheduled to begin in April 1968. Facilities at both the port and mines which represents an investment of approximately $200 million were designed to permit expansion.

Mount Goldsworthy Mining Associates continued its shipments of lump ore to Japan which began in June 1966. The following contracts were held: An initial 16.5-million-ton agreement with the Japanese for delivery of lump ore over a 7-year period beginning in 1966, and a 3.125-million-ton contract signed in 1967 for fines to be shipped at an annual rate of 0.5 million tons per year. Efforts were being made by the group to negotiate additional contracts.

The Mt. Newman development project was started in April 1967 by a consortium formed by the Amax Iron Ore Corp. of Delaware U.S.A. (25 percent), the Dampier Mining Co. Ltd. (30 percent), Pilbary Iron Ltd. (30 percent), with British and Japanese interests making up the remaining 15 percent. Operations were to be managed by Mount Newman Mining Co. Pty. Ltd. a wholly-owned subsidiary of Broken Hill Pty. Co. Ltd. (BHP). Contracts were let for a railroad, dredging, and other construction work to begin the $200 million project, and a total of 100 million tons of lump ore and fines were contracted for delivery to Japan in the period April 1969 through 1983.

Cliffs Western Australian Mining Pty. Ltd. continued work on its Robe River project and estimated total costs at about $180 million. Plans were approved by the Government for railroad and port location changes to give access to Cape Lambert where 100,000 ton carriers could be berthed. Tenders were received for a pellet plant and for a port at Cape Lambert. Japanese steel mills were offered 87.5 million tons of pellets over 21 years at 18.75 cents per unit, f.o.b., and 50.5 million tons of fines at 10.75 cents per unit. Shipments would begin in 1971, and if the contract was accepted, it would be the largest single iron ore export contract made to date.

A new company, Hanwright Iron Mines, was formed by the discoverer of the Hamersley Range iron ore deposits, Larry Hancock and his partner. The company obtained extensive leases on which ore was being proven, and plans were to be submitted to the Government for an investment in facilities to produce and ship 3 million tons of pellets annually. The possibility of later producing either a metallized product or steel was included in the proposal.

Other Western Australian groups in the process of entering the iron ore business included the Mt. Gibson Mining Co. Pty. Ltd., and the Murchison Exploration & Development Co. Mt. Gibson, organized in September 1967, expected to build a pellet plant with a 2-million-ton-per-year throughput. Murchison was making feasibility studies based on a temporary reserve awarded by the Government in the Weld Range near Cue.

Tasmania.—The Savage River Mines project was essentially complete at year-end, and all components were reported operating successfully. Pellet capacity was rated at 2.25 million tons annually. The product was to contain 67.5 percent iron with shipments scheduled for April 1968, and all output to go to Japan under a 20-year contract. Pickands Mather & Co. held about 12 percent interest in the project. Additional American capital was invested in a participating company, North-West Iron Co. Ltd.

Industrial & Mining Investigations Pty. Ltd. was exploring leases north and south of those held by Savage River Mines, and negotiations were underway for possible establishment of a steel industry in Tasmania.

TECHNOLOGY

Technologic improvements in mining, transporting, and beneficiating iron ore continued to be directed primarily toward cost reduction and the production of higher grade furnace feed. This was becoming increasingly important in producing countries as the international market recorded more and more offers of high-grade iron ore at reduced prices.

Refinements were made in methods of computing characteristics of blocked-out ore sections and in tailoring blasting techniques to individual tracts of ore. Further increases in capacity and size of equipment for handling and transporting ore were indicated at some of the larger operations following equipment test periods. Innovations used in several beneficiation schemes promised higher grade products from the taconite-type ores.

Exploration for new deposits continued in many countries in spite of the apparent world oversupply of iron ore. A helicopter borne high-resolution electromagnetic system was being operated successfully in Canada. Better coverage in the rugged terrain with a minimum of ground clearance was claimed, as well as lower costs for operation in remote areas.[4]

Trucks with capacities exceeding 100 tons for off highway ore movement from mine to crushers were operating successfully in several locations. The largest apparently was a 160-ton electric-drive LeTourneau-Westinghouse unit which was being field tested at Kaiser's Eagle Mountain, California, operation.

Electric shovels with interchangeable dippers having capacities as high as 16 cubic yards were in use, and allowed handling of maximum sized pieces of taconite which the latest model crushers were capable of reducing.

Innovations to rod and ball mills increased capacity by reducing down time. One consisted of mechanical means for replacing the rods or balls during mill operation, thus eliminating some of the down time formerly required for this purpose.

The new Butler and the National pellet plants managed by The Hanna Mining Co. were the first commercial taconite operations on the Mesabi to utilize air-swept, dry autogenous grinding. The Butler plant was equipped with five, 26 foot by 6 foot autogenous primary mills each powered by

[4] Engineering and Mining Journal. V. 168, No. 11, November 1967, p. 27.

a 3,000-hp. motor. Even larger mills were planned for use in a Canadian installation.

Among the patents granted during the year for ore reduction was one for a process using dry comminution followed by dry magnetic concentration to produce coarse taconite concentrates.

Autogenous grinding tests in jet–type mills with both hot gases from a jet engine and super-heated steam as energy carriers were made on Krivoi Rog ore in the U.S.S.R. Considerable savings were reported for each over conventional ball mills; the super–heated steam mills showed the greatest efficiency.[5] Also in the U.S.S.R., results of boulder reduction in an open-pit iron mine using a high voltage A.C. electric test apparatus showed savings of 2 to 1 over the usual secondary drill–and–blast methods.

The development of autogenous grinding as a tool in size reduction was discussed in a review published in 1967.[6]

The Erie Mining Co. successfully applied the use of stationary screens for separation of (minus) −325 mesh material in its taconite beneficiation operation at Hoyt Lakes. This significant operation involved a unique patented device to keep the screens from blinding and was described as producing better concentrate at a lower cost than the flotation scheme formerly used.

Researchers at the Colorado School of Mines experimented with hydroxamate as a collector for iron oxides. In flotation tests with two natural iron ores, high grade concentrates were obtained with indicated economic advantage over conventional fatty acid flotation.[7]

The application of computers and automation in general, to activities involving iron ore from exploration through the final smelting stage continued to expand. Taconite reserves in Minnesota were being calculated by the State using computer methods. Grade, thickness, and tonnage of beds in the various tracts were obtained in a fraction of the time formerly required.[8]

A sophisticated system using the computer to determine the grade, to classify, and to program the dumping sequence of ores moving from mine sites for final blending and loading at the port of Sept-Iles was developed in Canada over the last few years by the Iron Ore Company of Canada.

In general, the larger and more modern ore processing plants were being equipped with centralized controls, and a computer was usually employed in the system for both control and logging of operations. The newer blast furnace designs called for maximum use of programmed controls. A belt conveyor system was favored over the skip hoist in at least one plant.

Other uses to which the computer was increasingly applied include continuous iron ore slurry analysis, plant power programing, monitoring operating variables, and storage of input data for later use.

Interest in agglomeration of iron ores, especially in pelletizing, continued as many fundamental investigations were reported. These dealt with variables such as temperature, size, balling time, additives, and pellet strength. A number of agglomerating patents were issued involving new methods and equipment for both briquetting and pelletizing of iron ore. The last two parts of a comprehensive article covering in detail concentrating and pelletizing of taconite in the United States and Canada were published.[9] The article presented an excellent history and status report on taconite operations.

Plants incorporating the latest improvements in the concentration and pelletization of taconite were capable in 1967 of producing pellets containing 64 to 68 percent iron and less than 6 percent silica. A higher grade product was expected to depend largely upon the application of prereduction techniques.

There was considerable activity in the development of direct reduction processes and prereduced ores both here and abroad. Patents on reduction roasting of ores using gaseous and liquid hydrocarbons were assigned to several companies, as were patents on processes using solid reductants.

An international conference on production and use of prereduced iron ores was

[5] Mining & Minerals Engineering (London). V. 3, No. 1, January 1967, p. 9.

[6] Bond, Fred C. Autogenous Grinding Evolution. Min. Cong. J., v. 53, No. 6. June 1967, pp. 48–54.

[7] Fuerstenau, M. C., J. D. Miller, and G. Gutierrez. Selective Flotation of Iron Oxide. Trans. Soc. Min. Eng., v. 238, No. 2, June 1967, pp. 200–203.

[8] Weaton, George F., Jr. Estimating Minnesota's Taconite Reserve by Computer. Skillings' Min. Rev., v. 56, No. 1, Jan. 7, 1967, pp. 6–7, 14–15.

[9] DeVaney, Fred D. The Concentration and Pelletizing of Taconite—P. III. Min. Proc., v. 8, No. 1, January 1967, pp. 22–27, P. IV., v. 8, No. 2, February 1967, pp. 18–23.

held at Evian, France, during which the worldwide status of direct reduction and prereduced ores was reviewed in detail.[10] It was noted that the High Authority, European Coal and Steel Community (ECSC), had provided considerable financial aid for developmental work, resulting in a new direct reduction process which was tested in a pilot plant.

The HyL direct reduction process was being studied by Brazil, the United Kingdom, Saudi Arabia, Taiwan, and other countries for possible use in producing reduced iron products from local ores.

Beneficiation studies, including prereduction of the Wabana ore in attempts to maintain commercial production, were reported.[11] The high phosphorus content of the ore and the poor recovery efficiencies achieved in beneficiation attempts to produce a furnace feed competitive with other high–grade ores available on the world market were primary factors contributing to the failure of this long–time operation in Newfoundland.

The Japanese Government was planning long-range research and development of a direct steelmaking method. The project would start in 1968 and would involve the production of prereduced pellets for use in large-capacity electric furnaces. In New Zealand a contract was awarded for installation of a Stelco-Lurgi reduction plant. Native iron sands previously tested in pilot plant operations were to be used as the ore.

Direct reduction of iron ore on a commercial scale in this country was close as construction neared completion on the McWane Cast Iron Pipe Company's plant at Mobile, Ala. The plant was scheduled for operation late in 1968. High-grade imported ore fines were to be used in the Dwight-Lloyd-McWane (DLM) process to produce iron for foundry purposes.

The Midland-Ross Corp. in a joint research program with the National Steel Corp. worked with the Hanna Mining Co. to develop a commercial "heat-fast" metallizing system for producing prereduced pellets. The system uses a carbon reductant mixed in the pellets which are cycled continuously on a direct-fired rotary hearth furnace. The National Steel Corporation's pellet plant in Minnesota, which started production in 1967, was designed for future conversion to this metallizing procedure if desired. Midland-Ross also announced plans to build and operate a commercial plant in Portland, Oreg., using the same process. The plant would take high-grade fines from South America and convert them to 95-percent-iron pellets for an electric-furnace steel mill to be built by the Gilmore Steel Corp. Operation of the plant was expected to start in 1968.

Notable improvements have been made in electric furnace operations, and the McWane and Gilmore installations, although relatively small, may be forerunners of larger plants to be built in this country and abroad. Operations of this type could have considerable influence on future iron and steel production and will probably make re–evaluation of the blast furnace necessary in many areas where iron and steel needs are limited and where high capital investments are not desirable.

An indication of further evolutionary trends in this field was the examination by several countries of direct iron and steelmaking from iron ore by continuous processing. One direct-reduction continuous process, studied by the U.S. Steel Corp. for several years on a laboratory scale, was being scaled up to a pilot plant operation. Although drastic changes in processing methods were not expected in the near future, preparations were being made in the major producing countries in the event of a significant breakthrough for continuous conversion of ore to metal.

Bureau of Mines Research.—Results of a study of iron ore resources in a section of the Appalachians was published.[12] In the area drilled, bed thickness and grade were not consistent and the samples of the hematitic material failed to respond to beneficiation techniques for producing a high grade concentrate with good recovery. The publication illustrates the need for additional research in order to make the large hematitic sandstone deposits of the Clinton formation economically feasible to mine.

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10 Steel Times (London). V. 194, No. 5163, June 30, 1967, pp. 753–760, v. 195, No. 5169, Aug. 11, 1967, pp. 161–166.

11 Korzekwa, T. M., A. J. Last, and R. L. Cavanagh. A Study of the Semi–Reduction of Wabana Iron Ore. Canadian Min. & Met. Bull. (Montreal), v. 60, No. 663, July 1967, pp. 789–794.

12 Fish, George E., Jr. Clinton Hematitic Sandstone Deposits, Butt Mountain Area, Giles County, Va. BuMines Rept. of Inv. 6966, 1967, 39 pp.

Marginal and submarginal iron-bearing materials from the Gogebic, Marquette, and Menominee Ranges were studied using reductive roasting-magnetic separation, and flotation methods for upgrading to usable concentrates. The resources and metallurgical evaluations were published.[13]

Nonmagnetic taconite composite samples from the Mesabi Range were evaluated also and results published.[14] These investigations were part of continuing efforts being made by the Bureau to develop profitable utilization of all of the Nation's major iron resources.

Other projects at the Bureau's research centers included continued collection, evaluation, and storage of core samples at the Twin Cities location in Minnesota, studies on properties of iron minerals, preparation of oxidized and prereduced iron ore pellets, metallized concentrate production, processing of manganiferous iron ores, and various beneficiation schemes including flotation.

The Bureau's Iron Range Demonstration Plant at Keewatin, Minn., reached a stage of partial completion with occupation of a new administration and laboratory building by project personnel, and start of construction on the raw materials and rotary kiln sections of the plant. Processing of nonmagnetic taconites and other offgrade iron ores using scrap iron to effect conversion to a usable magnetic iron ore will be demonstrated.

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[13] Heising, L. F., and D. W. Frommer. Lake Superior Iron Resources: Preliminary Samples and Metallurgical Evaluation of Selected Michigan-Wisconsin Iron Formations. BuMines Rept. of Inv. 6895, 1967, 31 pp.

[14] Heising, L. F., C. B. Daellenbach, and E. E. Anderson. Lake Superior Iron Resources. Reexamination of Nonmagnetic Taconite Occurrences in the Hibbing, Minn., Area by Flotation, Magnetic Separation, and Petrographic Methods. BuMines Rept. of Inv. 6991, 1967, 21 pp.

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

District and State	Employment: Average number of men employed	Employment: Time employed: Average number of days	Employment: Time employed: Total man shifts (thousands)	Employment: Time employed: Man hours: Average per shift	Employment: Time employed: Man hours: Total (thousands)	Production [1]: Crude ore (thousand long tons)	Production [1]: Usable ore (Thousand long tons)	Production [1]: Usable ore: Iron contained [2]: (Thousand long tons)	Production [1]: Usable ore: Iron contained [2]: Natural (percent)	Average per man: Crude ore: Per shift	Average per man: Crude ore: Per hour	Average per man: Usable ore: Per shift	Average per man: Usable ore: Per hour	Average per man: Usable ore: Iron contained: Per shift	Average per man: Usable ore: Iron contained: Per hour
1966:															
Lake Superior:															
Minnesota	9,871	294	2,904	8.0	23,259	116,906	54,682	31,074	56.8	40.26	5.03	18.83	2.35	10.70	1.34
Michigan	3,615	292	1,054	8.0	8,432	24,820	14,322	8,565	59.8	23.55	2.94	13.59	1.70	8.13	1.02
Total	13,486	294	3,958	8.0	31,691	141,726	69,004	39,639	57.4	35.81	4.47	17.43	2.18	10.01	1.25
Southeastern States:															
Alabama and Georgia	801	227	182	8.8	1,609	5,813	2,028	825	40.7	31.94	3.61	11.14	1.26	4.53	.51
Northeastern States:															
New Jersey, New York, Pennsylvania	2,589	260	674	8.0	5,389	11,355	4,652	2,977	64.4	16.85	2.11	6.90	.86	4.42	.55
Western States:															
Montana and Wyoming	601	316	190	8.0	1,520	5,019	1,971	1,118	56.7	26.42	3.30	10.37	1.30	5.88	.74
Missouri	1,006	289	291	8.0	2,325	2,869	1,928	1,282	66.5	9.86	1.23	6.63	.83	4.41	.55
Nevada and Utah	420	243	102	8.2	843	3,288	2,937	1,903	64.8	32.24	3.90	28.79	3.48	18.66	2.26
Total	2,027	288	583	8.0	4,688	11,176	6,836	4,303	62.9	19.17	2.38	11.73	1.46	7.38	.92
Undistributed [3]	1,438	266	383	8.0	3,071	13,137	7,238	4,097	56.6	34.30	4.28	18.90	2.36	10.70	1.33
Grand total	20,341	284	5,780	8.0	46,448	183,207	89,758	51,841	57.7	31.70	3.94	15.53	1.97	8.97	1.12

[1] Includes manganese bearing ore in the Lake Superior District.
[2] Average content of all types of ore shipped.
[3] Includes Arizona, California, Colorado, Idaho, Mississippi, New Mexico, and Texas.

Table 2A.—Employment at iron ore mines and beneficiating plants, quantity and tenor of ore produced and average output per man, by districts and States

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 long tons)	Iron contained[1]: Percent (natural)	Average per man^p: 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
1967:															
Lake Superior:															
Minnesota	9	295	2,729	8.0	21,843	116,151	50,157	28,735	57.3	42.56	5.32	18.38	2.30	10.53	1.32
Michigan	3	306	1,036	8.0	8,291	28,638	14,030	8,391	59.8	27.64	3.45	13.54	1.69	8.10	1.01
Total	13	298	3,765	8.0	30,134	144,789	64,187	37,126	57.8	38.45	3.85	17.05	2.13	9.86	1.23
Southeastern States:															
Alabama and Georgia	1	243	167	8.5	1,428	4,720	1,889	767	40.6	28.26	3.31	11.31	1.32	4.59	.54
Northeastern States:															
New York and Pennsylvania	2	270	642	8.0	5,134	10,329	4,197	2,686	64.0	16.09	2.01	6.54	.82	4.18	.52
Western States:															
Montana, Utah, Wyoming	1	295	268	8.0	2,142	6,059	3,556	1,976	55.6	22.61	2.83	13.27	1.66	7.37	.92
Missouri	1	304	283	8.0	2,265	2,390	1,802	1,225	67.9	8.45	1.06	6.37	.80	4.33	.54
Total	2	300	551	8.0	4,407	8,449	5,358	3,201	59.7	15.33	1.92	9.72	1.22	5.81	.73
Undistributed[2]	1	257	349	8.0	2,788	15,110	7,734	4,630	59.8	43.30	4.28	22.16	2.77	13.27	1.66
Grand total	19	290	5,474	8.0	43,891	183,397	83,365	48,410	58.1	33.50	4.18	15.23	1.90	8.84	1.10

^p Preliminary
[1] Average content of all types of ore shipped.
[2] Includes Arizona, California, Colorado, Idaho, Mississippi, Nevada, New Mexico, and Texas.

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	1966					1967				
	Number of mines	Hematite	Brown ore	Magnetite	Total	Number of mines	Hematite	Brown ore	Magnetite	Total
Lake Superior:										
Michigan	17	W	-------	W	24,820	15	W	-------	W	28,638
Minnesota	59	52,376	1,404	62,298	116,078	45	48,948	83	67,120	116,151
Total	76	52,376	1,404	62,298	140,898	60	48,948	83	67,120	144,789
Southeastern States:										
Alabama	19	778	3,390	--------	4,168	15	1,036	2,638	---------	3,674
Georgia	17	--------	1,645	--------	1,645	11	--------	1,046	---------	1,046
Total	36	778	5,035	--------	5,813	26	1,036	3,684	---------	4,720
Northeastern States:										
New Jersey, New York, Pennsylvania	7	--------	-------	11,355	11,355	7	--------	-------	10,329	10,329
Western States:										
Arizona	3	W	-------	W	W	3	W	-------	W	W
California	3	W	-------	W	W	3	W	-------	W	W
Colorado	3	--------	W	W	W	2	--------	W	W	W
Idaho	3	W	-------	W	W	2	--------	-------	W	W
Mississippi	1	--------	W	--------	W	1	--------	W	---------	W
Missouri	6	--------	87	2,782	2,869	3	--------	W	W	2,390
Montana	1	--------	-------	12	12	2	--------	-------	11	11
Nevada	6	W	-------	W	1,224	4	W	-------	W	W
New Mexico	3	--------	-------	15	15	2	W	-------	W	W
Texas	6	--------	W	--------	W	6	--------	W	---------	W
Utah	6	W	-------	W	2,064	5	W	-------	W	1,912
Wyoming	4	W	-------	W	5,007	5	W	-------	W	4,136
Total	45	W	87	2,809	11,191	38	W	W	11	8,449
Undistributed	---	21,398	2,218	22,621	13,122	-----	20,152	2,622	29,412	15,110
Grand total	164	74,552	8,744	99,083	182,379	131	70,136	6,389	106,872	183,397

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

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	1966 Open pit	1966 Underground	1966 Total	1967 Open pit	1967 Underground	1967 Total
Lake Superior:						
Michigan	18,248	6,572	24,820	23,456	5,182	28,638
Minnesota	114,851	1,227	116,078	115,750	401	116,151
Total	133,099	7,799	140,898	139,206	5,583	144,789
Southeastern States:						
Alabama	3,390	778	4,168	2,638	1,036	3,674
Georgia	1,645	--------	1,645	1,046	--------	1,046
Total	5,035	778	5,813	3,684	1,036	4,720
Northeastern States:						
New Jersey, New York, Pennsylvania	W	W	11,355	W	W	10,329
Western States:						
Arizona	W	--------	W	W	--------	W
California	W	--------	W	W	--------	W
Colorado	163	--------	163	W	--------	W
Idaho	W	--------	W	W	--------	W
Mississippi	W	--------	W	W	--------	W
Missouri	264	2,605	2,869	W	W	2,390
Montana	12	--------	12	11	--------	11
Nevada	W	W	1,224	W	--------	W
New Mexico	15	--------	15	W	--------	W
Texas	W	--------	W	W	--------	W
Utah	2,064	--------	2,064	1,912	--------	1,912
Wyoming	4,265	742	5,007	W	W	4,136
Total	6,783	3,347	11,354	1,923	W	8,449
Undistributed	19,248	6,290	12,959	24,769	7,196	15,110
Grand total	164,165	18,214	182,379	169,582	13,815	183,397

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

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	1966			1967		
	Direct to consumers	To beneficiation plants	Total	Direct to consumers	To beneficiation plants	Total
Lake Superior:						
Michigan	4,272	21,048	25,320	3,011	25,692	28,703
Minnesota	12,863	103,794	116,657	11,149	104,583	115,732
Total	17,135	124,842	141,977	14,160	130,275	144,435
Southeastern States:						
Alabama	150	3,976	4,126	201	3,402	3,603
Georgia	------	1,645	1,645	--------	1,046	1,046
Total	150	5,621	5,771	201	4,448	4,649
Northeastern States:						
New Jersey, New York, Pennsylvania	------	11,382	11,382	--------	10,331	10,331
Western States:						
Arizona	W	---------	W	W	---------	W
California	W	W	W	W	W	W
Colorado	164	---------	164	W	---------	W
Idaho	11	---------	11	W	---------	W
Mississippi	------	W	W	--------	W	W
Missouri	------	2,804	2,804	------	2,443	2,443
Montana	12	---------	12	10	---------	10
Nevada	W	W	1,223	W	W	W
New Mexico	------	13	13	W	W	W
Texas	------	W	W	--------	W	W
Utah	1,413	716	2,129	W	W	1,888
Wyoming	58	4,968	5,026	W	W	4,153
Total	1,658	8,501	11,382	10	2,443	8,494
Undistributed	647	14,179	13,603	1,800	19,483	15,242
Grand total	19,590	164,525	184,115	16,171	166,980	183,151

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

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	1966				1967			
	Hematite	Brown ore	Magnetite	Total	Hematite	Brown ore	Magnetite	Total
Lake Superior:								
Michigan	W	-----	W	14,322	W	-----	W	14,072
Minnesota	31,909	772	21,599	54,280	27,924	58	22,175	50,157
Total	31,909	772	21,599	68,602	27,924	58	22,175	64,229
Southeastern States:								
Alabama	705	876	------	1,581	877	751	------	1,628
Georgia	------	447	------	447	------	261	------	261
Total	705	1,323	------	2,028	877	1,012	------	1,889
Northeastern States:								
New Jersey, New York, Pennsylvania, Virginia	------	-----	4,652	4,652	------	-----	4,197	4,197
Western States:								
Arizona	W	-----	W	W	W	-----	W	W
California	W	-----	W	W	W	-----	W	W
Colorado	------	W	W	163	------	W	W	W
Idaho	W	-----	W	W	W	W	W	W
Mississippi	------	W	------	W	------	W	------	W
Missouri	------	W	W	1,928	------	W	W	1,802
Montana	------	-----	12	12	------	-----	11	11
Nevada	W	-----	W	1,000	W	-----	W	W
New Mexico	------	-----	12	12	W	-----	W	W
Texas	------	W	------	W	------	W	------	W
Utah	W	-----	W	1,937	W	-----	W	1,708
Wyoming	W	-----	W	1,959	W	-----	W	1,837
Total	W	W	24	7,011	W	W	11	5,358
Undistributed	13,988	818	13,566	7,063	12,190	690	14,273	7,734
Total all States	46,602	2,913	39,841	89,356	40,991	1,760	40,656	83,407
Byproduct ore [1]	------	-----	------	791	------	-----	------	772
Grand total	46,602	2,913	39,841	90,147	40,991	1,760	40,656	84,179

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

[1] Cinder and sinter obtained from treating pyrites. Ore was treated in Arizona, Colorado, Delaware, 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	1966				1967			
	Direct shipping ore	Agglomerates	Concentrates	Iron content (natural percent)	Direct shipping ore	Agglomerates	Concentrates	Iron content (natural percent)
Lake Superior:								
Michigan	4,318	8,786	1,218	59	3,007	10,588	477	60
Minnesota	12,853	21,741	19,686	56	11,111	24,327	14,719	57
Total	17,171	30,527	20,904	57	14,118	34,915	15,196	58
Southeastern States:								
Alabama	192	------	1,389	36	273	------	1,355	40
Georgia	------	------	447	44	------	------	261	45
Total	192	------	1,836	38	273	------	1,616	41
Northeastern States:								
New Jersey, New York, Pennsylvaina, Virginia	------	4,099	553	63	------	W	W	W
Western States:								
Arizona	W	------	------	W	W	------	------	W
California	W	W	W	W	W	W	W	W
Colorado	163	------	------	66	W	------	------	W
Idaho	W	------	------	W	W	------	------	W
Mississippi	------	------	W	W	------	------	W	W
Missouri	------	1,733	195	66	------	1,791	11	68
Montana	12	------	------	45	11	------	------	45
Nevada	W	------	W	W	W	------	W	W
New Mexico	------	------	12	58	W	------	W	W
Texas	------	W	W	W	------	W	W	W
Utah	1,413	------	524	52	W	------	W	W
Wyoming	40	1,404	515	56	W	W	W	W
Total	1,628	[r] 3,137	[r] 1,246	59	11	1,791	11	68
Undistributed	584	[r] 2,321	[r] 5,158	59	1,796	7,632	6,047	59
Total all States	19,575	[r] 40,084	[r] 29,697	57	16,198	44,338	[2] 22,871	58
Byproduct ore [1]	------	791	------	68	------	772	------	68
Grand total	19,575	[r] 40,875	[r] 29,697	57	16,198	45,110	[2] 22,871	58

[r] Revised. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Cinder and sinter obtained from treating pyrites.

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

Table 8.—Shipments of usable iron ore from mines in the United States in 1967

(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				Total value
	Direct shipping ore	Agglomerates	Concentrates	Total quantity	Direct shipping ore	Agglomerates	Concentrates	Total quantity	
Lake Superior:									
Michigan	3,011	10,336	783	14,130	1,801	6,183	468	8,452	$162,610
Minnesota	11,149	23,884	14,424	49,457	6,387	13,683	8,264	28,334	468,623
Total	14,160	34,220	15,207	63,587	8,188	19,866	8,732	36,786	631,233
Southeastern States:									
Alabama	201	------	1,271	1,472	80	------	508	588	8,286
Georgia	------	------	267	267	------	------	120	120	1,450
Total	201	------	1,538	1,739	80	------	628	708	9,736
Northeastern States: New Jersey, New York, Pennsylvania, Virginia	------	3,551	350	3,901	------	2,273	224	2,497	54,410
Western States:									
Arizona	W	------	------	W	W	------	------	W	W
California	W	W	W	W	W	W	W	W	W
Colorado	W	------	------	W	W	------	------	W	W
Idaho	W	------	------	W	W	------	------	W	W
Mississippi	------	------	W	W	------	------	W	W	W
Missouri	------	1,800	71	1,871	------	1,224	48	1,272	26,673
Montana	10	------	------	10	5	------	------	5	81
Nevada	W	------	W	641	W	------	W	391	2,858
New Mexico	W	------	W	W	W	------	W	W	W
Texas	------	W	W	W	------	W	W	W	W
Utah	W	------	W	1,708	W	------	W	905	11,916
Wyoming	W	W	W	1,854	W	W	W	1,075	19,186
Total	10	1,800	71	6,084	5	1,224	48	3,648	60,714
Undistributed	1,801	4,121	5,385	7,104	1,009	2,437	3,171	4,246	61,418
Total all States	16,172	43,692	22,551	82,415	9,282	25,800	12,803	47,885	817,511
Byproduct ore [1]	------	601	------	601	------	407	------	407	7,016
Grand total	16,172	44,293	22,551	83,016	9,282	26,207	12,803	48,292	824,527

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

[1] Cinder and sinter obtained from treating pyrites. Ore treated in Arizona, Colorado, Delaware, Pennsylvania, Tennessee, and Virginia.

Table 9.—Iron ore produced in the 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 District	Total [1]
1854–1962	317,204	275,304	316,446	100,201	2,372,298	65,640	5,667	3,452,759
1963	5,706	3,729	1,314	774	43,570	515	524	56,132
1964	7,898	4,551	1,602	865	47,256	513	420	63,106
1965	8,973	4,595	810	782	50,280	367	625	66,432
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
Total [1]	359,601	296,591	320,334	103,528	2,613,767	69,375	8,066	3,771,261

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

Table 10.—Average analyses of total tonnage (bill-of-lading weights) of all grades of iron ore from all ranges of Lake Superior district

Year	Thousand long tons	Content, percent [1] Iron	Phosphorus	Silica	Manganese	Alumina	Moisture
1963	57,591	56.34	0.074	8.19	0.52	1.10	6.30
1964	64,222	56.67	.073	8.13	.45	1.09	6.17
1965	64,689	56.93	.067	8.14	.47	.97	6.05
1966	69,724	56.82	.068	7.99	.49	.64	6.20
1967	63,845	57.81	.060	7.63	.47	.57	5.69

[1] Iron on natural basis; phosphorus, silica, manganese, and alumina on dried basis.
Source: American Iron Ore Association.

Table 11.—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)
1962	46,942	69,969	67.1
1963	57,277	73,564	77.7
1964	64,329	84,300	76.3
1965	64,667	84,073	76.9
1966	70,451	90,041	78.2
1967	66,243	82,415	80.3

[1] Excludes byproduct ore.

Table 12.—Consumption of iron ore and agglomerates in the United States in 1967

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

State	Iron ore [1]		Agglomerates [2]		Miscellaneous [3]	Total
	Blast furnaces	Steel furnaces	Blast furnaces	Steel furnaces		
Alabama, Kentucky, Tennessee, Texas	6,771	132	4,242	W	134	11,280
California, Colorado, Utah	4,463	444	2,611	W	71	7,589
Maryland and West Virginia	3,262	361	7,981	W	W	11,605
Illinois and Indiana	15,060	842	11,906	W	W	27,808
Michigan and Minnesota	6,151	116	4,391	W	30	10,688
New York, Ohio, Pennsylvania, New Jersey	32,320	1,811	23,481	W	31	57,644
Undistributed	------	------	--------	611	199	809
Total [4]	68,028	3,707	54,613	611	466	127,424

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed".
[1] Includes 33,180,000 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 due to independent rounding.

Table 13.—Usable iron ore [1] consumed in agglomerating plants and agglomerate produced from this ore in 1967, by States

(Thousand long tons)

State	Iron ore [1] consumed	Agglomerate produced
Alabama, Kentucky, Texas	2,856	3,138
California, Colorado, Utah	2,214	2,602
Maryland and West Virginia	5,672	5,961
Illinois and Indiana	8,987	10,858
Michigan and Minnesota	1,521	2,540
New York, Ohio, Pennsylvania	15,175	18,530
Total [2]	36,426	43,629

[1] Does not include material used in aggolmerate produced at mine site.
[2] Data may not add to totals shown due to independent rounding.

Table 14.—Production of agglomerates [1] in the United States, by types

(Thousand long tons)

Type	Agglomerate produced	
	1966	1967
Sinter and nodules	r 48,400	[2] 45,995
Pellets	r 36,711	41,972
Total [3]	r 85,110	87,967

r Revised.
[1] Production at mines and consuming plants.
[2] Includes 17,233 thousand tons of self-fluxing sinter.
[3] Data may not add to totals shown due to independent rounding.

Table 15.—Stocks of usable iron ore at mines [1] Dec. 31, by districts

(Thousand long tons)

District	1966	1967
Lake Superior	r 7,802	8,404
Southeastern States	298	454
Northeastern States	r 3,063	3,359
Western States	r 997	913
Total	r 12,160	13,130

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 1967

(Per long ton)

District	Direct-shipping ore			Concentrates			Agglomerates
	Hematite	Brown ore	Magnetite	Hematite	Brown ore	Magnetite	
Lake Superior	$7.03	----	------	$7.67	W	-------	$12.14
Southeastern	W	------	------	W	$5.45	-------	-------
Northeastern	----	------	------	------	-------	$10.47	14.29
Western	5.87	$5.94	$6.66	6.84	11.02	7.28	11.75
Total	6.94	5.94	6.66	7.56	7.24	7.52	12.26

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	1965		1966		1967	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada	4,560	$54,399	3,911	$48,567	2,258	$29,069
Germany, West	92	553	62	382	43	270
Japan	2,431	25,425	3,778	42,876	3,639	42,179
Other countries	2	41	28	332	3	67
Total	7,085	80,418	7,779	92,157	5,943	71,585

Table 18.—U.S. imports for consumption of iron ore, by countries

(Thousand long tons and thousand dollars)

	1965		1966		1967	
	Quantity	Value	Quantity	Value	Quantity	Value
Algeria	51	$356	-------	-------	-------	-------
Australia	(1)	2	10	$101	1	$18
Brazil	2,279	23,380	2,723	26,695	1,640	14,905
Canada	23,756	264,360	23,941	273,309	24,214	276,597
Chile	2,660	23,253	2,268	19,810	1,365	11,286
Liberia	2,813	19,978	3,390	24,851	3,099	23,737
Mauritania	94	1,128	107	1,563	24	302
Mexico	10	43	(1)	1	-------	-------
Nigeria	12	171	-------	-------	-------	-------
Norway	-------	-------	41	369	436	2,217
Peru	957	10,350	1,043	11,281	879	9,404
Sweden	57	1,108	82	1,523	148	1,840
Venezuela	12,273	97,925	12,592	102,040	12,820	103,718
Other	141	1,734	62	811	1	55
Total	45,103	443,788	46,259	462,354	44,627	444,079

[1] Less than ½ unit.

Table 19.—U.S. imports for consumption of iron ore, by customs districts

(Thousand long tons and thousand dollars)

Customs district	1966		1967	
	Quantity	Value	Quantity	Value
Baltimore	9,794	$89,426	9,008	$84,192
Buffalo	2,735	35,050	2,460	32,842
Chicago	4,812	54,509	6,287	72,435
Cleveland	7,090	75,490	7,344	76,330
Detroit	2,121	29,959	1,693	24,590
Duluth	2	17	1	7
Galveston	------	-------	1	17
Houston	627	8,279	438	5,421
Mobile	4,274	37,419	4,056	34,947
New Orleans	494	5,394	612	5,412
Norfolk	425	4,004	236	2,170
Philadelphia	13,881	122,752	12,466	105,495
Savannah	------	-------	24	210
Seattle	1	10	1	9
Other	3	45	(1)	2
Total	46,259	462,354	44,627	444,079

[1] Less than ½ unit.

Table 20.—World production of iron ore, iron ore concentrates, and iron ore agglomerates, by countries [1]

(Thousand long tons)

Country	1963	1964	1965	1966	1967 [p]
North America:					
Canada	26,914	34,219	35,678	[r] 40,691	41,654
Guatemala [e]	6	7	8	8	9
Mexico (60 percent Fe equivalent)	2,291	2,284	2,613	2,271	2,653
United States [2]	73,599	84,836	87,439	90,147	84,179
South America:					
Argentina	98	93	114	152	220
Brazil	11,042	16,694	17,873	[r] 22,887	23,129
Chile	8,373	9,697	[r] 11,953	[r] 12,019	10,851
Colombia	684	[r] 699	695	652	795
Peru	6,516	6,425	6,992	7,664	7,538
Uruguay	1	2	[e] 2	---------	---------
Venezuela	11,562	15,409	17,234	17,479	16,854
Europe:					
Albania	255	345	[r] 389	[r] 404	NA
Austria	3,675	3,507	3,480	3,420	3,418
Belgium	94	60	90	122	[e] 90
Bulgaria	645	705	1,773	2,567	[e] 2,660
Czechoslovakia	3,357	2,801	[r] 2,407	[r] 2,202	[e] 1,970
Denmark	84	89	64	54	56
Finland	360	466	669	646	633
France	56,978	59,976	58,592	[r] 54,191	48,443
Germany:					
East	1,635	1,608	1,604	[r] 1,694	1,722
West	12,694	11,430	10,676	9,318	8,418
Greece	[r] 34	---------	[r] 6	15	17
Hungary	721	763	750	735	[e] 710
Italy	1,008	862	773	772	725
Luxembourg	6,880	6,575	6,215	6,425	[e] 6,275
Norway	1,967	2,089	2,425	2,322	3,181
Poland	2,568	2,638	2,817	3,006	[e] 3,075
Portugal	259	212	208	[r] 189	193
Rumania	2,250	1,901	2,440	2,639	2,752
Spain	5,111	5,026	[r] 5,601	4,989	5,005
Sweden	23,264	26,199	29,019	27,761	27,824
Switzerland	94	89	111	65	4
U.S.S.R.	[r] 135,304	[r] 143,285	151,009	[r] 157,740	165,347
United Kingdom	14,912	16,326	15,415	[r] 13,658	12,740
Yugoslavia	2,261	2,271	2,464	2,454	2,539
Africa:					
Algeria	1,945	2,696	3,083	[e] 1,670	[e] 1,970
Angola	628	885	802	779	[e] 810
Guinea, Republic of	652	894	743	[e] 1,575	---------
Liberia	7,401	12,794	15,707	16,593	17,936
Mauritania	1,652	5,000	6,185	7,044	[e] 7,870
Morocco	1,019	874	936	1,001	870
Rhodesia, Southern	645	811	[e] 1,340	NA	NA
Sierra Leone	1,882	1,962	2,110	2,268	2,065
South Africa, Republic of [3]	4,390	4,754	5,724	6,690	7,615
South-West Africa, Territory of	15	9	32	37	[e] 37
Sudan	-------	(4)	34	38	[e] 38
Swaziland	-------	59	1,004	1,566	1,715
Tunisia	851	924	1,099	1,248	904
United Arab Republic	481	440	499	435	[e] 490
Asia:					
China, mainland [e] [5]	34,400	36,400	38,400	39,400	27,600
Hong King	112	114	132	135	142
India [6]	19,679	[r] 21,026	23,286	25,920	25,744
Iran [7]	21	[e] 20	59	[e] 79	NA
Japan [8]	2,387	2,517	2,470	2,338	2,184
Korea:					
North	3,799	4,724	[e] 5,800	[e] 5,900	[e] 6,400
South	493	674	723	777	687
Malaysia	7,264	6,465	6,873	5,763	5,350
Philippines	1,363	1,345	1,415	1,443	1,482
Thailand	16	188	738	681	540
Turkey	735	961	1,506	1,594	1,462
Oceania:					
Australia	5,515	5,668	6,696	11,425	18,517
New Caledonia	294	302	275	217	201
Total [9]	[r] 515,135	[r] 572,094	[r] 607,269	[r] 627,974	618,308

[e] Estimate. [r] Revised. [p] Preliminary. NA Not available.
[1] Compiled mostly from data available May 1968.
[2] Includes byproduct ore.
[3] Includes byproduct magnetite as follows: 1963, 522; 1964, 845; 1965, 893; 1966, 878; and 1967, 860.
[4] Less than ½ unit.
[5] Roughly, containing 50 percent iron.
[6] Includes production from Goa as follows: 1963, 4,921; 1964, 5,956; 1965, 6,480; 1966, 6,431; and 1967, 7,086.
[7] Year ending March 20 of following year.
[8] Includes iron sand production; excludes byproduct ore.
[9] Total is of listed figures only; no undisclosed data included.

Table 21.—World trade of iron ore, iron-ore concentrates, and iron-ore agglomerates, in 1966 [1]

(Thousand long tons)

Exports by countries of origin	Fe Percent	Production	Exports	North America: Canada	North America: United States	South America: Argentina	Europe: Austria	Europe: Belgium-Luxembourg	Europe: Czechoslovakia	Europe: France	Europe: Germany, East	Europe: Germany, West	Europe: Hungary	Europe: Italy	Europe: Netherlands	Europe: Poland	Europe: Rumania	Europe: United Kingdom	Europe: Other Europe	Asia: Japan	Other Countries
North America:																					
Canada	55	40,691	30,694	---	24,282	---	---	84	---	62	---	[2]698	---	1,134	[2]523	---	---	2,221	---	1,690	---
Mexico	60	2,271	(3)	---	(3)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
United States	57	[4]90,147	8,712	4,380	---	---	---	28	---	---	---	69	---	---	1	---	---	---	---	4,232	2
South America:																					
Brazil	67	22,887	12,706	385	2,977	783	311	430	389	[2]705	---	2,929	---	759	98	275	---	721	[2]134	1,810	---
Chile	64	12,019	10,913	---	2,395	104	---	102	---	---	---	563	---	---	---	---	---	---	---	7,749	---
Colombia	43	652	NA	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Peru	63	7,664	6,208	---	693	---	---	---	---	301	---	423	---	258	---	---	---	---	---	4,533	---
Venezuela	62	17,479	16,768	17	12,908	---	---	35	---	---	---	[2]1,581	---	862	[2]86	---	---	1,279	---	---	---
Europe:																					
Austria	31	3,420	(3)	---	---	---	---	(3)	---	---	---	---	---	---	---	---	---	---	---	---	---
Belgium-Luxembourg	30	6,547	22	---	---	---	---	---	---	21	---	1	---	---	---	---	---	---	---	---	---
Bulgaria	62	2,567	NA	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Finland	66	646	209	---	---	---	---	---	29	---	---	77	---	---	13	87	---	---	3	---	---
France	31	54,191	17,907	---	---	---	---	13,162	---	---	---	4,683	---	---	---	---	---	62	---	---	---
Germany, West	27	9,318	296	---	---	---	279	4	---	7	---	---	---	---	2	---	---	1	3	---	---
Greece	49	15	32	---	---	---	---	---	---	---	---	25	---	---	7	---	---	---	---	---	---
Italy	50	772	19	---	---	---	---	---	---	18	---	---	---	---	---	---	---	---	1	---	---
Norway	65	2,322	1,481	---	38	---	---	2	---	---	---	570	---	---	3	96	---	463	309	---	(3)
Poland	34	3,006	19	---	---	---	---	---	---	---	---	---	---	---	---	---	---	19	---	---	---
Portugal	50	189	(3)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	(3)	---	---
Spain	50	4,989	1,014	---	---	---	---	1	---	40	---	632	---	36	29	---	---	265	4	---	7
Sweden	61	27,761	22,188	---	78	---	---	5,205	204	410	56	9,114	---	490	365	676	---	5,073	479	---	38
Switzerland	36	65	31	---	---	---	---	---	---	---	---	31	---	---	---	---	---	---	---	---	---
U.S.S.R.	60	157,740	25,705	---	---	---	349	---	7,541	---	2,553	524	2,531	---	---	7,726	2,390	941	894	[2]193	63
United Kingdom	28	13,658	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Yugoslavia	43	2,454	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Other East Europe	---	7,674	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Africa:																					
Algeria	54	[e]1,670	[2]1,581	---	---	---	---	---	---	---	---	[2]44	---	561	[2]19	[2]20	---	[2]612	[2]325	---	---
Angola	63	779	617	---	---	---	---	15	---	[2]20	---	302	---	---	---	---	---	---	10	270	---
Guinea, Republic of	51	[e]1,575	618	---	---	---	133	---	86	---	108	---	---	---	---	237	---	43	9	---	2

Table 21.—World trade of iron ore, iron-ore concentrates, and iron-ore agglomerates, in 1966 [1]—Continued
(Thousand long tons)

Exports by countries of origin	Fe Percent	Production	Exports	Exports by countries of destination: North America: Canada	North America: United States	South America: Argentina	Europe: Austria	Europe: Belgium-Luxembourg	Europe: Czechoslovakia	Europe: France	Europe: Germany, East	Europe: Germany, West	Europe: Hungary	Europe: Italy	Europe: Netherlands	Europe: Poland	Europe: Rumania	Europe: United Kingdom	Europe: Other Europe	Asia: Japan	Other Countries
Liberia	65	16,593	16,556	---	3,246	---	---	946	---	979	---	[2] 6,152	---	1,648	1,122	---	---	1,604	539	320	---
Mauritania	64	7,044	7,022	---	118	---	---	761	---	1,432	---	1,195	---	1,284	386	15	---	1,571	98	162	---
Morocco	58	1,001	777	---	---	---	---	---	134	54	---	159	---	---	---	---	---	215	207	---	8
Sierra Leone	64	2,268	2,183	---	---	---	---	---	---	7	---	612	---	335	919	---	---	310	---	---	---
South Africa, Republic of	62	6,690	3,040	---	---	---	---	---	---	63	---	---	---	---	82	---	---	---	---	2,895	---
Sudan	60	38	47	---	9	---	---	---	---	---	---	---	---	---	---	---	---	---	38	---	---
Tunisia	55	1,248	862	---	---	---	---	---	31	31	---	30	---	297	13	52	---	209	199	---	---
United Arab Republic	50	435	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Asia:																					
China, mainland	50	e 39,400	[2] 328	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	[2] 320	8
Hong Kong	56	135	312	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	312	---
India, including Goa	61	25,920	13,442	---	---	---	---	157	741	51	30	639	95	23	---	207	417	---	330	10,752	---
Japan	55	2,338	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Korea:																					
North	37	e 5,900	449	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	[2] 449	---
South	50	777	631	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	631	---
Malaysia	56	5,763	5,681	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	5,607	74
Philippines	58	1,443	[2] 1,575	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	[2] 1,575	---
Turkey	54	1,594	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Oceania:																					
Australia	65	11,425	1,964	---	---	---	---	87	---	---	---	---	---	42	26	---	---	---	---	1,775	34
New Caledonia	55	217	198	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	198
Other countries	---	2,577	NA	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Total	---	e 627,974	212,807	4,782	46,744	887	1,072	21,019	9,155	4,201	2,747	31,053	2,626	7,729	3,694	9,391	2,807	15,609	3,582	45,275	434

e Estimate. NA Not available.
[1] Compiled from data available May 1968.
[2] Import detail of customs returns of the respective country.
[3] Less than ½ unit.
[4] Includes byproduct ore.

Iron and Steel

By John W. Thatcher [1]

For the United States iron and steel industry, 1967 was a year of lowered demand, production, and shipments for both pig iron and steel. Raw steel production reached 127.2 million tons, 6.9 million tons below the record 1966 figure; shipments totaled 84 million tons compared with 90 million in 1966. Lagging shipments to the automobile industry and the steel haulers' strike affected domestic shipments, along with inroads made by foreign producers.

In the face of increasing competition from abroad, steel companies made impressive progress in their efforts to improve technology and increase efficiency. Basic oxygen steel production increased 22 percent, electric furnace production was higher, and planned capacity for continuous casting gave promise of higher production yields in the near future.

Table 1.—Salient iron and steel statistics
(Thousand short tons)

	1963	1964	1965	1966	1967
United States:					
Pig iron:					
Production	71,840	85,458	88,207	91,287	86,799
Shipments	72,211	85,693	88,391	90,884	86,819
Exports	70	176	28	12	7
Imports for consumption	645	736	882	1,187	605
Steel:[1]					
Production of ingots and castings (all grades):					
Carbon	98,714	114,442	116,651	118,732	113,190
Stainless	1,204	1,443	1,493	1,651	1,451
All other alloy	9,343	11,191	13,318	13,718	12,572
Total	109,261	127,076	131,462	134,101	127,213
Index (1957–61) = 100	111.8	130.0	134.5	137.2	130.1
Total shipments of steel mill products	75,555	84,945	92,666	89,995	83,897
Exports of major iron and steel products	2,670	4,065	2,888	2,144	2,079
Imports of major iron and steel products [2]	5,637	6,630	10,640	11,043	11,446
World production:					
Pig iron [3]	310,000	350,000	369,000	382,000	391,000
Steel ingots and castings	427,000	483,000	506,000	525,000	543,000

NA Not available.
[1] American Iron and Steel Institute.
[2] Data not comparable for all years.
[3] Includes ferroalloys.

Trends and Developments.—The domestic steel industry spent $2.4 billion for capital improvements in 1967, a 10 percent increase over that of 1966. The outlook for 1968 is for an even larger expenditure. Capital expenditures for new plants and facilities have totaled about $14 billion during the last 10 years and are estimated at $9 billion for the next 4 years.

Emphasis of modernization programs was placed on rolling and finishing facilities, and on a more diversified product spectrum. The finishing side of the steel mill, and new products such as steel foil, weathering steels, and tinfree steels are critical areas in the domestic industry and are given priority in order to meet the

[1] Commodity specialist, Division of Mineral Studies.

increasing demand for better quality steels and to meet the challenge of alternate materials. The construction and modernization of primary production facilities proceeded throughout the industry, primarily to meet the need for greater efficiency.

United States Steel Corp. spent $575 million in 1967 (up 30 percent over that for 1966) for replacement, modernization, and extension of facilities. New authorizations during 1967 totaled $775 million. At the end of the year the amount required to complete all authorized projects was $1,150 million, an alltime high level. Nearing completion at the South Works, Chicago, Ill., were three basic oxygen furnaces and a 32-foot hearth blast furnace. A large continuous slab casting unit began its break-in at Gary, Ind., in conjunction with the startup of a computer-controlled 84-inch hot strip mill, a 52-inch cold reduction mill, and a high-speed tinning line. U.S. Steel moved ahead with construction of its plate mill complex at Baytown, Tex., as well as the cold-rolling facilities at Irvin, Tex., and the four strand unit for continuous casting of blooms and billets at Torrence, Calif. Improvements were also affected at plants in Lorain, Ohio, Joliet, Ill., and Fairless Hills, Pa. A major program was announced to increase the silicon sheet steel production by 30 percent at the Vandergrift, Pa., plant. At yearend, U.S. Steel announced plans to phase out its production of cold finished bar products at Newburgh, Ohio, by mid-1968.

Bethlehem Steel Corp. announced details of Phase II plans for its 5-year expansion project at Burns Harbor, Ind. Initial output of 1.5 million tons will be provided by two 250-ton oxygen converters drawing hot metal from a 35-foot hearth blast furnace—largest in the U.S. industry. Ultimate capacity of the plant will be 5 million tons a year. Phase I was the initial building program by which Bethlehem made its debut as a Midwest steel producer. Completion of Phase II in 1970 will mark Bethlehem expanding to become a fully integrated steel producer at Burns Harbor, complete with hot metal facilities and a harbor through which raw materials can be furnished. Estimated cost of Phase I and II is $900 million. Total capital expenditures in 1967 were $353 million. Expansion programs proceeded at all other major plants including rolling and finishing facilities at Sparrows Point, Md., Bethlehem, Pa., and Lackawanna, N.Y. Bethlehem announced at midyear it had ordered its first production continuous casting machine, which will be installed at the Johnstown, Pa., plant. Additionally, two basic oxygen furnaces, to be installed at the Bethlehem Pa., plant, will bring to a total of seven such furnaces operated by the firm.

Capital expenditures for Republic Steel Corp. totaled $162 million in 1967, the largest part of which was allocated to its Cleveland, Ohio, works for installation of a 84-inch hot strip mill and related cold mill facilities, for blast furnace rebuilding, for a water pollution abatement program, and for other improvements. Construction at the Canton, Ohio, plant of four 200-ton electric furnaces, two continuous casting units, and new vacuum melting and vacuum degassing facilities will double Republic's capacity to produce high-strength alloy steel. Other improvements underway during the year included blast furnace relines at Buffalo, N.Y., and Gadsden, Ala.; billet and skelp mill modernization at Youngstown, Ohio; rebuilding the bar mill complex at Buffalo, N.Y.; and start of construction of a 14-inch bar mill at Chicago, Ill. A new plate mill which went onstream at Gadsden, Ala., in 1967 put Republic in a good position relative to the booming southern market for plate.

Armco Steel Corporation's major project at Middleton, Ohio, which involves building a new steel mill alongside of an old one, moved toward the target completion date of mid-1968. An 80-inch hot strip mill, part of a 3,300-foot hot rolling complex, is the key facility. Raw steel production will be boosted by the installation of two 200-ton oxygen converters. Construction of electric furnaces proceeded at Butler, Pa., Kansas City, Mo., Sand Springs, Okla., and Houston, Tex. Vacuum degassing and continuous casting were being installed at Butler, Pa., and cold mill facilities were completed at Ashland, Ky., during the year.

National Steel Corp. contracted to buy 3,300 acres near Pittsburg, Calif. The firm declined to comment on plans for development of the property, which has access to the Pacific Ocean through a 50-mile-long, 30-foot-deep channel. National specializes in the types of light, flat-rolled and coated sheets that are widely consumed in the Pacific coast market. Work continued on the electric furnace-continuous casting billet complex at National's Great Lakes Steel Div., Detroit, Mich., and planning was started for a second BOF at the plant. The firm's Weirton Steel Division, Weirton, W. Va., reported smooth operation of its new 300-ton oxygen converters and was nearing break-in on the vacuum degrassing and continuous casting units.

Youngstown Sheet & Tube Co. progressed in construction of an 84-inch hot strip mill and conversion of a blooming mill to a universal mill at its Indiana Harbor Works, East Chicago, Ind. In addition, a 32-foot hearth blast furnace was completed and two 260-ton oxygen converters were being constructed. Completion of the project will further integrate the plant toward the flat roll market.

Jones & Laughlin Steel Corp., the nation's fifth largest steelmaker, continued construction of the Chicago area's newest steel mill at Hennepin, Ill. As with other new mills, the Hennepin plant will integrate backwards starting with the finishing mills. A completed 84-inch cold rolling mill and continuous galvanizing line are supplied with semifinished steel from the Cleveland Works. Installation of oxygen converters and continuous casting at Aliquippa, Pa., and improvements at Hammond, Ind., and Cleveland, Ohio, are also part of a 3-year, $400 million, expansion program.

PRODUCTION AND SHIPMENTS OF PIG IRON

Responding to a lessened demand from the steel and foundry industries, pig iron production and shipments dropped 5 and 4.5 percent, respectively, from the record highs of 1966. Although Pennsylvania and Ohio continued to lead in pig iron production, these two States showed a decrease in production and shipments while Indiana, the Nation's third leading producer, showed a slight gain.

According to the American Iron and Steel Institute (AISI), there were 233 pig iron blast furnaces on January 1, 1968, two fewer than on the same day in 1967. Of these, 168 were in blast, an increase of 10. The average production per blast furnace day rose to 1,570 tons. This was a 5-percent increase over that of 1966 and was a significant indication of industry efforts to increase blast furnace efficiency.

Metalliferous Materials Consumed in Blast Furnaces.—The agglomerate charge consisted of 34.7 million tons of sinter, 16.7 million tons of self fluxing sinter, 36.9 million tons of pellets, 9.7 million tons of foreign agglomerates. No nodule consumption was reported.

According to AISI, blast furnace consumption of oxygen decreased from 9 billion cubic feet in 1966 to 8.7 billion in 1967. Data collected by the Bureau of Mines showed that 39.9 billion cubic feet of natural gas, 4.5 billion cubic feet of coke-oven gas, and 68.5 million gallons of oil were consumed by blast furnaces in 1967.

CONSUMPTION OF PIG IRON

Consumption of pig iron decreased 4.8 percent, almost equal to the 5.1-percent decrease in steel production. All districts in the United States showed decreases in consumption except the East South Central, which showed a slight increase. Plants in the Middle Atlantic and East North Central districts consumed about 77 percent of the total.

PRICES

Pig iron and steel prices increased slightly during 1967. The average composite pig iron price, published by Iron Age, was $56.38 per short ton, compared with $56.34 in 1966. The Iron Age figure for the composite price of finished steel was 6.496 cents per pound, compared with 6.445 cents per pound in 1966.

FOREIGN TRADE

Exports of steel products decreased 3 percent in 1967, continuing the downward trend begun in 1965. Exports of sheet and strip increased while exports of ingots and tin mill products decreased. Pig iron exports continued to drop sharply; tonnage in 1967 was 4 percent of that for 1964.

Imports of steel products increased 4 percent in 1967, establishing a record high and prompting the introduction of several import quota bills in Congress. Sheets and strip, steel plate, wire rod, and pipe led the list of products in terms of volume. Combined imports from the European Economic Community increased substantially while imports from Japan decreased; these supply sources accounted for 42 percent and 39 percent of the total, respectively. Imports of pig iron dropped 50 percent as no imports were received from Communist countries or from the Republic of South Africa.

The sixth tariff negotiating conference sponsored by the General Agreement on Tariffs and Trade (GATT), known as the "Kennedy Round," terminated on June 30, 1967, after 3 years of deliberations. The Kennedy Round will result in a five-stage reduction of U.S. steel tariffs from a weighted average of 7.44 percent in 1966 to 6.5 percent in 1972. Other major countries reduced their tariffs on steel generally by more than the United States, with the result that steel tariffs are now more closely harmonized among major countries.

WORLD REVIEW

World production of pig iron (including ferroalloys) and steel established a record in 1967, as the decrease in U.S. production was outweighed by production increases in Japan, Italy, and the U.S.S.R.

Formation during the year of the International Iron and Steel Institute offered hope that there will be greater understanding among the producing nations of the complexities and problems facing the world steel industry.

NORTH AMERICA

Canada.—Hawker Siddeley Canada Ltd. announced on October 13 that its Dominion Steel and Coal Corp. (Dosco) blast furnace and open hearth facilities at Sydney, Nova Scotia, would be closed on April 30, 1968. Reasons given for closing the 70-year-old plant were depletion of local iron ore deposits, outdated equipment, poor location relative to markets, and increasing competition resulting from excess steel capacity throughout the world. Operating losses were reported to be $4.3 million in 1966 and $6.4 million for the first half of 1967.

In December, the Nova Scotia House of Assembly approved a purchase agreement between the company and Provincial officials by which Dosco was to operate the plant as Provincial agents from January 1, 1968, until April 30, 1968. Thereafter a crown corporation will operate the plant until April 30, 1969, or until a buyer is found. Purchase price was reported to be about $23 million.

Canada's first research facility devoted to applied research in the field of iron and steel manufacturing technology was opened in June by the Steel Company of Canada Ltd. (Stelco). Research activities to be carried out at the $4 million center will be designed to develop improved steel products, to increase productivity by the development of new and improved manufacturing processes, and to utilize Stelco's waste materials by development of methods to transform them into profitable byproducts.

Dominion Foundries and Steel Ltd. (DOFASCO) put in operation in June a new $25 million automated five-stand cold reduction mill.

Canada Petrofina, a subsidiary of the Belgium Petrofina organization, announced plans to build an iron powder plant near its Montreal refinery in partnership with Consolidated Quebec Smelting and Refining.

Mexico.—Each of the four top producers in Mexico plan to double capacity by 1970; however, the country will probably remain a net importer of steel for the foreseeable future.

Hojalata y Lamina, S.A. (HyL), announced plans to construct an integrated steel plant near Pueblo which will produce

250,000 tons of steel products per year in the form of billets, bars, shapes, and wire. Plant design includes a direct reduction facility of the HyL type, three electric furnaces, two 4-strand continuous casting machines, and a continuous light-section and wire-rod mill.

Altos Hornos de Mexico, S.A., began operating its third blast furnace in November 1966, increasing the ingot capacity of the Monclova works to more than 1.5 million tons. Other elements of the expansion program include a basic oxygen steel plant, raw material crushing plants, blooming mill, coke oven plant, and a 150-ton-per-day oxygen plant—all of which will increase capacity to over 2 million tons and will broaden the company's product mix.

Cía. Fundidora de Fierro y Acero Monterrey, S.A., completed the installation of its third blast furnace and had underway the installation of a 56-inch, 4-stand, tandem cold mill. Capacity is expected to reach 1 million tons by 1969.

Tubos de Acero de Mexico, S.A., opened a HyL sponge-iron facility at its Vera Cruz plant, thus replacing most of the company's scrap needs.

SOUTH AMERICA

Argentina.—Argentina, like other Latin American steel producers, was involved in an ambitious program to boost tonnage. The Government target for raw steel products by 1972 is 4.5 million tons, a threefold increase over 1967 production.

The Government authorized Sociedad Mixta Siderúrgica Argentina (SOMISA), the State-owned steel company, to proceed with expansion plans to increase capacity from 1.2 million tons of steel ingots to 2.2 million tons by 1974. In a decree published August 22, Argentine official banks and entities were empowered to give SOMISA the guarantees for foreign borrowing required to finance the expansion. The first phase, to be in operation by 1971, will involve a new sinter plant and improvements to rolling mills. The second phase will include a basic oxygen furnace (BOF) shop and a continuous casting line and is scheduled for completion in 1972. The third phase is to be completed by 1973, and designates construction of a coking plant and second blast furnace. Cost of the entire project is estimated at $195 million.

The Argentine Government approved several modifications to the program originally approved in 1965 for the construction of a new integrated steel plant by Propulsora Siderúrgica S.A. at Ensenada. Decree 1296/67 obligates Propulsora to place the hot rolling mill in operation during 1972 and the blast furnaces and steel plant in operation during 1974. However, these dates may be advanced or delayed, depending on market demands. The first stage of the project calls for an investment of $60 million, 50 percent of which will come from equity financing and 50 percent from private interests. The equity financing will come from Italy and the remainder will be negotiated with private interests in Italy, the United Kingdom, and Japan. According to trade sources, Propulsora is guaranteed raw materials at about world prices, which when sold locally should generate profits for the financing necessary for the second and third stages.

Brazil.—Expansion plans of the Brazilian steel industry were revealed in January in a report prepared by Booz Allen & Hamilton International for the National Bank of Economic Development. It was based on the findings of a committee of Brazilian Ministers, representatives of the steel industry, and officials from the World Bank and International Monetary Fund. The report recommended that the main expansion to 7.5 million tons annually by 1972 should take place in the three large Government-controlled integrated works, Campanhia Siderúrgica Nacional (CSN), Usinas Siderúrgicas de Minas Gerais (USIMINAS), and Cia Siderúrgica Paulesta (COSIPA). It also suggested that new plants producing light-rolled products be installed at Recife and Corumba to meet regional needs. The report further recommended that annual production be raised to 9.6 million tons by 1975. The investment necessary was estimated at $603 million.

The three major steel producers, CSN, USIMINAS, and COSIPA reached an agreement in September in which they subscribed to a policy for the unification of sales, prices, and marketing methods.

Chile.—The Export-Import Bank announced in March it had authorized a $25 million Alliance for Progress loan to

Compañía de Acero del Pacífico S.A (CAP) to help expand its steel production from 650,000 tons to 1 million tons annually. The total cost will be about $130 million and will include new finishing mills, an electrolytic tinning line, two oxygen converters, an oxygen plant, and ancillary equipment. Additional financing needed will be made available from CAP's corporate resources, Chilean financial institutions, and a loan from European sources.

Colombia.—By Resolution No. 370 the Superintendency of Economic Regulation on December 26 freed semifinished and finished iron and steel products of domestic manufacture from price control. Two days after the price control removal, Acerías Paz del Rio S.A., the country's largest and only integrated steel mill, raised its prices by an average of 25 percent. The price increase will result in increased profits for 1968 and thereby improve the position of the company to receive international credits for development programs.

The first stage expansion plan of Acerías Paz del Rio is scheduled for completion in 1968 while the second stage awaited financing.

Peru.—The Peruvian Government signed a decree on September 29 approving the contract between Corporacion Peruana del Santa and the member companies of the Italian-French Consortium, CONSIDER-ENSID, for the construction of a $67 million rolling mill at the Chimbote steel plant. A new blast furnace was reported to be in operation in October at the plant and two oxygen converters and a continuous casting line were reported to be in the planning stage or under construction.

EUROPE

European Coal and Steel Community (ECSC).—Raw steel production for ECSC countries totaled 99 million tons in 1967, a 6-percent increase over that of 1966, due mainly to an 18-percent increase in exports to third countries. Exports to the United States increased 38 percent and exceeded those from Japan. Internal consumption showed no marked increase, although there were considerable variations from one ECSC country to another. In the first half of the year prices tended to stabilize; however, in the second half prices declined, as production exceeded consumption.

The ECSC forecasted a capacity of 132 million tons by 1970, due mainly to increased facilities for oxygen steelmaking. Emphasis over the next few years will be on modernization, including reorganization, replacement of obsolete plants, and, in some cases, closures. Mergers of August Thyssen-Hutte and Huttenwerk Oberhaussen in West Germany, and de Wendel, Sidelor, and Société Mosellane de Sidérurgie in France are indicative of the trend toward large production groups.

Italian steel production in 1967, 17.5 million tons, showed the largest percentage increase of any country in the Community. Despite higher production, consumption outstripped steel output and Italy remained a net importer of steel in 1967. During the year, Italy added 1 million tons of capacity and showed signs of threatening France for the second spot in the Community.

It was announced that the U.S.S.R. will build a 48-inch diameter pipeline from the Ukraine to Italy (a distance of 1,860 miles) for gas transmission; the pipeline will require about 1.7 million tons of pipe.

Italsider S.P.A ordered a second real-time computer system for its plant at Cornigliano, Italy. The new unit will be used for production control, order acceptance programing, control of shipments, inventory, raw materials, work in progress, and finished products. The first unit was installed in 1963.

Austria.—VOEST Steel Manufacturing Company began assembly in April of two oxygen converters which are to be installed at the Taiyun Works, 300 miles from Peking, mainland China, sometime in 1968. Reports of capacity range from 600,000 tons of steel to 1.5 million tons annually.

Bulgaria.—When present expansion plans are completed, Bulgaria will have an annual steelmaking capacity of 4.5 million tons and will be able to supply 65 percent of domestic demand for rolled products.

The U.S.S.R. was reported to have signed an agreement with Bulgaria to expand the capacity of the Kremikovtsi steel plant from 1 million to 1.5 million tons of rolled steel. The U.S.S.R. is to provide technical assistance and equipment including a blast furnace, a coking plant, and an electric furnace. Other facilities under construction include a 100-ton oxygen converter, hot strip mills, a finishing mill, and a ferroalloy shop.

Czechoslovakia.—Expansion of steelworks continued in 1967 with considerable assistance from the U.S.S.R. At the East Slovakia Ironworks, Kosice, the No. 2 blast furnace was due to be blown in at yearend. The No. 2 BOF shop, which will contain two 130-ton vessels, was under construction during the year.

At Kladno, in Western Bohemia, the United Steel Works is replacing obsolete facilities with a new plant designed to produce 1 million tons of high-grade steel yearly. Major equipment will be two electric furnaces, two oxygen converters, two continuous casting installations, and a vacuum degassing plant.

Finland.—The second phase of expansion of the state-controlled steel company, Rautaruukki Oy, was officially inaugurated at the company's main plant at Raahe on October 21. New facilities include two oxygen converters, three continuous slab casting machines, and auxiliary equipment—all obtained from the U.S.S.R. The new plate mill was purchased from a British concern.

Greece.—The integrated Greek steel company, Halyvourgiki S.A., reportedly will spend $20 million to expand its production range to include coils, plates for shipbuilding, and shapes so as to fully utilize the blast furnaces. Part of the additional plant will be finished in 1968 and the rest in 1969 with initial output set at 500,000 tons.

Hungary.—Reports from Budapest indicate that a new iron foundry will be built in northern Hungary which will start production in 1972. The plant will employ 4,000 workers and will produce 110,000 tons of castings per year.

A new electric steel plant was under construction at the Diosgyor Works, with an annual capacity of 75,000 tons. A 50-ton furnace will be supplied by the U.S.S.R

Poland.—The largest continuous billet casting unit in Europe began operating at the Huta Zawierce steel plant in Kratowice province in January. The new installation, designed and constructed by Polish engineers, is the third of its type in Poland and has an annual productive capacity of 280,000 tons.

The U.S. Treasury Department published in the Federal Register on November 2, 1967, its formal finding of dumping with respect to cast iron soil pipe imported from Poland.

Sweden.—Although raw steel production stagnated in 1967, expansion of productive capacity continued at a pace to keep Sweden among the world leaders in use of modern equipment.

As a result of an expansion program announced in March, the Grängesberg Co.'s, Oxelösund iron and steel works will become one of Europe's largest producers of heavy and medium plate. The company stated it will install two additional Kaldo converters and a two-strand continuous slab casting machine, which with ancillary equipment, will raise raw steel capacity to over 1 million tons per year and plate production to 600,000 tons per year.

Grängesberg also announced it will expand its cold rolled stainless steel sheet capacity at the Nyby works from 17,000 tons per year to 40,000 tons by 1969.

The Höganäs Company, one of the world's leading producers of sponge iron and iron powder, will construct an atomization plant at Höganäs with an annual capacity of 40,000 tons of iron powder.

United Kingdom.—The second largest steel company in the free world was brought into existence with the nationalizing of the British steel industry on July 28, 1967. The new entity, the British Steel Corporation, has an ingot capacity of 30 million net tons, second only to the United States Steel Corporation. The company is made up of the 14 largest raw steel producers in Great Britain, who represent 94 percent of the steelmaking capacity. The involved companies control 145 subsidiaries as well as 47 foreign affiliates. The remaining 210 companies in the private sector are non-integrated producers of specialty steels. The nationalization cutoff point was 475,000 tons of raw steel capacity. For the purpose of operations and sales, the 14 companies were divided on a geographic basis into the following four regional divisions: Midland, Northern, Scottish and Northwest, and South Wales.

U.S.S.R.—The Karaganda Iron and Steel Works, Kazakhstan, will install two more blast furnaces, reportedly the world's largest when put into operation. An oxygen converter shop, plate mill, and continuous sheet mill will also be constructed. The works will specialize in autobody sheets and will form the third steel center being set up in the eastern regions.

AFRICA

Algeria.—Construction of Algeria's first integrated iron and steel works was underway in 1967. The ironmaking facility will be supplied by France, the melting shop by the U.S.S.R., and a hot strip mill by two Italian companies, Innocenti and Marelli. Ironmaking is scheduled to start late in 1968, steelmaking toward the end of 1969, and rolling mill production in early 1971. Ultimate annual capacity of the strip mill is expected to be 150,000 tons of plates and 800,000 tons of sheet and light plate in coil. Pipemaking capacity will be 100, 000 tons annually.

A decree published in Algiers on May 6 brought the importation of iron, steel, and other metals under national control. Société Nationale de Sidérurgie, the state-run national iron and steel company will now have a monopoly on the import of these products, which account for 5 to 10 percent of total imports in tonnage and value. With state control of imports, Algeria can make the placing of orders conditional on the exporting country taking Algerian iron ore.

ASIA

Japan.—Unlike most major steelmaking nations, who have been emphazing programs to modernize existing facilities, Japan has been emphasizing investments in new facilities to meet the booming domestic market for steel products. New blast furnaces and oxygen converters installed in 1966 and 1967 resulted in a remarkable 30-percent increase in raw steel production in 1967, and a consolidation of Japan's position as the third largest steelmaking country in the world. Expansion underway in 1967 will boost Japanese capacity past 90 million tons by 1972. With domestic consumption estimated at 72 million tons, a substantial amount will continue to be available for export.

Production expansion in 1967 involved new coastal steelmaking complexes, each with production capabilities of 8 to 10 million tons. Yawata Iron & Steel Co., Ltd., embarked on a long term program to expand its Kimitsu works and convert it to integrated production. Sumitomo Metals has under construction an integrated tidewater steel-works at Kashima, north of Tokyo.

TECHNOLOGY

The basic oxygen steelmaking process, which just 10 years ago accounted for only 1.3 million tons of steel production, produced 41.5 million tons or about one-third of the total U.S. output in 1967. It represented a 22.2-percent increase over 1966 production while total raw steel output dropped 5 percent. Capacity in the United States was estimated at 43 million tons at the end of 1967 and is expected to increase to 65 million tons by 1970.[2]

In 1967 Japan produced 65 percent of total raw steel by the basic oxygen process, West Germany 30 percent, and the U.S.S.R. 6 percent. Installed world capacity at the end of 1967 was 165 million tons. This is expected to increase to about 260 million tons by 1970.[3]

Design parameters and operating data for 11 U.S. oxygen converter vessels and 10 foreign vessels were discussed and analyzed. Heat size ranged from 130 tons to 335 tons; that is, from high-carbon, alloy, or phosphoric double-slag practice at the lower extreme to very fast operating practice for low-carbon steels at the upper extreme. Annual capacity, bath depth, freeboard, shell diameter, height, inside volume, and various ratios were plotted against heat size and lines of regression were determined for all relationships by

[2] Stone, J. K. L–D Steelmaking At Mid-1967. J. of Metals, v. 19, No. 7, July 1967, pp. 10–11, 36.

[3] Metal Bulletin (London). L–D's Inexorable Growth. No. 5240, Oct. 17, 1967, pp. 15, 18–21.
Stone, J. K. World Distribution of L–D Basic Oxygen Steel Plants. 33/The Magazine of Metals Producing, v. 5, No. 10, October 1967, pp. 116–124.

the least-squares method. From the lines of regression an optimum configuration was determined for a 200-ton-capacity basic oxygen converter.[4]

Steelmaking by the open hearth process has declined from the 1956 peak of 103 million tons (90 percent of total production) to about 70.7 million tons (55 percent of total production) in 1967. A further decline to about 50 million tons by 1969 and to 25 million tons by 1972 is predicted. Phase-out of this process, which has been the work horse of the industry for more than 20 years, is expected sometime between 1980 and 1990.

Although the open hearth as a steel producer lost ground to the basic oxygen process, it still remained the major source of this metal in 1967, and considerable effort went into raising the efficiency of the furnace. Improvements were made in charging, in intense-firing burners for decreasing time of melting, furnace refractories, continuous carbon analysis, and control of fume from the operations.

Another significant, although not spectacular, development in U.S. steelmaking has been the steady increase in electric arc melting capacity and its wide application for the production of carbon steel. In contrast to the earlier applications of the electric arc process which involved small furnaces used almost exclusively for alloy and stainless steels, furnaces, comparable in size to the BOF and the open hearth, are now available that produce large tonnages of ordinary carbon steel. At yearend there were over 200 electric arc furnaces operational in the United States, seven of which were in the 200-ton capacity class. Annual capacity was estimated at 20 million tons, which will be increased to about 30 million tons when the 45 to 50 new furnaces under construction at yearend are completed. Most industry experts expect an accelerated growth rate in the near future with electric furnace steel production about equaling BOF production in the 1990's.

With the phase-out of open hearth furnaces and the steady rise in steel consumption, electric furnace operators are assured of an adequate future scrap supply. Electric furnaces, however, are not restricted to 100 percent scrap charge. Hojalata y Lamina, S.A., (HyL) in Monterrey, Mexico, has made electric furnace steel since 1957 using substantial amounts of sponge iron. Pilot work at The Steel Company of Canada, Ltd., demonstrated the feasibility of continuously charging prereduced iron-ore pellets in amounts of from 15 to 100 percent of the electric furnace charge. Preliminary economic studies showed that the process can produce steel in quantities up to 2.5 million tons at competitive costs to that of the conventional blast furnace-basic oxygen furnace combination. Additionally, the process offers the possibility of continuous steelmaking.[5] Work at the Albany (Oreg.) Metallurgy Research Center of the Federal Bureau of Mines has shown the production of carbon steel by the continuous addition of prereduced iron ore to molten automobile scrap in an electric furnace charge appears to have certain operational advantages over conventional cold-melt, batch-charging techniques. Among these are: (1) lower tramp element content in the ingot, (2) shorter heat times and lower electrical energy consumption, (3) improved energy input rate during the continuous addition, and (4) flexibility of charge composition by varying the ratios of scrap to prereduced iron ore.

Plans for commercial development of direct iron and steel processes in the United States were noted in 1967. The Oregon Steel Division of Gilmore Steel Corp., San Francisco, Calif., announced plans to build an integrated electric steel plant at Portland, Oreg., using prereduced pellets for raw material. Metallized pellets will be obtained from an adjacent plant being constructed by the Midland-Ross Corporation, Cleveland, Ohio. McWane Cast Iron Pipe Co., Mobile, Ala., has an integrated plant under construction to convert iron ore directly to metal. A composite charge of pellets made from iron ore, coal and oystershell are carbonized and prereduced on a traveling grate for smelting in a submerged-arc electric furnace. A West German firm announced plans to construct a new plant at Georgetown, S.C., involving an electric furnace, continuous casting facilities, and a rolling mill. Raw material will be scrap, with the

[4] Stone, J. K., and E. J. Prince. Survey of Large L-D Furnace Configurations. Iron and Steel Eng., v. 44, No. 2, February 1967, pp. 65–75.

[5] Sibakin, J. G., P. H. Hookings, and G. A. Roeder. Electric Arc Steelmaking With Continuously Charged Reduced Pellets. Blast Furnace & Steel Plant, v. 55, No. 9, September 1967, pp. 816–829.

possibility of pelletized iron ore being used in the future.

The first commercial spray steelmaking plant went into operation at the Lancashire Steel Manufacturing Co. Ltd., Manchester, England. This unit has a capacity of 50 tons per hour and was installed early in the year. A second installation is presently under construction at Shelton Iron and Steel Co., Ltd., Stoke-on-Trent. This works presently has four casting machines with a total of 11 strands and the product from the spray steelmaking process will be continuously cast. Others actively interested in this process are the United Steel Co., Ltd., the Millom Hematite Ore and Iron Co. Ltd., The Broken Hill Pty. Co. Ltd., New South Wales, Australia, and at least three U.S. steelmaking companies. Millom is planning to enter the steelmaking business with a full-scale plant and has applied for approval and assistance from the Iron and Steel Board. United Steel is considering spray steelmaking installations at the Workington Iron & Steel Co. and at Appleby-Frodingham Steel Co. works at Scunthorpe. With the object of undertaking commercial exploitation, The British Iron and Steel Research Association (BISRA) has established two subsidiary organizations to supply technical assistance and negotiate licensing agreements for this process. Advantages claimed for the spray process are the small capital investment needed, relatively low labor costs, and the possibility of a continuous steelmaking system.

The growth of continuous casting capacity in the United States has been explosive. At the end of 1966 there was 800,000 tons per year of capacity installed; at the end of 1967, 1 million tons; and by the end of 1969 there will be over 13 million tons of billet blooms and slab capacity installed and operating. It is estimated that there will be 40 million tons of continuous casting capacity at the start of this process' second decade in 1972.

Most of the continuous casting units in production by yearend 1967 were steel plants with capacities of less than 200,000 tons per year. These companies accounted for 90 percent of continuous casting production in 1967 and, since the first commercial machine started up in 1962, have played a major role in pioneering and developing this casting revolution. The key reason for gambling on this innovation has been a low-cost increase in capacity, although the resulting layout compactness has been important for companies with limited space. Additionally, continuous casting has made it easy for a small steelmaker to make high-quality products and to upgrade the product mix.

In 1968, several large slab casters will join the numerous high-capacity billet casters put onstream in 1967 and will push annual capacity to 3.5 million tons by yearend. With these new machines larger steel companies will become the major factors in future continuous casting production and technology development.

Although continuous casting has been adopted for a variety of steels, some problems remain:

1. Inherent center porosity in slabs and billets.

2. Longitudinal and transverse cracking.

3. Some grades of steel cannot be bent as required on semilow-head and low-head machines.

4. Single-strand casting capacity ranges from 1/4 to 1/6 of rolling mill capacity on billets and 1/6 to 1/8 on slabs.

The elimination of center porosity is basis for the improvement claims of Böhler Strand Reduction (BSR). Böhler Brothers Ltd. of Kapfenberg, Austria, patented a process for reducing the cast section by rolling while the center is still liquid to a maximum of 20 percent reduction. Other advantages claimed are a comparative absence of segregation, surface quality comparable to that of rolled billets, and choice of several finished sizes from a single cross-section cast.[6]

Two steel companies in the United States, The Timken Roller Bearing Co. and Great Lake Steel Division of National Steel Corp., will adapt BSR to continuous casting practice.

French researchers developed rules for continuous casting of rimmed steels.[7]

A tabulation of installations throughout the world including startup date, designer,

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[6] Steel Times (London). The Bohler Strand Reducing Process. V. 195, No. 5174, Sept. 15, 1967, pp. 314–316.

[7] P. Rocquet, J. C. Rossi, and J. Adam Gironne. Comparative Quality on Flat Rolled Products Produced From Continuously Cast and Conventionally Rolled Slabs. J. Metals, v. 19, No. 8, August 1967, pp. 57–61.

number of strands, ladle capacity, and other data was presented.[8]

President Johnson signed into law at the end of November the Air Quality Act of 1967, which will accelerate the battle against pollution. The new measure allocated significantly larger sums to the clean air struggle, but puts most of the burden for enforcing tougher standards on the States.

Increased spending by the steel industry is aimed at cleaner air and water. The 1966 outlay totaled $59 million for air and water pollution control equipment. The industry has $652 million invested or authorized for pollution control and related equipment, and was one of the earliest to strive for cleaner air and water. A breakdown of expenditures between 1951 and 1965 shows that $210 million was spent on water pollution control, and $239 million for smoke, dust, and fume control—operating, maintenance or power costs are not included. As older facilities are retired and replaced with more modern equipment, pollution control devices are a regular part of the design.[9]

[8] 33/The Magazine of Metals Producing. Continuous Casting Round Up. V. 5, No. 8, August 1967, pp. 75–95.
[9] Iron & Steel Engineer. Development in the Iron and Steel Industry During 1967. V. 45, No. 1, January 1968, pp. D1–D80.

Table 2.—Pig iron produced and shipped in the United States, in 1967, by States

(Thousand short tons and thousand dollars)

State	Production	Shipped from furnaces	
		Quantity	Value
Alabama	4,307	4,292	$235,408
Illinois	6,222	6,198	348,627
Indiana	12,167	12,196	696,954
Ohio	14,377	14,332	866,826
Pennsylvania	20,541	20,593	1,152,342
California, Colorado, Utah	4,762	4,758	280,148
Kentucky, Maryland, Texas, West Virginia	10,826	10,817	622,661
Michigan, Minnesota	7,450	7,504	413,337
New York	6,148	6,130	349,398
Total [1]	86,799	86,819	4,965,700

[1] Data may not add exactly to totals shown due to independent rounding.

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	1966 [1]	1967 [2]
Brazil	1,525	1,978
Canada	4,938	3,933
Chile	1,179	1,641
Peru	381	236
Venezuela	6,235	5,298
Other countries	1,230	1,509
Total	15,488	14,595

[1] Excludes 25,181 tons used in making agglomerates.
[2] Excludes 24,340 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	1966			1967		
	Quantity	Value		Quantity	Value	
		Total	Average per ton [2]		Total	Average per ton
Foundry	1,577	$87,471	$55.47	1,534	$87,072	$56.76
Basic	82,997	4,703,961	56.68	79,931	4,565,113	57.11
Bessemer	2,857	162,473	56.87	2,844	169,338	59.54
Low-phosphorous	232	14,076	60.67	215	13,055	60.72
Malleable	2,888	166,375	57.61	1,996	113,851	57.04
All other (not ferroalloys)	333	19,233	57.76	299	17,272	57.77
Total [3]	90,884	5,153,589	56.71	86,819	4,965,700	57.20

[1] Includes pig iron transferred directly to steel furnaces at same site.
[2] Revised.
[3] Data may not add to totals due to individual rounding.

Table 5.—Number of blast furnaces (including ferroalloy blast furnaces) in the United States, by States

State	January 1, 1967			January 1, 1968		
	In blast	Out of blast	Total	In blast	Out of blast	Total
Alabama	10	7	17	10	9	19
California	4	------	4	4	------	4
Colorado	4	------	4	4	------	4
Illinois	12	7	19	14	4	18
Indiana	20	3	23	22	2	24
Kentucky	2	1	3	2	1	3
Maryland	7	3	10	10	------	10
Michigan	9	------	9	9	------	9
Minnesota	2	------	2	1	1	2
New York	13	3	16	12	3	15
Ohio	31	19	50	33	14	47
Pennsylvania	40	21	61	42	19	61
Tennessee	-----	3	3	-------	3	3
Texas	2	------	2	2	------	2
Utah	3	------	3	3	------	3
Virginia	1	1	2	1	1	2
West Virginia	4	------	4	4	------	4
Total	164	68	232	173	57	230

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 [3]	Net total	Net coke	Fluxes	Pig iron produced	Metalliferous materials consumed per ton of pig iron made: Net ores and agglomerates [1]	Net scrap [2]	Miscellaneous [3]	Total	Coke and fluxes consumed per ton of pig iron: Net coke	Fluxes
1966:																
Alabama	2,018	1,521	3,980	7,617	135	41	7,793	3,731	990	4,389	1.735	0.031	0.009	1.775	0.850	0.225
Illinois	4,831	W	6,255	11,185	426	127	11,738	4,555	1,500	6,540	1.710	.065	.019	1.794	.696	.229
Indiana	5,045	971	13,573	19,651	187	697	20,534	7,261	1,588	11,955	1.644	.016	.058	1.718	.607	.133
Ohio	4,934	1,709	17,619	24,287	1,343	1,425	27,055	10,849	3,766	16,302	1.490	.082	.087	1.659	.666	.231
Pennsylvania	6,074	5,762	21,385	33,154	1,043	1,978	36,175	14,099	3,181	21,677	1.530	.048	.091	1.669	.650	.147
California, Colorado, Utah	W	W	4,720	8,220	849	184	9,253	2,920	925	4,896	1.679	.173	.037	1.889	.596	.189
Maryland, West Virginia, Kentucky, Texas	W	4,253	11,904	17,941	213	907	19,061	6,851	1,750	11,129	1.612	.019	.082	1.713	.616	.157
Michigan and Minnesota	W	W	11,240	12,649	237	164	13,050	4,724	1,348	7,932	1.595	.030	.021	1.646	.596	.170
New York	2,572	556	7,137	10,274	218	393	10,886	4,045	1,414	6,466	1.589	.033	.060	1.682	.626	.219
Total [4]	31,422	15,488	97,812	144,979	4,651	5,915	155,545	59,035	[5] 16,462	91,287	1.588	.051	.065	1.704	.647	.180
1967:																
Alabama	2,252	1,178	4,279	7,608	118	13	7,739	3,546	786	4,307	1.766	0.027	0.003	1.797	0.823	0.183
Illinois	3,961	W	6,399	10,129	368	338	10,835	4,273	1,378	6,222	1.628	.058	.054	1.741	.687	.221
Indiana	4,836	850	14,230	19,320	191	465	19,976	7,273	1,659	12,167	1.588	.016	.038	1.642	.598	.136
Ohio	4,321	1,095	16,123	20,940	1,024	1,508	23,472	9,509	3,041	14,377	1.457	.071	.105	1.633	.661	.212
Pennsylvania	5,535	4,643	21,528	30,882	959	1,594	33,435	13,042	2,530	20,541	1.503	.047	.078	1.628	.635	.123
California, Colorado, Utah	W	W	4,823	8,218	870	145	9,233	2,811	860	4,762	1.726	.183	.030	1.939	.590	.181
Maryland, West Virginia, Kentucky, Texas	W	3,319	12,458	17,933	122	905	18,960	6,648	1,689	10,826	1.656	.011	.084	1.751	.614	.156
Michigan and Minnesota	W	W	10,528	12,818	232	187	13,237	4,448	1,230	7,450	1.721	.031	.025	1.777	.597	.165
New York	1,363	544	7,667	9,382	215	487	10,084	3,731	1,079	6,148	1.526	.035	.079	1.640	.607	.176
Total [4]	28,175	14,595	98,035	137,230	4,099	5,643	146,972	55,280	[6] 14,252	86,799	1.581	.047	.065	1.693	.637	.164

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 exactly to totals shown due to independent rounding.

[5] Fluxes consisted of the following: 9,789 limestone, 6,251 dolomite, and 423 other fluxes excluding 5,133 limestone, 2,541 dolomite, and 331 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: 8,246 limestone, 5,604 dolomite, and 402 other fluxes excluding 5,111 limestone, 2,877 dolomite, and 317 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				
1963	88,437	397	963	8,544	10,920	109,261
1964	97,655	443	858	15,442	12,678	127,076
1965	93,866	327	586	22,879	13,804	131,462
1966	84,804	221	278	33,928	14,870	134,101
1967	70,550	140	(2)	41,434	15,089	127,213

[1] Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. Omits about 2 percent of total steel production.
[2] Included with 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 [1]	Pig iron	Ferro-alloys [2]	Iron and steel scrap
	Domestic	Foreign				
1963	1,783	3,995	885	66,188	1,557	56,506
1964	2,114	4,816	1,379	78,925	1,819	64,348
1965	1,818	4,400	[3] 1,061	81,040	1,898	68,272
1966	1,348	3,768	[4] 870	83,947	1,915	68,778
1967	954	2,905	[5] 600	80,404	1,818	65,027

[1] Includes consumption of pig iron and scrap by ingot producers and iron and steel foundries.
[2] Includes ferromanganese, spiegeleisen, silicomanganese, manganese briquets, manganese metal, ferrosilicon, ferrochromium alloys, and ferromolybdenum.
[3] Includes 567 sinter, 386 pellets, 100 nodules, and 8 other agglomerates. (418 foreign origin.)
[4] Includes 435 sinter, 348 pellets, 86 nodules and other agglomerates. (348 foreign origin.)
[5] Includes 306 sinter, 217 pellets, 77 nodules and other agglomerates. (378 foreign origin.)

Table 9.—Consumption of pig iron in the United States, by type of furnace

(Thousand short tons)

Type of furnace or equipment	1967	
	Thousand short tons	Percent of total
Open hearth	46,386	53.1
Bessemer	87	.1
Oxygen converter	33,553	38.4
Electric [1]	378	.4
Cupola	3,162	3.6
Air	147	.2
Direct castings	3,658	4.2
Total	87,371	100.0

[1] Includes a small quantity of pig iron consumed in crucible furnaces.

Table 10.—Consumption of pig iron in the United States, by districts and States

(Thousand short tons)

District and State	1967
New England:	
Connecticut	31
New Hampshire	(1)
Massachusetts	48
Rhode Island	38
Vermont	6
Total	123
Middle Atlantic:	
New Jersey	86
New York	5,742
Pennsylvania	20,913
Total	26,741
East North Central:	
Illinois	6,208
Indiana	12,462
Michigan	7,377
Ohio	13,869
Wisconsin	215
Total	40,131
West North Central:	
Iowa	71
Kansas	6
Minnesota	491
Missouri	31
Total	599
South Atlantic:	
Delaware	(1)
Maryland	5,713
Florida	3
Georgia	12
North Carolina	(1)
South Carolina	13
Virginia	106
West Virginia	2,259
Total	8,106
East South Central:	
Alabama	3,765
Kentucky	1,623
Tennessee	125
Total	5,513
West South Central:	
Louisiana	1
Oklahoma	14
Texas	1,190
Total	1,205
Rocky Mountain: Colorado, Utah	(1)
Pacific Coast:	
California	2,245
Washington	12
Total	2,257
Other States	2,694
Grand total [2]	87,371

[1] Included with other States total.
[2] Does not add exactly to total because of individual rounding

Table 11.—Average value of pig iron at blast furnaces in the United States, by States
(Per short ton)

State	1967
Alabama	$54.85
California, Colorado, Utah	58.88
Illinois	56.25
Indiana	57.15
New York	57.00
Ohio	60.48
Pennsylvania	55.96
Other States [1]	56.55
Average	57.20

[1] Kentucky, Maryland, Michigan, Minnesota, Texas, West Virginia.

Table 12.—Free-on-board value of steel mill products in the United States in 1966 [1]
(Cents per pound)

Product	Carbon	Alloy	Stainless	Average
Ingots	(2)	17.832	41.414	6.104
Semifinished shapes and forms	5.862	11.755	46.769	7.062
Plates	6.823	9.684	51.877	7.933
Sheets and strips	7.276	16.082	45.112	8.172
Tin mill products	9.278	--------	--------	9.278
Structural shapes and piling	6.615	(3)	--------	6.615
Bars	8.114	14.274	65.721	9.883
Rails and railway-track material	7.630	--------	--------	7.630
Pipes and tubes	10.562	14.819	112.535	11.881
Wire and wire products	12.943	35.401	83.094	14.386
Other rolled and drawn products	11.849	17.552	72.198	14.103
Average total steel	7.982	13.486	55.741	9.015

[1] This table represents the weighted average value based on the quantity of each type of steel shipped; therefore, it reflects shifts in the distribution of the 3 classes of steel.
[2] 15 to 35 percent of total shipments are included with interplant transfers. Transfers to other plant of the same company are included with shipments to other companies and only constitute about 10 to 25 percent for carbon steel, electrical sheets, strips and wire rope cable, alloy steel wire rods, and cold finished bars.
[3] Included with Plates.

Table 13.—U.S. exports of major iron and steel products

Products	1966		1967	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Semimanufactures:				
Ingots and other primary forms:				
Puddled bars and pilings, blocks, lump and other primary forms of iron or steel, n.e.c	2,684	$332	5,880	$699
Blooms, billets, ingots, slabs, sheet bars, and roughly forged pieces	r 338,544	r 28,143	302,498	26,330
Coils for rerolling	42,840	32,940	60,486	34,446
Blanks for tubes and pipes, iron or steel	1,039	182	1,453	251
Total	r 385,107	r 61,597	370,317	61,726
Bars, rods, angles, shapes and sections:				
Wire rods	12,184	2,269	7,107	1,598
Bars, rods, and hollow-drill steel	72,922	24,643	78,857	26,193
Concrete reinforcing bars	24,219	3,394	21,577	2,904
Angles, shapes, and sections	r 130,206	r 22,240	113,789	18,454
Plates and sheets:				
Steel plates	17,934	8,787	15,622	8,517
Steel sheets	165,153	45,968	140,347	41,905
Black plate	24,611	1,982	19,854	1,895
Iron and steel plates, n.e.c	179,362	39,817	254,410	53,725
Tinplate and terneplate	301,394	44,501	283,542	25,687
Tinplate circles, cobbles, strip and scroll	12,354	1,229	15,380	1,485
Hoop and strip	49,720	25,460	56,874	28,071
Total	r 990,059	r 220,290	1,007,359	210,434

Table 13.—U.S. exports of major iron and steel products—Continued

Products	1966 Short tons	1966 Value (thousands)	1967 Short tons	1967 Value (thousands)
Manufactures:				
Rails and railway track construction materials:				
Rails	30,071	$4,333	21,617	$3,211
Joints and tie plates	9,831	1,901	8,605	1,820
Sleeper and track material of iron or steel, n.e.c	3,681	1,894	2,126	1,304
Wire:				
Steel wire coated or uncoated	4,892	3,878	4,744	4,474
Steel wire, bare	18,605	6,140	10,995	4,191
Galvanized wire	4,669	1,714	3,775	1,418
Barbed wire	1,124	305	752	237
Fencing and fence gates of iron or steel wire	2,062	[1] 767	1,860	[1] 691
Fencing wire, n.e.c	684	324	775	295
Spring wire	11,310	4,814	13,340	6,080
Cables, ropes, bands, and slings	12,155	8,726	12,858	8,585
Tubes, pipes, and fittings:				
Cast-iron pressure pipe and fittings	r 52,296	r 10,254	22,919	6,236
Cast-iron soil pipe and fittings	23,844	4,630	33,026	6,325
Steel tube and pipe fittings, unions and flanges	17,419	21,687	17,189	21,261
Steel tube and pipe fittings, welded	12,331	19,469	13,324	20,258
Malleable iron tube and pipe fittings, n.e.c	1,463	1,307	1,623	1,625
Electrical conduit fittings of iron or steel	11,358	8,731	10,655	8,040
Iron tube and pipe fittings n.e.c	6,029	8,172	6,217	8,769
Seamless tubes and pipe	213,411	84,781	183,802	77,165
Welded, clinched or riveted tubes and pipe	68,735	29,525	70,602	30,982
Castings and forgings	77,150	50,874	91,523	58,425
Finished structural parts and structures:				
Fabricated structural iron and steel	r 85,824	r 34,267	77,078	31,621
Doors, door and window sash, frames, and molding and trim	2,645	2,982	2,270	2,776
Fabricated steel plate, including stacks and weldments	13,355	5,221	14,311	6,496
Construction materials, n.e.c	r 11,480	r 6,223	8,734	4,918
Storage tanks, lined or unlined	27,626	16,803	19,514	11,585
Nails, tacks, staples and spikes:				
Track spikes	741	217	663	199
Nails, tacks, staples, n.e.c	7,525	5,801	7,289	5,879
Bolts	17,650	16,314	19,948	18,122
Nuts	5,234	8,059	5,126	8,967
Screws, rivets, washers	13,953	20,104	14,140	21,246
Total	r 769,153	r 390,217	701,400	383,201
Advanced manufactures:				
Buildings (prefabricated and portable)	--------	r 5,835	---------	7,802
Finished structures and structural parts of iron and steel n.e.c	--------	18,897	---------	17,737
Hardware and parts	--------	8,826	---------	9,609
Chains and parts	11,922	17,458	11,884	16,742
House heating boilers	--------	19,278	---------	19,407
Plumbing fixtures and fittings	--------	4,976	---------	5,663
Tools	--------	r 52,541	---------	51,676
Utensils and parts (cooking, kitchen and hospital)	r 3,793	7,988	3,597	7,901
Other	--------	67,860	---------	65,401
Total	--------	r 203,659	---------	201,938
Grand total	--------	r 875,763	---------	857,299

r Revised.
[1] In addition wire cloth as follows: 1966, $3,421,345 (7,489,299 square feet); 1967, $3,813,600 (7,734,244 square feet).

Table 14.—U.S. imports for consumption of pig iron, by countries

(Short tons)

Country	1965	1966	1967
Australia	801	13,241	-------
Belgium-Luxembourg	2,065	1,793	-------
Brazil	73,537	-------	-------
Canada	485,089	393,593	408,066
Czechoslovakia	-------	67,968	-------
Finland	66,422	64,655	33,617
Germany:			
East	r 82,289	104,891	49,700
West	64,220	79,750	41,947
Italy	68	-------	-------
Mexico	-------	-------	28
Mozambique	-------	22,801	-------
Netherlands	-------	4,506	9,869
Norway	666	-------	10,900
Rhodesia	-------	72,664	22,400
Rumania	-------	32,599	-------
South Africa, Republic of	12,867	133,824	-------
Spain	42,085	9,002	-------
Sweden	11,203	-------	1,922
U.S.S.R	34,188	185,394	-------
United Kingdom	6,595	58	7,075
Venezuela	-------	-------	19,710
Total:			
Short tons	882,095	1,186,739	605,234
Value (thousands)	$38,438	$45,914	$27,599

r Revised.

Table 15.—U.S. imports for consumption of major iron and steel products

Products	1966 Short tons	1966 Value (thousands)	1967 Short tons	1967 Value (thousands)
Iron products:				
Cast iron pipes, tubes, and fittings	26,336	$3,963	20,183	$3,593
Malleable cast-iron fittings	3,779	1,636	7,124	2,763
Bars of wrought iron	484	138	306	93
Castings and forgings	5,853	2,039	6,839	2,658
Total	36,452	7,776	34,452	9,107
Iron or steel Products:				
Ingots, blooms, billets, slabs and sheet bars	218,861	35,153	367,954	31,298
Bars:				
Concrete reinforcement bars	r 673,424	49,488	567,026	42,003
Solid and hollow, n.e.c	586,505	67,691	650,125	75,609
Hollow drill steel	5,400	2,032	5,014	1,953
Plates and sheets:				
Black plate	9,327	851	9,887	1,001
Steelplate	948,761	86,875	1,022,939	95,145
Steel sheets	3,620,636	379,374	4,212,528	437,829
Plates and sheets of iron or steel	3,150	986	2,668	684
Plates, sheets and strip of iron or steel	19,568	3,831	11,558	3,030
Strip of iron or steel	59,633	23,236	67,591	23,112
Tinplate and terneplate	125,080	22,097	156,351	27,112
Structural iron and steel	86,043	19,376	119,564	27,682
Angles, shapes and sections	1,354,450	122,045	1,030,169	94,346
Wire rods of steel	1,150,309	108,022	1,076,472	101,865
Sheet piling	40,596	4,079	29,669	3,050
Pipes, tubes and fittings	1,088,433	162,415	1,098,157	174,036
Rails for railways	19,495	1,873	18,208	1,607
Rail braces, tie plates and joint bars	856	117	2,048	246
Circular saw plates	(1)	1,370	(1)	1,327
Wire:				
Barbed wire	76,501	9,806	69,387	9,392
Round wire	434,897	82,156	432,340	83,046
Flat wire	15,637	7,441	16,731	7,882
Rope and strand	80,720	23,443	94,369	27,634
Galvanized wire fencing and fencing wire	52,990	7,861	56,373	8,598
Wire used in card clothing	NA	342	NA	319
Bale ties of iron or steel	25,006	3,278	16,247	2,138
Nails	289,161	43,134	229,845	37,411
Steel castings and forgings	21,554	5,358	48,533	13,366
Total	r 11,006,993	1,273,730	11,411,753	1,333,221
Advanced manufactures:				
Bolts, nuts, rivets, and washers	108,259	36,695	127,398	43,664
Chains and parts	21,008	12,717	19,765	12,090
Screws	----------	17,880	----------	20,342
Tools	----------	25,055	----------	36,523
Other	----------	5,758	----------	9,530
Total	----------	98,105	----------	122,149
Grand total	----------	1,379,611	----------	1,464,477

r Revised. NA Not available.
1 Saws reported in number, 1966: 157,990; 1967: 321,425.

Table 16.—World production of pig iron (including ferroalloys), by countries [1] [2]

(Thousand short tons)

Country	1963	1964	1965	1966	1967 p
North America:					
Canada	6,059	r 6,717	r 7,261	7,400	7,108
Mexico (includes sponge iron)	r 1,134	r 1,291	r 1,325	r 1,595	1,836
United States	73,853	87,922	91,016	94,000	89,479
South America:					
Argentina	481	666	751	r 593	692
Brazil	2,773	2,937	2,644	3,237	e 3,340
Chile	480	494	355	r 491	549
Colombia	223	226	225	186	228
Peru [3]	32	30	22	r 31	32
Venezuela	333	356	368	387	465
Europe:					
Austria	2,326	2,434	2,429	2,424	2,363
Belgium	7,622	r 8,870	9,222	9,072	9,912
Bulgaria	292	504	766	913	1,093
Czechoslovakia	5,847	6,361	r 6,468	r 6,910	e 7,055
Denmark	76	79	83	90	83
Finland	406	710	1,085	r 1,030	1,144
France [4]	r 15,770	r 17,461	r 17,379	r 17,178	17,284
Germany:					
East	2,370	2,491	2,577	2,698	2,778
West	25,253	29,963	29,751	28,013	30,166
Hungary	1,544	1,653	1,750	r 1,812	1,813
Italy	4,264	3,996	6,207	7,074	8,228
Luxembourg	3,954	4,620	4,569	4,367	4,365
Netherlands	1,884	2,147	2,606	2,435	e 2,845
Norway	826	985	1,202	1,256	e 1,360
Poland	5,947	6,220	6,349	6,455	7,254
Portugal	265	r 298	304	274	e 316
Rumania	1,881	2,121	2,226	2,423	e 2,400
Spain	2,187	2,172	r 2,653	r 2,441	e 3,010
Sweden	2,232	2,583	2,713	2,646	2,770
Switzerland	49	35	30	30	26
U.S.S.R. [5]	64,696	68,759	72,955	r 77,453	82,453
United Kingdom	16,342	19,347	19,555	17,595	16,971
Yugoslavia	1,168	1,184	1,295	1,342	1,297
Africa:					
Rhodesia, Southern	260	351	276	287	NA
South Africa, Republic of	2,676	3,182	3,972	4,126	3,770
United Arab Republic	226	212	191	e 185	NA
Asia:					
China, mainland e	18,700	19,800	20,900	22,000	15,400
India	7,431	7,425	7,839	7,981	7,665
Japan	22,525	26,951	31,041	36,094	45,239
Korea:					
North	r 1,278	r 1,477	e r 1,600	e r 1,650	e 1,950
South [3]	r 9	r 8	r 29	r 47	e 34
Taiwan	60	68	79	78	e 95
Turkey [6]	434	442	551	906	934
Oceania: Australia	4,118	r 4,463	r 4,755	r 5,295	5,575
Total [1] [7]	r 310,286	r 350,011	r 369,374	r 382,500	391,377

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

1 Pig iron is also produced in the Congo (Kinshasa), but quantity produced is believed to be negligible.
2 Compiled mostly from data available May 1968.
3 Excluding ferroalloys.
4 Excluding electric furnace and aluminothermic ferroalloys.
5 U.S.S.R. in Asia included with U.S.S.R. in Europe.
6 Includes foundry iron.
7 Total is of listed figures; no undisclosed data included.

Table 17.—World production of steel ingots and castings, by countries [1]

(Thousand short tons)

Country	1963	1964	1965	1966	1967 p
North America:					
Canada	r 8,197	r 9,128	r 10,068	10,003	**9,694**
Mexico	2,247	2,593	2,743	r 3,046	**3,332**
United States [2]	109,261	127,076	131,462	134,101	**127,213**
South America:					
Argentina	1,006	r 1,394	r 1,508	r 1,397	**1,462**
Brazil	r 3,158	r 3,369	r 3,333	e 4,210	**e 4,130**
Chile	574	644	526	r 636	**703**
Colombia	245	254	267	239	**278**
Peru	84	90	104	r 88	**87**
Uruguay	8	15	14	r 11	**14**
Venezuela	401	485	r 689	r 592	**775**
Europe:					
Austria	3,249	3,521	3,551	3,520	**3,332**
Belgium	8,298	9,624	10,107	9,829	**10,621**
Bulgaria	508	524	648	772	**1,366**
Czechoslovakia	8,375	9,234	9,478	10,062	**e 10,800**
Denmark	396	437	454	446	**438**
Finland	340	409	400	440	**434**
France	19,214	21,501	21,319	21,589	**21,688**
Germany:					
East	4,512	4,751	4,813	r 5,006	**e 5,180**
West	34,830	41,159	40,588	38,929	**40,503**
Greece	230	231	231	231	**176**
Hungary	2,617	2,607	2,778	2,919	**3,019**
Ireland	22	22	22	30	**NA**
Italy	11,196	10,795	13,978	15,034	**17,516**
Luxembourg	4,445	5,025	5,054	4,839	**4,939**
Netherlands	2,582	2,924	3,468	3,612	**3,753**
Norway	597	677	745	r 805	**e 872**
Poland	8,823	9,450	10,018	10,858	**11,520**
Portugal	r 245	265	289	r 284	**333**
Rumania	2,981	3,350	3,777	4,045	**4,505**
Spain	2,747	3,472	3,876	r 4,296	**5,064**
Sweden	4,300	r 4,899	5,208	5,251	**5,256**
Switzerland	355	380	380	472	**489**
U.S.S.R. [3]	r 88,434	r 93,744	100,333	r 106,822	**112,656**
United Kingdom	25,222	29,378	30,252	27,233	**26,763**
Yugoslavia	1,750	1,849	1,950	2,058	**2,019**
Africa:					
Rhodesia, Southern	93	141	143	143	**NA**
South Africa, Republic of	3,124	3,463	3,630	3,643	**4,111**
United Arab Republic	217	194	197	e 200	**NA**
Asia:					
China, mainland e	13,200	15,400	16,500	17,600	**12,100**
India	6,581	6,554	7,129	7,198	**7,040**
Japan	34,724	43,871	45,372	52,673	**68,513**
Korea:					
North	1,127	r 1,248	1,356	e 1,435	**1,598**
South	179	r 184	r 209	r 237	**363**
Taiwan	303	331	485	331	**e 330**
Turkey	428	536	734	1,035	**1,164**
Oceania: Australia	5,129	r 5,563	r 6,021	6,493	**6,931**
Total [4]	r 426,554	r 482,761	r 506,207	r 524,693	**543,080**

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

[1] Compiled mostly from data available May 1968.

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

[3] U.S.S.R. in Asia included with U.S.S.R. in Europe.

[4] Total is of listed figures only; no undisclosed data included.

Iron and Steel Scrap

By John W. Thatcher[1]

The iron and steel scrap industry experienced a disappointing year as demand by steel producers and iron foundries fell below the high levels of the previous 2 years. Demand improved toward yearend as steel production rose to meet hedge buying against a possible steel strike in 1968. The improvement, however, was not enough to prevent a 7-percent decrease in scrap consumption and a 10-percent decrease in receipts of purchased scrap. Low prices throughout most of the year, reflecting the lack of interest in merchant scrap, improved toward yearend. The United States continued as a net exporter of scrap since the domestic situation, coupled with high steel production in Japan and some European countries, encouraged exports and inhibited imports.

The processing revolution in the scrap industry continued in 1967 as the installation of new fragmentizers moved eastward. The total, advertised capacity of shredders in operation at yearend, about equaling the aggregate tonnage of cars junked in 1967, points to the magnitude of this revolution. Supershredders went into operation in Cleveland, Ohio, Detroit, Mich., Philadelphia, Pa., and Everett, Mass., bringing to 16 the number of these plants in the United States. The installation of 33 small- and medium-sized shredders gave a grand total of 68 shredders of all sizes in the United States, 13 in the East, eight in the South, 28 in the Midwest, 14 in the Southwest, and seven on the Pacific Coast. Total capacity was estimated at 6 million tons of scrap annually.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient iron and steel scrap, and pig iron statistics in the United States

(Thousand short tons)

	1966	1967
Stocks Dec. 31:		
Scrap at consumer plants	r 8,188	7,793
Pig iron at consumer and supplier plants	r 2,968	2,842
Total	r 11,156	10,635
Consumption:		
Scrap	91,583	85,361
Pig iron	91,770	87,371
Imports for consumption, scrap (including tinplate scrap)	407	229
Exports, iron and steel scrap	5,774	7,504
Price: Scrap, No. 1 heavy-melting, Pittsburgh, average—per long ton [1]	$30.48	$26.63
Value: Scrap, all grades, for export [2]	$33.45	$36.61

r Revised.
[1] Iron Age.
[2] As computed from export data obtained from the Bureau of the Census.

Legislation and Government Programs.—Public Law 90-45 extended the suspension of duties on the imports of scrap metal for 1 year beginning July 1, 1967.

Early in the year, the Bureau of Mines published the results of a nationwide study of the junk car problem. Entitled "Automobile Disposal, a National Problem," case studies were presented of factors influencing the accumulation of automobile scrap in 54 sample districts representative of urban, suburban, and rural conditions in various parts of the United States. Other relevant Bureau publications issued during the year were Information Circular 8344, "Iron and Steel Scrap in the Intermountain and Northwestern Plains States"; Information Circular 8342, "Iron and Steel Scrap Survey in Illinois, Indiana, Iowa, Michigan, Minnesota, and Wisconsin"; and Information Circular 8329, "Iron and Steel Scrap in the Southeast."

In 1966, the Business and Defense Services Administration of the U.S. Department of Commerce published "Iron and Steel Scrap Consumption Problems," an analysis of the technical and economic factors governing scrap usage in ironmaking and steelmaking. The report emphasizes the problems of limited acceptability of No. 2 bundles, includes recommendations for increasing scrap consumption, and projects scrap usage to the years 1970 and 1975. In March 1967, the same agency published "Motor Vehicle Abandonment in U.S. Urban Areas," a discussion of the cause and possible solutions to the problem of junk car accumulation in metropolitan areas.

AVAILABLE SUPPLY

During 1967, a net supply of 85 million short tons of iron and steel scrap was available to consumer plants, a decrease of 8 percent from the previous year. Production of home scrap decreased 6 percent and receipts from dealers and other sources decreased 10 percent, both factors reflecting the 5-percent decrease in steel production for the year. The portion of available new supply made up by home scrap increased from 60 percent in 1966 to 62 percent in 1967, continuing a trend begun over a decade ago.

CONSUMPTION

The effect on scrap consumption of increased, basic-oxygen steelmaking became noticeable in 1967, as the proportion of scrap used in steelmaking furnaces decreased from 45.1 percent to 44.7 percent. This small decrease represented about 600,000 tons of scrap replaced by pig iron due to changing steelmaking technology. This effect is expected to be more pronounced in 1968 as steel production from the basic-oxygen process approaches that for the open hearth. The scrap proportion of the total metallics charged to ironmaking and ferroalloy furnaces remained at the 1966 level, 74.4 percent.

Following the fortunes of the steel industry, total consumption of iron and steel scrap decreased in 1967, reversing the upward trend of the previous 3 years. Scrap consumption dropped 6.2 million tons, or 7 percent, while pig iron consumption dropped 4.4 million tons, or 5 percent. The proportion of scrap in the total metallics charged to ironmaking, steelmaking, and ferroalloy furnaces decreased from 49.9 percent in 1966 to 49.4 percent in 1967.

STOCKS

Total iron and steel scrap stocks held by consumers on December 31, 1967, were 5 percent below the quantity held on the same date in 1966, and equaled a 33-day supply at an average daily consumption rate of 234,508 tons.

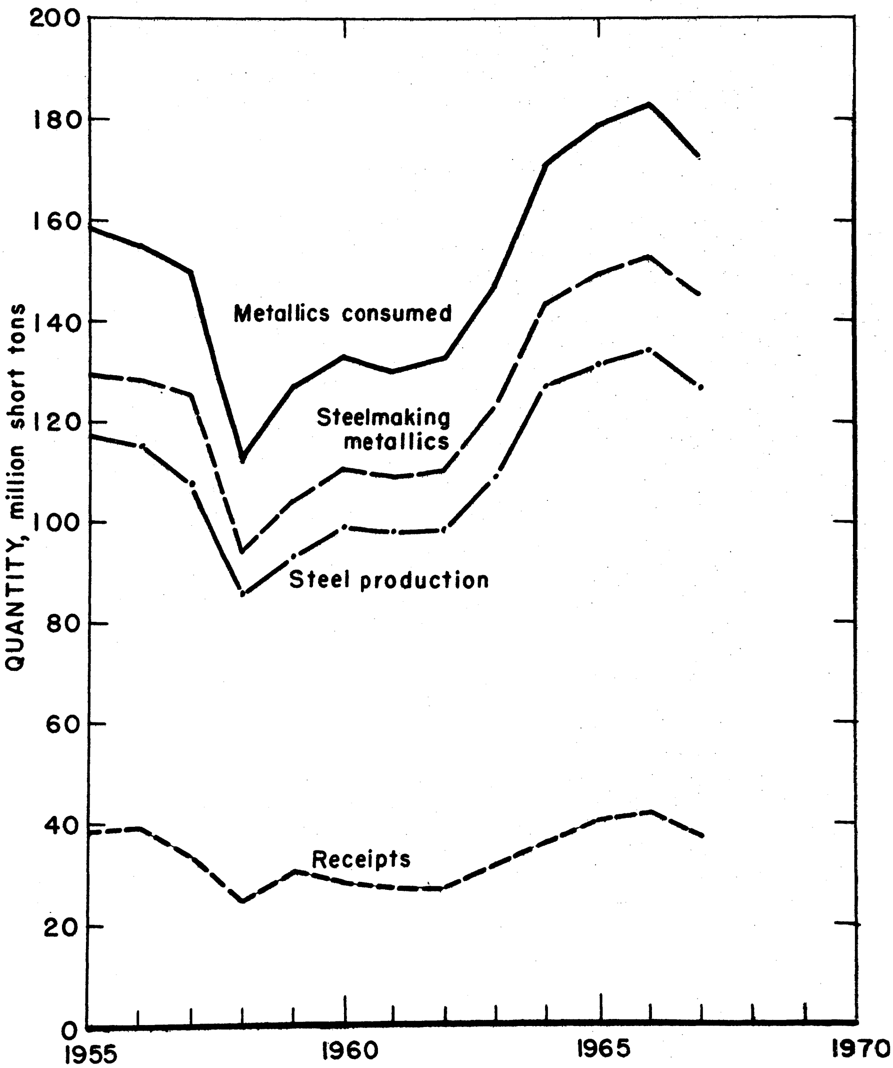

Figure 1.—Metallics consumed—Total iron and steel scrap plus pig iron; Steelmaking metallics—Total iron and steel scrap plus pig iron consumed in steelmaking furnaces; Steel production (AISI); Receipts of purchased scrap by consumers.

PRICES

The average composite price of No. 1 heavy melting scrap fell to $27.62, the lowest price recorded for this bellwether grade since 1950, demonstrating the imbalance between dealers' supply and consumers' demand during most of the year. The monthly composite price ranged from $26.50 in May and June to $29.84 in December, when steel mills began operating at a high level to meet hedge buying.

The composite price for No. 2 bundles averaged $20.42 per long ton, a drop of $1.38 from 1966 and the lowest price since 1963. The monthly composite price climbed from a low of $19.73 in May to a high of $22 in December.

The average value of export increased $3.16 per long ton above that for 1966, mainly owing to an increase in exports of No. 1 and No. 2 heavy melting steel scrap.

FOREIGN TRADE

A near record high export to Japan compensated for a drop in exports to Canada and other countries and was the major factor in establishing the fourth highest scrap export total in U.S. history. Exports in 1967 were exceeded only by those in 1960, 1961, and 1964. Exports to the European Coal and Steel Community (ECSC) countries showed a net decrease as did those to countries in North and South America. No exports were reported to Yugoslavia, which imported 100,749 tons from the United States in 1966. Exports to Taiwan decreased again in 1967, continuing a 3-year trend. Tonnage and value of exports exceeded imports by 7.4 million tons and $242.7 million, respectively.

Relative to imports, noteworthy features in 1967 were a return of total tonnage to the level maintained prior to the 1966 record year, and a shift in sources for smaller tonnages of scrap imports. Imports from Canada decreased 46 percent, but still made up 94 percent of the total. Rumania supplied most of the remaining tonnage, the first time in more than 10 years that imports have been reported from that country. Imports from ECSC countries were lower as the scrap demand of the Community steel industries increased. Steel production in the United Kingdom decreased making more scrap available for export.

WORLD REVIEW

Belgium.—The Belgian Government asked the High Authority of the ECSC to be allowed to grant financial aid to scrap yards that are threatened by imports from nonmember countries. The Government claimed that, if not remedied, the situation may lead to unemployment for about 1,000 workers in the scrap industry. Permission to impose a tax on imported scrap was also requested from the High Authority.

A new company, Société Belge des Réalisations Métallurgiques Bérémet, included Swiss, British, French, and Luxembourg interests and was established to process scrap for blast furnace use.

France.—Steel production remained at about the 1966 level. However, purchased scrap decreased to 4,349,000 tons, a 3-year low.

Germany, West.—The steel industry consumed 17,437,000 tons of scrap in making 40,504,000 tons of steel. The increases in these quantities over those for 1966, 3 and 4 percent, respectively, indicated that although scrap consumption was higher, the scrap to pig iron ratio declined. Purchased scrap increased 10 percent to 10,119,000 tons, owing mainly to a 477,000-ton increase in scrap imports over the 739,000 tons imported in 1966.

United Kingdom.—Changes in the structure of the scrap processing industry were noted as more efficient means of scrap collecting, processing, and distribution were sought to maintain the competitive position of the steelmaking industry in the world market. Two trends were apparent. The first was the introduction of large fragmentizing units with accompanying mergers and partnerships of smaller merchants. The second was a greater swing toward "on site" processing where scrap merchants tie themselves to specific steel plants.

The United Kingdom's first car fragmentizer, installed by Fragmentation Heckett-Birds Ltd. at St. Helens, Lancashire, began limited production in September. In preliminary tests, cars were fragmentized at an average rate of 15 seconds each. Full production is expected to be 2,000 tons of scrap per week. The first large-scale shredder system in the United Kingdom, erected by Proler Cohen

Ltd. at Willesden, was due to start full-scale operation by yearend. Additionally, the sale of two small-scale shredders in the United Kingdom brought to a total of four the fragmentizers that were either operational or under construction in 1967.

Described as one of the world's most modern scrap processing and handling plants inside a steelworks, Scrap Processors Ltd. new facility at the Spencer works of Richard Thomas and Baldwins Limited was officially opened in October. The $3 million plant, which is designed to process up to 100,000 tons of scrap per year for the Spencer BOF shop, consists of two shears, a baler, and equipment to load 120-ton-capacity charging boxes.

TECHNOLOGY

Interest generated by the President in 1965 when action on wastes, particularly discarded automobiles, was announced, followed by Federal legislation to provide research funds, began to show results in 1967. Increased activity took place in both the private and Government sectors to find ways for better utilization of iron and steel scrap as a secondary raw material, and eliminate the accumulations of junked vehicles. The scrap industry in general gave indications of turning more to technology for help in solving the problems of preparing the ferrous materials for maximum utilization by the steel makers.

The Institute of Scrap Iron and Steel announced the formation of the Scrap Research Foundation. One area mentioned previously by the organization for research was the possibility of using chemistry to improve scrap processing.

The American Foundrymen's Society moved to study scrap specifications, establish the maximum quantities of acceptable impurities, and increase and accelerate use of auto scrap.

The steel industry demonstrated that scrap usage in the BOF operations could be increased by the use of addition agents or by preheating the scrap.

A unique system for fragmentizing iron and steel scrap was patented which was particularly directed to automobile body disposal. The fully integrated system consists of the following demountable and portable units: (1) a combination flattener and hydraulic shear, (2) a cleaner-compactor, and (3) a permanent magnet separator. Scrap which has been flattened and sheared by the first unit is fed to the cleaner-compactor which works and cleans the scrap nuggets by a cylindrical gear array rotating inside of a drum. The ferrous scrap is then magnetically separated from dirt and nonferrous scrap. Advantages claimed by the manufacturer include a product density variable from 70 to 120 pounds per cubic foot, unusually low copper content, and long operating periods with few maintenance problems.[2]

Two modifications of BOF practice, the use of an exothermic addition compound and the preheating of scrap, promise to raise the percentage of scrap in the furnace charge. Pittsburgh Steel Company has produced more than 1,200 BOF heats, using either 40 or 51 percent scrap in the charge, by addition of calcium carbide to the furnace. Disadvantages noted for this method included increased consumption of fluorspar and oxygen, limited range of steels produced, and decreased life of the furnace lining.

Preheating scrap to increase its use in the BOF appeared more promising than the use of calcium carbide. Scrap preheating has been routine for about 3 years at International Harvester Co., Wisconsin Steel Works Division, Chicago. The amount of preheating has varied with scrap prices, but has averaged 67 percent of all heats (capability is 80 percent), and has increased scrap usage about 6 percent. No refractory damage has been found that could be attributed solely to preheating.

Preheating scrap began in October in the BOF shop of the Pittsburgh Steel Co., Monessen, Pa., using an oxygen-fuel oil burner rather than an oxygen-natural gas burner. For low-carbon heats, the scrap portion was raised to 40 percent, an increase of 8 percent over standard practice. In some cases, a 50-percent scrap charge was used. In addition to cutting costs, scrap preheating resulted in less depend-

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[2] Eidal, Roy M. (assigned to Southwest Factories, Inc., Oklahoma City Okla.). Automobile Body Disposal Apparatus. U.S. Pat. 3,356,016, Dec. 5, 1967.

ence on hot metal and, hence, more flexibility of operation.

The frequent melts that are possible with modern, more efficient steel furnaces has required the development of bigger. more maneuverable charging machines for rapid recharging operations, such as the giant scrap-charging machine built for the Bethlehem, Pa., plant of the Bethlehem Steel Corp. The machine has its own car drive, two sets of controls, and two boxes with 2,000-cubic-foot capacity for charging basic-oxygen furnaces.

The first Tezuka, electric-furnace, scrap-compacting press to be installed in the United States went into operation at Southwest Steel Rolling Mills, Inc., Los Angeles, Calif. The press produces a 20-ton bale, that is custom-designed to conform to the interior configuration of the furnace and, therefore, provides a complete charge that eliminates backcharging. In addition to increasing production from 20 to 30 percent, the following benefits are also claimed: (1) power costs are reduced about 10 percent, (2) electrode breakage is eliminated, and (3) refractory wear is reduced from 20 to 50 percent.

Bureau of Mines research on various phases of the ferrous scrap problem was in progress throughout the year at several Bureau research centers. The experimental plant to demonstrate the use of automobile scrap for conversion of nonmagnetic iron ore to an acceptable type for upgrading moved nearer completion. Additional facilities for the project were constructed during the year in Minnesota.

Table 2.—Iron and steel scrap supply [1] available for consumption in 1967, by districts and States

(Thousand short tons)

District and State	Home production	Receipts from dealers and all others	Total new supply	Shipments [2]	New supply available for consumption
New England:					
Connecticut	94	90	184	7	177
Maine and New Hampshire	6	9	15	--------	15
Massachusetts	89	103	192	5	187
Rhode Island	52	62	114	3	111
Vermont	10	16	26	--------	26
Total	251	280	531	15	516
Middle Atlantic:					
New Jersey	207	523	730	17	713
New York	2,604	1,604	4,208	77	4,131
Pennsylvania	11,864	6,618	18,482	1,780	16,702
Total	14,675	8,745	23,420	1,874	21,546
East North Central:					
Illinois	4,501	4,296	8,797	381	8,416
Indiana	7,161	3,005	10,166	871	9,295
Michigan	4,334	3,837	8,171	148	8,023
Ohio	8,522	6,384	14,906	940	13,966
Wisconsin	585	522	1,107	86	1,021
Total	25,103	18,044	43,147	2,426	40,721
West North Central:					
Iowa	242	411	653	5	648
Kansas and Nebraska	54	105	159	1	158
Minnesota	229	239	468	14	454
Missouri	272	688	960	20	940
Total	797	1,443	2,240	40	2,200
South Atlantic:					
Delaware and Maryland	2,751	464	3,215	264	2,951
Florida	14	121	135	--------	135
Georgia	117	336	453	2	451
North Carolina	39	158	197	--------	197
South Carolina	15	32	47	--------	47
Virginia	172	386	558	9	549
West Virginia	843	1,014	1,857	1	1,856
Total	3,951	2,511	6,462	276	6,186
East South Central:					
Alabama	1,932	1,558	3,490	232	3,258
Kentucky and Mississippi	816	786	1,602	78	1,524
Tennessee	176	213	389	10	379
Total	2,924	2,557	5,481	320	5,161
West South Central:					
Arkansas and Louisiana	22	38	60	2	58
Oklahoma	54	169	223	2	221
Texas	1,552	1,408	2,960	172	2,788
Total	1,628	1,615	3,243	176	3,067
Rocky Mountain:					
Arizona, Colorado, Montana, Nevada, Utah	1,262	546	1,808	60	1,748
Pacific Coast:					
California and Hawaii	1,555	1,632	3,187	133	3,054
Oregon	43	177	220	5	215
Washington	123	434	557	5	552
Total	1,721	2,243	3,964	143	3,821
U.S. total [3]	52,312	37,984	90,296	5,330	84,966

[1] New supply available for consumption is a net figure computed by adding home production to receipts from dealers and all others and deducting scrap shipped, transferred or otherwise disposed of during the year. The plus or minus difference in stock levels at the beginning and end of year is not taken into consideration.
[2] Include scrap shipped, transferred or otherwise disposed of during the year.
[3] Detail may not add to totals due to individual rounding.

Table 3.—Consumption of iron and steel scrap and pig iron in the United States in 1967, by type of consumer and type of furnace or equipment

(Thousand short tons)

Type of furnace or equipment	Type of consumer		
	Scrap	Pig iron [1]	Total
Manufacturers of steel ingots and castings: [2]			
Open-hearth	32,442	46,305	78,747
Basic oxygen converter [3]	13,932	33,553	47,485
Bessemer	------	79	79
Electric [4]	14,965	285	15,250
Total steelmaking furnaces	61,339	80,222	141,561
Cupola	1,049	220	1,269
Air	50	15	65
Blast [5]	4,724	--------	4,724
Direct castings	------	2,987	2,987
Miscellaneous	18	--------	18
Total	67,180	83,444	150,624
Manufacturers of steel castings: [6]			
Open-Hearth	601	81	682
Bessemer	5	--------	5
Electric	2,364	39	2,403
Total steelmaking furnaces	2,970	120	3,090
Cupola	424	14	438
Air	75	30	105
Total	3,469	164	3,633
Iron foundries and miscellaneous users:			
Bessemer	36	8	44
Electric [4]	682	54	736
Total steelmaking furnaces	718	62	780
Cupola	12,404	2,928	15,332
Air	975	102	1,077
Direct castings	------	671	671
Ferroalloy	511	--------	511
Miscellaneous	104	--------	104
Total	14,712	3,763	18,475
Total:			
Open-hearth	33,043	46,386	79,429
Basic oxygen converters [3]	13,932	33,553	47,485
Bessemer	41	87	128
Electric [4]	18,011	378	18,389
Total steelmaking furnaces	65,027	80,404	145,431
Cupola	13,877	3,162	17,039
Air	1,100	147	1,247
Blast [5]	4,724	--------	4,724
Direct castings	------	3,658	3,658
Ferroalloy	511	--------	511
Miscellaneous	122	--------	122
Total	85,361	87,371	172,732

[1] Includes molten metal.
[2] Includes only those castings made by companies producing steel ingots.
[3] Includes scrap and pig iron processed in metallurgical blast cupolas and used in oxygen converters.
[4] Includes small quantities of scrap and pig iron consumed in crucible furnaces and vacuum melting.
[5] Includes consumption in all blast furnaces producing pig iron.
[6] Excludes companies that produce both steel ingots and steel castings.

Table 4.—Proportion of iron and steel scrap and pig iron used in furnaces in the United States

(Percent)

Type of furnace	1966 Scrap	1966 Pig iron	1967 Scrap	1967 Pig iron
Open-hearth	41.5	58.5	41.6	58.4
Basic-oxygen converter	29.0	71.0	29.3	70.7
Bessemer	17.2	82.8	32.0	68.0
Electric [1]	98.4	1.6	97.9	2.1
Cupola	80.6	19.4	81.4	18.6
Air	90.4	9.6	88.2	11.8

[1] Includes crucible furnaces and vacuum melting.

Table 5.—Consumption of iron and steel scrap and pig iron in the United States in 1967, by districts and States

(Thousand short tons)

District and State	Scrap	Pig iron	Total
New England:			
Conn	179	31	210
Maine and N. H	15	2	17
Mass	197	48	245
R. I	110	38	148
Vt	26	6	32
Total	527	125	652
Middle Atlantic:			
N. J	720	86	806
N. Y	4,091	5,742	9,834
Pa	16,809	20,913	37,722
Total	21,620	26,741	48,362
East North Central:			
Ill	8,395	6,208	14,603
Ind	9,239	12,462	21,701
Mich	8,031	7,377	15,408
Ohio	14,055	13,869	27,924
Wis	1,017	215	1,232
Total	40,737	40,131	80,868
West North Central:			
Iowa	663	71	734
Kans	123	6	129
Minn	448	491	939
Mo	1,051	31	1,082
Nebr	38	-------	38
Total	2,323	599	2,922
South Atlantic:			
Del. and Md	3,087	5,801	8,888
Fla	132	3	135
Ga	455	12	467
N. C	203	34	237
S. C	52	13	65
Va	553	106	659
W. Va	1,783	2,259	4,042
Total	6,265	8,228	14,493
East South Central:			
Ala	3,247	3,765	7,012
Ky and Miss	1,570	1,623	3,193
Tenn	378	125	503
Total	5,195	5,513	10,708
West South Central:			
Ark and La	57	1	58
Okla	227	14	241
Tex	2,866	1,190	4,056
Total	3,150	1,205	4,355
Rocky Mountain:			
Ariz., Colo., Mont., Nev., Utah	1,788	2,570	4,358
Pacific Coast:			
Calif. and Hawaii	2,993	2,245	5,238
Ore	220	------	220
Wash	542	12	554
Total	3,755	2,257	6,012
U.S. total [1]	85,361	87,371	172,732

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

Table 6.—Consumption of iron and steel scrap and pig iron by districts and States, by type of manufacturers in 1967

(Thousand short tons)

District and State	Steel ingots and castings [1]		Steel castings [2]		Iron foundries and miscellaneous users	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
New England:						
Conn.	59	------	6	------	114	32
Maine	------	------	------	}		------
Mass.	------	------ }	20	1 }	192 }	49
N. H.	------	------				
R. I.	44	23	------	------	66	15
Vt.	------	------	------	------	27	6
Total	103	23	26	1	399	102
Middle Atlantic:						
N. J.	237	------	79	3	404	83
N. Y.	3,149	5,596	157	19	786	127
Pa.	15,518	20,722	464	35	827	156
Total	18,904	26,318	700	57	2,017	366
East North Central:						
Ill.	6,747	5,789	472	28	1,176	391
Ind.	8,301	12,244	191	1	747	217
Mich.	4,660	6,797	147	1	3,224	579
Ohio	11,550	13,237	464	48	2,041	584
Wis.	------	------	309	5	708	210
Total	31,258	38,067	1,583	83	7,896	1,981
West North Central:						
Iowa	------	------	52	1	611	70
Kans.	------	------	96	------ }	52	6
Nebr.	------	------	13	------		------
Minn.	252	440	51	1	145	50
Mo.	840	------	109	9	102	22
Total	1,092	440	321	11	910	148
South Atlantic:						
Del.	2,939 }	5,796 }	40	------	------	------
Md.				------	108	5
Fla.	113	------	7	------	12	3
Ga.	515 }	------	10	------	36 }	46
N. C.		------	------	------	98	
S. C.	------	------	------	------	52	13
Va.	------	------	144	1	409	105
W. Va.	1,724	2,246	36	2	23	11
Total	5,291	8,042	237	3	738	183
East South Central:						
Ala.	2,134	3,114	136	------	977	651
Ky.	1,232	1,588	------	------	275	35
Miss.	80 }	------	------	------	------	------
Tenn.		------	28	2	333	123
Total	3,446	4,702	164	2	1,585	809
West South Central:						
Ark.	------	------ }	49	1	------	------
La.	------				8	------
Okla.	157	------	22	------	48	14
Tex.	2,217	1,110	69	------	580	80
Total	2,374	1,110	140	1	636	94
Rocky Mountain:						
Ariz., Colo., Mont., Nev., Utah	1,539	2,562	89	1	159	7
Pacific Coast:						
Calif. and Hawaii	2,533	2,170	120	3	340	72
Oreg.	162	------	50	------	7	------
Wash.	478	10	39	2	25	1
Total	3,173	2,180	209	5	372	73
U.S. total	67,180	83,444	3,469	164	14,712	3,763

[1] Includes only those castings made by companies producing steel ingots.
[2] Excludes companies that produce both steel ingots and steel castings.

Table 7.—Consumption of iron and steel scrap and pig iron in open-hearth furnaces in 1967, by districts and States

(Thousand short tons)

District and State	Scrap	Pig iron	Total
New England and Middle Atlantic:			
N. Y and R. I.	1,337	1,556	2,893
Pa.	8,695	14,675	23,371
Total	10,032	16,231	26,264
East North Central:			
Ill.	2,587	3,517	6,104
Ind.	5,795	6,617	12,412
Mich. and Wis.	1,022	927	1,949
Ohio	5,239	7,041	12,280
Total	14,643	18,102	32,745
West North Central:			
Minn. and Mo.	290	449	739
South Atlantic:			
Del., Md., W. Va.	3,396	5,792	9,188
East and West South Central:			
Ala., Ky., Tex.	2,503	3,348	5,851
Rocky Mountain and Pacific Coast:			
Calif., Colo., Utah	2,178	2,465	4,643
U.S. total [1]	33,043	46,386	79,429

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

Table 8.—Consumption of iron and steel scrap and pig iron in electric [1] steel furnaces in the United States in 1967, by districts and States

(Thousand short tons)

District and State	Scrap	Pig iron	Total
New England:			
Conn.	92	7	99
Mass. and N. H.	26	1	27
Total	118	8	126
Middle Atlantic:			
N. J.	370	7	377
N. Y.	305	7	312
Pa.	3,588	36	3,623
Total	4,263	50	4,312
East North Cental:			
Ill.	3,303	18	3,321
Ind.	167	5	172
Mich.	455	4	459
Ohio	2,656	45	2,701
Wis.	296	9	305
Total	6,877	81	6,958
West North Central:			
Iowa	56	---	56
Kans. and Nebr.	109	---	109
Minn.	36	1	37
Mo.	928	---	928
Total	1,129	1	1,130
South Atlantic:			
Del. and Md.	112	1	113
Fla., Ga., N. C.	645	1	646
Va., and W. Va.	361	1	362
Total	1,118	3	1,121
East South Central:			
Ala.	406	1	407
Ky.	545	---	545
Miss. and Tenn.	95	---	95
Total	1,046	1	1,047
West South Central:			
Ark., La., Okla.	227	2	229
Tex.	1,266	206	1,472
Total	1,493	208	1,701
Rocky Mountain:			
Ariz., Colo., Nev., Utah	244	1	245
Pacific Coast:			
Calif. and Hawaii	996	11	1,007
Oreg.	212	---	212
Wash.	514	11	525
Total	1,722	22	1,744
U.S. total [2]	18,010	378	18,388

[1] Includes small quantities of scrap and pig iron consumed in crucible furnaces and vacuum melting.
[2] Data may not add to totals shown due to individual rounding.

Table 9.—Consumption of iron and steel scrap and pig iron in cupola furnaces in the United States in 1967, by districts and States.

(Thousand short tons)

District and State	Scrap	Pig iron	Total
New England:			
Conn	58	18	76
Me. and N. H	7	-----	7
Mass	172	45	217
R. I	56	13	69
Vt	26	6	32
Total	319	82	401
Middle Atlantic:			
N. J	324	78	402
N. Y	683	124	807
Pa	578	180	758
Total	1,585	382	1,967
East North Central:			
Ill	1,138	172	1,310
Ind	730	206	936
Mich	3,657	499	4,156
Ohio	2,066	284	2,350
Wis	599	180	779
Total	8,190	1,341	9,531
West North Central:			
Iowa	427	67	494
Kans	27	6	33
Minn	144	50	194
Mo	82	22	104
Nebr	25	-----	25
Total	705	145	850
South Atlantic:			
Fla. and Ga	47	15	62
Md	133	7	140
N. C	98	33	131
S. C	48	13	61
Va	380	105	485
W. Va	11	7	18
Total	717	180	897
East South Central:			
Ala	884	657	1,541
Ky	162	35	197
Tenn	346	124	470
Total	1,392	816	2,208
West South Central			
La. and Okla	53	12	65
Tex	440	89	529
Total	493	101	594
Rocky Mountain:			
Colo., Mont., Utah	98	39	137
Pacific Coast:			
Calif	351	71	422
Oreg. and Wash	28	1	29
Total	379	72	451
U.S. total [1]	13,877	3,162	17,039

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

Table 10.—Consumption of iron and steel scrap and pig iron in air furnaces in the United States in 1967, by districts and States

(Thousand short tons)

District and State	Scrap	Pig iron	Total
New England:			
Conn., Mass., N. H., R. I	46	12	58
Middle Atlantic:			
N. J. and N. Y	25	4	29
Pa	218	37	255
Total	243	41	284
East North Central:			
Ill	103	15	118
Ind. and Mich	210	13	223
Ohio	277	31	308
Wis	81	23	104
Total	671	82	753
West North Central:			
Iowa, Minn., Mo	20	3	23
South Atlantic, East and West South Central, Pacific Coast:			
Calif., Tex., W. Va	119	7	126
U.S. total [1]	1,099	145	1,244

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

Table 11.—Consumption of iron and steel scrap in blast furnaces in the United States in 1967, by districts and States

(Thousand short tons)

District and State	Scrap
Middle Atlantic:	
N. Y	326
Pa	1,420
Total	1,746
East and West North Central:	
Ill	508
Ind., Mich., Minn	523
Ohio	1,289
Total	2,320
South Atlantic, East and West South Central:	
Ala. and Tex	296
Ky., Md., W. Va	232
Total	528
Rocky Mountain:	
Colo. and Utah	130
U.S. total	4,724

Tabel 12.—Consumption of iron and steel scrap, in 1967 by type of manufacturers and grades

(Thousand short tons)

Grades of scrap	Steel ingots and castings	Steel castings	Iron foundries and miscellaneous users
Steel scrap, excluding rerolling rails:			
Carbon	58,200	2,916	5,462
Alloy, excluding stainless	2,683	151	171
Stainless	797	34	32
Cast iron, including borings	5,500	368	9,047
Total	67,180	3,469	14,712

Table 13.—Consumption of iron and steel scrap, by grades, by district and States, in 1967

(Thousand short tons)

District and State	Carbon steel (excludes re-rolling rails)	Alloy steel (excludes stainless)	Stainless steel	Cast iron (includes borings)
New England:				
Conn.	78	8	32	61
Maine	6	----------	--------	9
Mass.	62	----------	2	133
R. I.	46	3	--------	61
Vt.	7	----------	--------	20
Total	199	11	34	284
Middle Atlantic:				
N. J.	409	12	4	295
N. Y.	3,184	79	83	746
Pa.	12,671	1,477	399	2,262
Total	16,264	1,568	486	3,303
East North Central:				
Ill.	6,784	181	40	1,390
Ind.	8,176	118	30	915
Mich.	5,181	34	94	2,722
Ohio	11,081	729	99	2,146
Wisc.	557	5	4	451
Total	31,779	1,067	267	7,624
West North Central:				
Iowa	443	----------	--------	220
Kans.	98	----------	--------	25
Minn.	294	5	--------	149
Mo.	867	9	2	173
Nebr.	15	----------	--------	23
Total	1,717	14	2	590
South Atlantic:				
Del.	2,794	20	57	216
Fla.	126	----------	--------	6
Ga.	424	----------	--------	32
N. C.	112	----------	--------	91
S. C.	6	5	--------	41
Va.	321	2	--------	230
W. Va.	1,749	5	--------	29
Total	5,532	32	57	645
East South Central:				
Ala.	2,451	82	------------	714
Ky.	1,230	104	4	169
Miss.	63	----------	--------	----------
Tenn.	149	----------	--------	229
Total	3,893	186	4	1,112
West South Central:				
Ark. and La.	49	----------	--------	8
Okla.	196	----------	--------	31
Tex.	2,288	42	2	534
Total	2,533	42	2	573
Rocky Mountain:				
Ariz., Colo., Mont., Nev., Utah	1,506	52	--------	229
Pacific Coast:				
Calif. and Hawaii	2,505	16	10	474
Oreg.	205			2
Wash.	445	17	1	79
Total	3,155	33	11	555
U.S. total	66,577	3,005	863	14,915

Table 14.—Home scrap produced in 1967, by source and type of manufacturers

(Thousand short tons)

	Source of scrap			Total
	Recirculating [1]	Obsolete [2]	Other, including slag	
Manufacturers of steel ingots and castings	38,577	3,374	2,361	44,312
Manufacturers of steel castings	1,442	9	17	1,468
Iron foundries and miscellaneous users	6,283	113	136	6,532
Total	46,302	3,496	2,514	52,312

[1] Includes home, plant, or recycled iron and steel scrap.
[2] Includes molds, stools, machinery, and buildings; excludes rerolling rails.

Table 15.—Consumers receipts and total consumption of iron and steel scrap in 1967, by grades

(Thousand short tons)

Grades of scrap (excludes rerolling rails)	Receipts			Total consumption
	From dealers	From others	Total	
Carbon steel:				
Low-phosphorus plate and punchings	2,506	823	3,329	4,051
Cut structural and plate	1,074	23	1,097	1,222
Steel car wheels	165	6	171	179
No. 1 heavy melting	4,729	2,438	7,167	28,049
No. 1 and electric furnace bundles	4,685	1,819	6,504	7,213
No. 2 and all other bundles	4,153	541	4,694	5,354
Turnings and borings	2,360	198	2,558	2,913
Slag scrap (iron content)	282	626	908	2,939
All other carbon steel	3,596	1,239	4,835	14,659
Alloy steel, excludes stainless	381	173	554	3,004
Stainless steel	307	53	360	863
Cast iron:				
Borings	697	357	1,054	1,595
All other cast iron scrap	3,812	941	4,753	13,320
Total	28,747	9,237	37,984	85,361

Table 16.—Consumers stocks of iron and steel scrap and pig iron Dec. 31, 1967, in the United States, by districts and States

(Thousand short tons)

District and State	Scrap	Pig iron
New England:		
Conn	14	3
Maine and N. H	1	-----
Mass	11	6
R. I	16	5
Vt	2	-----
Total	44	14
Middle Atlantic:		
N. J	84	14
N. Y	452	444
Pa	1,580	502
Total	2,116	960
East North Central:		
Ill	1,026	263
Ind	864	76
Mich	432	173
Ohio	940	533
Wis	53	28
Total	3,315	1,073
West North Central:		
Iowa	58	6
Kans	5	1
Minn	73	15
Mo	73	5
Nebr	2	-----
Total	211	27
South Atlantic:		
Del. and Md	268	14
Fla	13	-----
Ga	35	1
N. C	9	1
S. C	1	1
Va	29	11
W. Va	168	73
Total	523	101
East South Central:		
Ala	299	446
Ky., Miss	146	37
Tenn	13	7
Total	458	490
West South Central:		
Ark., La., Okla	36	3
Tex	218	46
Total	254	49
Rocky Mountain: Ariz., Colo., Mont., Nev., Utah	358	88
Pacific Coast:		
Calif. and Hawaii	355	27
Ore	34	-----
Wash	123	12
Total	512	39
U.S. total [1]	7,793	2,842

[1] Data may not add to totals shown due to individual rounding.

Table 17.—Consumer stocks of iron and steel scrap, by grades, by districts and States, Dec. 31, 1967

(Thousand short tons)

District and State	Carbon steel (excludes re-rolling rails)	Alloy steel (excludes stainless)	Stainless steel	Cast iron (includes borings)
New England:				
Conn.	5	(1)	(1)	6
Mass.	3	--------	--------	8
N. H.	(1)	--------	--------	--------
R. I.	12	(1)	--------	3
Vt.	1	--------	--------	1
Total	21	--------	--------	18
Middle Atlantic:				
N. J.	41	14	--------	42
N. Y.	346		(1)	71
Pa.	1,117	168	40	256
Total	1,504	182	40	369
East North Central:				
Ill.	890	19	15	112
Ind.	697	9		148
Mich.	297	4	7	125
Ohio	744	33	15	149
Wis.	36	--------	--------	17
Total	2,664	65	37	551
West North Central:				
Iowa	47	--------	--------	11
Kans. and Nebr.	6	--------	--------	1
Minn.	58	--------	--------	15
Mo.	55	--------	--------	18
Total	166	--------	--------	45
South Atlantic:				
Del.	(1)	(1)	--------	(1)
Fla.	13	--------	--------	--------
Ga.	33	--------	--------	2
Md.	177	(1)	(1)	62
N. C.	(1)	--------	--------	(1)
S. C.	--------	--------	--------	(1)
Va.	21	--------	--------	8
W. Va.	162	(1)	--------	5
Total	406	--------	--------	77
East South Central:				
Ala.	233	--------	--------	66
Ky.	116	(1)	(1)	6
Miss.		--------	--------	--------
Tenn.	7	--------	--------	7
Total	356	--------	--------	79
West South Central:				
Ark.	4	--------	--------	--------
La.		--------	--------	1
Okla.	(1)	--------	--------	(1)
Tex.	197	4	--------	17
Total	201	4	--------	18
Rocky Mountain:				
Ariz., Colo., Mont., Nev., Utah	242	(1)	--------	111
Pacific Coast:				
Calif. and Hawaii	271	3	(1)	80
Oreg.	31	--------	(1)	1
Wash.	99	1	--------	23
Total	401	4	--------	104
Other States	51	37	31	9
U.S. total [2]	6,010	294	108	1,383

[1] Combined with other States to avoid disclosing individual company confidential data.
[2] Data may not add to totals due to individual rounding.

Table 18.—Consumer stocks, production, receipts, consumption, and shipments of iron and steel scrap in 1967, by grades

(Thousand short tons)

Grades of scrap (excludes rerolling rails)	Stocks Jan. 1 [r]	Home scrap produced	Receipts from dealers and all others	Total consumption	Shipments	Stocks Dec. 31
Steel scrap:						
Carbon	6,274	38,859	31,263	66,578	3,808	6,010
Alloy, excludes stainless	316	2,531	555	3,005	103	294
Stainless	116	531	359	863	37	106
Cast iron, including borings	1,482	10,391	5,807	14,915	1,382	1,383
Total	8,188	52,312	37,984	85,361	5,330	7,793

[r] Revised.

Table 19.—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:				
1966 [r]	6,822	389	982	8,193
1967	6,538	342	913	7,793
Pig iron stocks:				
1966 [r]	2,481	25	456	2,962
1967	2,433	25	384	2,842

[r] Revised.

Table 20.—Average monthly price and composite price for No. 1 heavy melting scrap in 1967

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price [1]
January	$28.50	$27.50	$27.50	$27.83
February	28.00	26.50	28.50	27.66
March	29.50	26.50	28.25	28.00
April	27.50	26.50	27.50	27.17
May	26.70	25.30	27.50	26.50
June	27.50	25.50	26.50	26.50
July	27.75	25.75	27.00	26.84
August	29.00	26.50	27.50	27.65
September	29.75	26.50	27.50	27.92
October	27.90	25.70	27.70	27.10
November	29.50	27.25	28.50	28.41
December	30.00	30.00	29.50	29.84
Average:				
1967	28.47	26.63	27.79	27.62
1966	32.15	30.48	29.98	30.87

[1] Composite price, Chicago, Pittsburgh, Philadelphia.

Source: Iron Age, Jan. 4, 1968.

Table 21.—Stocks, production, receipts, consumption, and shipments of pig iron

(Thousand short tons)

Year	Stocks Jan. 1	Production	Receipts	Consumption	Shipments	Stocks Dec. 31
1966	2,330	91,724	8,493	91,770	r 7,809	2,968
1967	2,968	86,804	7,541	87,371	7,100	2,842

r Revised.

Table 22.—U.S. exports of iron and steel scrap, by countries

(Short tons)

Destination	Iron and steel scrap including tinplate and terneplate scrap		Rerolling material	
	1966	1967	1966	1967
Argentina	22,214	22,317		
Australia	178	3,045		
Belgium-Luxembourg	886	2,322		
Brazil	193	858		
Canada	739,442	542,373	2,989	1,132
Colombia	11,263	5,145		
Denmark		6,775		
France	8,712	13,851		
Germany, West	14,709	1,477		
Hong Kong	368	409		
Italy	321,781	217,139		
Japan	3,079,256	5,300,261	22,359	19,211
Korea, South	279,410	306,757	13,938	91,928
Mexico	779,602	747,280	3,476	8,783
Nansei and Nanpo Islands	4,522		3,417	
Netherlands	761	962		
Pakistan	20,208	24		
Peru	23,727	20		
Philippines	80	11,819		
Spain	84,759	85,472		
Sweden	45,834	27,943		
Taiwan	128,970	83,076	61,080	15,651
Thailand	157	12,022		
Turkey	35,413	28,977		
United Arab Republic	41,651	63,986		
United Kingdom	647	1,370		
Venezuela	26,409	17,608		25,748
Viet-Nam, South	576	197		
Yugoslavia	100,749			
Other	1,189	692		
Total:				
Short tons	5,773,666	7,504,177	107,259	162,453
Value (thousands)	$172,418	$245,303	$5,043	$5,933

Table 23.—U.S. exports and imports for consumption of iron and steel scrap by classes

Class	1966 Short tons	1966 Value (thousands)	1967 Short tons	1967 Value (thousands)
Exports:				
Nos. 1 and 2 heavy melting steel scrap	3,172,004	$95,852	3,912,908	$122,429
Nos. 1 and 2 baled steel scrap	1,441,164	33,329	1,900,584	45,808
Borings, shovelings, and turnings	377,223	7,989	462,152	9,009
Iron scrap	260,490	7,716	446,801	12,777
Rerolling material	107,259	5,043	162,453	5,933
Other steel scrap (terneplated and tinplated)	522,785	27,532	781,732	55,280
Total	5,880,925	177,461	7,666,630	251,236
Imports:				
Iron and steel scrap	390,205	7,672	215,635	8,181
Tinplate scrap	16,450	535	13,527	381
Total	406,655	8,207	229,162	8,562

Table 24.—U.S. imports for consumption of iron an steel scrap, by countries

(Short tons)

Country	1966	1967
Australia	210	112
Belgium-Luxembourg	1,965	-------
Bermuda	1,064	-------
Canada	395,439	215,276
French West Indies	224	-------
Germany, West	498	4
India	174	499
Mexico	17	382
Netherlands	6,656	166
New Zealand	21	16
Rumania	-------	11,010
United Kingdom	342	1,557
Other	45	140
Total:		
Short tons	406,655	229,162
Value (thousands)	$8,207	$8,562

Iron Oxide Pigments

By F. E. Brantley [1]

Markets for iron oxides used as pigments generally followed the normal growth pattern of recent years. Ferritegrade iron-oxide demand continued its strong upward trend. The requirements of the fast-growing ferrite and electronic industries in 1966 and 1967 exceeded the capacities of domestic producers to supply certain desired grades, and imports were called on to relieve the shortages. The situation moderated only slightly in 1967, and imports remained up.

Mine production and crude pigments sold decreased approximately one-third from the corresponding 1966 figures, and was similar to a like decrease which occurred in 1961.

Table 1.—Salient iron oxide pigments statistics in the United States

	1963	1964	1965	1966	1967
Mine production short tons	56,700	59,300	57,000	63,200	39,900
Crude pigments sold or used do	55,900	59,700	56,200	63,900	41,800
Value thousands	$500	$446	$419	$476	$326
Finished pigments sold short tons	118,800	119,500	127,500	130,700	127,300
Value thousands	$21,135	$22,991	$23,549	$24,841	$26,720
Exports short tons	4,200	5,100	4,700	4,800	3,100
Value thousands	$1,306	$1,817	$1,380	$1,307	$1,312
Imports for consumption short tons	13,700	16,300	17,800	24,600	23,400
Value thousands	$1,469	$1,817	$2,165	$3,163	$3,203

DOMESTIC PRODUCTION

Crude iron oxide pigment material was mined by six companies in six States, and sold by seven companies in seven States. A substantial drop occurred in crude mine output and sales which may have been the result of several contributing factors. These included a decreased demand in some industrial areas such as automobile and appliance manufacture, and construction materials, and an overall inventory adjustment. Thirteen companies with 18 plants in nine States sold finished iron oxide pigments. Several finished iron oxide pigments producers improved processing facilities or added new units to obtain increases in production capacity.

The St. Joseph Lead Co. prepared to market a high-purity iron oxide powder late in the year. The powder was to be produced and processed by the Meramec Mining Co., at its Sullivan, Mo. plant, and sold for ferrite manufacture.

Consolidated Quebec Smelting and Refining of Canada planned to build a ferrite plant near Ogdensburg, N.Y. Iron oxide would be provided from its subsidiary in Ontario, Ferrox Iron Ltd.

CONSUMPTION AND USES

Although the quantity of material involved was down 3,000 tons, overall value of sales by U.S. processors of finished iron oxide pigments exceeded last year's record, reaching a total of $26.7 million. This was due to price increases that went into effect near the end of 1966 and early in 1967. Prices were increased on some im-

[1] Commodity specialist. Division of Mineral Studies.

ported pigments, but not to the extent of domestic price increases. Some of the increasing uses for high-purity iron oxides included ferrite applications in color television sets, small motors and alternators for automobiles, permanent magnets for closure devices, cordless appliances, and various types of magnetic tapes.

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	1966		1967	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Natural:				
Brown:				
Iron oxide (metallic)[1]	15,438	$2,567	12,881	$2,226
Umbers:				
Burnt	3,483	708	3,802	789
Raw	665	135	667	135
Red:				
Iron oxide	34,493	1,925	[2] 34,752	[2] 2,060
Sienna, burnt	1,178	373	1,164	387
Pyrite cinder	2,959	155	([2])	([2])
Yellow:				
Ocher [3]	4,881	277	4,654	262
Sienna, raw	655	193	600	174
Total natural	63,752	6,333	58,520	6,033
Manufactured:				
Black: Magnetic	3,154	991	3,781	1,654
Brown: Iron oxide	4,842	2,444	4,792	2,466
Red:				
Pure red iron oxides:				
Calcined copperas	21,776	6,113	19,486	5,635
Other chemical processes	6,588	1,974	[4] 12,109	[4] 3,463
Other manufactured red iron oxides	2,088	325	([4])	([4])
Venetian red	652	99	670	105
Yellow: Iron oxide	19,258	5,358	23,177	6,664
Total manufactured	58,358	17,304	64,015	19,987
Unspecified including mixtures of natural and manufactured red iron oxides	8,548	1,204	4,803	700
Grand total	130,658	24,841	127,338	26,720

[1] Includes some black magnetite and vandyke brown.
[2] Pyrite cinder included with red iron oxide for 1967.
[3] Includes some yellow iron oxide.
[4] Other manufactured red iron oxides included with other chemical processes for 1967.

PRICES

Price increases of some domestic types of iron oxide pigments were announced late in 1966 and extended into 1967. Advances ranged from 0.5 to 1 cent per pound for natural and manufactured grades. In general umbers and siennas were not changed. The price ranges shown in table 3 reflect variations which may be due to differences in quantity, quality, locality, or individual suppliers' views.

Table 3.—Prices quoted on finished iron oxide pigments, per pound, in bags, unless otherwise noted, as of December 31, 1967

Pigment	Low	High	Pigment	Low	High
Black:			Red:		
Pure	$0.1475	$0.1850	Domestic primers	$0.0575	$0.0575
Synthetic	.1275	.1300	Persian Gulf [1]	.0925	.1000
Brown:			Pure synthetic	.1425	.1625
Pure, synthetic	.1550	.1875	Spanish, docks, New York [1]	.0550	.0625
Metallic	.0625	.0775	Sienna, burnt	.1100	.2200
Umber, American, burnt [1]	.0775	.1150	Yellow:		
Umber, American, raw [1]	.0925	.1100	Ocher, domestic	.0300	.0425
Vandyke: American [1]	.1075	.1200	Ocher, French type	.0675	.0725
Sienna, American, burnt [1]	.1600	.2150	Pure, light lemon	.1325	.1525
			Other shades [1]	.1250	.1375

[1] Barrels
Source: Oil, Paint and Drug Reporter, American Paint Journal, and pigment processors.

FOREIGN TRADE

Tariff reductions on iron oxide pigments under the Kennedy Round trade agreements of 1967 were authorized by Presidental Proclamation 3822, signed December 16, 1967. These were to be effective January 1, 1968 as follows:

TSUS No.	*Pigments containing iron*	*Rate of duty 1967*	*1968*
	Iron oxides and iron hydroxides:		
473.30	Synthetic	10 percent ad valorem	9 percent ad valorem
	Natural:		
473.32	Ochers	0.125¢ per pound	0.1¢ per pound
473.36	Siennas	0.25¢ per pound	0.2¢ per pound
473.38	Umbers	0.1875¢ per pound	0.16¢ per pound
473.40	Other	16 percent ad valorem	14.5 percent ad valorem
	Other pigments:		
473.86	Vandyke brown	17 percent ad valorem	15 percent ad valorem

Staged annual reductions through 1972 were provided for and at the end of the 5-year period the duties would average about 50 percent less than in 1967.

Imports of natural iron oxide pigments remained at the same level in 1967 as for 1966. Manufactured iron oxide pigments in 1967 showed a slight decrease after a 51-percent increase in 1966 over that of 1965. Exports were down in 1967 by 34 percent although the value was virtually unchanged. Decreased shipments to Canada accounted for most of the loss, which apparently resulted from an increase in Canadian plant capacity. Also increased U.S. prices may have had some effect.

The Republic of South Africa supplied all of the ocher imported for consumption in the United States. Crude and processed siennas originated in Italy, the United Kingdom, and Cyprus. Italy supplied 63 percent of the total. Umbers came from Cyprus, Italy, and the United Kingdom, while all imported Vandyke brown was from West Germany.

Sixty-two percent of the synthetic iron oxide pigments imported were supplied by West Germany, 32 percent by Canada, 5 percent by the United Kingdom, with the remainder from the Netherlands, Japan, and Spain.

Table 4.—U.S. exports of iron oxide pigments, by countries

Destination	1966 Short tons	1966 Value (thousands)	1967 Short tons	1967 Value (thousands)
Argentina	102	$46	97	$47
Australia	216	103	328	189
Belgium-Luxembourg	10	9	10	6
Brazil	49	28	58	35
Canada	2,426	399	976	354
Chile	17	7	5	3
Colombia	26	9	10	4
France	153	53	143	63
Germany, West	156	61	467	166
Greece	5	3	27	17
Guatemala	22	6	37	10
Hong Kong	6	4	1	1
India	21	7	10	4
Italy	80	49	31	12
Japan	205	72	98	36
Mexico	9	7	28	17
Netherlands	75	36	72	85
New Zealand	25	3	27	6
Panama	13	3	14	4
Philippines	128	33	90	34
Sweden	42	13	3	1
Switzerland	6	6	5	4
United Kingdom	205	70	199	79
Venezuela	116	16	106	29
Viet-Nam, South	509	218	164	48
Other countries	131	46	117	58
Total	4,753	1,307	3,123	1,312

Table 5.—U.S. imports for consumption of selected iron oxide pigments

Pigments	1966 Short tons	1966 Value (thousands)	1967 Short tons	1967 Value (thousands)
Natural:				
Ocher, crude and refined	146	$8	236	$16
Siennas, crude and refined	1,192	145	951	104
Umber, crude and refined	3,762	135	4,275	162
Vandyke brown	554	49	272	24
Other [1]	3,662	200	3,670	271
Total	9,316	537	9,404	577
Manufactured (synthetic)	15,234	2,626	14,034	2,626
Grand total	24,550	3,163	23,438	3,203

[1] Classified by the Bureau of the Census as "Natural iron-oxide and iron-hydroxide pigments, n.s.p.f."

Table 6.—U.S. imports for consumption of iron-oxide and iron-hydroxide pigments, n.s.p.f.[1] by countries

Country	Natural				Synthetic			
	1966		1967		1966		1967	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Canada	(2)	(2)	73	$4	4,373	$888	4,494	$969
France	165	$15	55	5	295	39	-----	-----
Germany, West	30	3	-----	---	9,634	1,552	8,660	1,513
Italy	-----	---	10	1	-----	-----	-----	-----
Japan	-----	---	-----	---	5	1	1	1
Netherlands	-----	---	10	1	-----	-----	72	15
Spain	3,315	162	3,244	225	-----	-----	24	2
Sweden	-----	---	-----	---	1	1	-----	-----
United Kingdom	152	20	278	35	926	145	783	126
Total	3,662	200	3,670	271	15,234	2,626	14,034	2,626

[1] Not specifically provided for.
[2] Less than ½ unit.

WORLD REVIEW

Canada.—One plant, in Quebec, Red Mill Industries Limited, operated to produce natural pigment-grade iron oxide from limonite ores. High-grade natural iron oxide, and ferrites were produced in Ontario, by Ferrox Iron Ltd.

Germany, West.—New construction completed by Farbenfabriken Bayer AG, Leverkusen, included a yellow iron oxide pigment unit at its Uedingen plant, expanded red iron oxide pigment capacity, and additional black iron oxide pigment production facilities. Output was to be largely for export.

United Kingdom.—Pfizer Ltd. announced an expansion of its iron oxides works at Stalybridge, Cheshire, to meet demands in the United Kingdom for high-purity iron oxide and for future export markets. New processing equipment was installed also to allow production of additional products.

TECHNOLOGY

Technologic trends in iron oxide pigment production have been directed toward fine sizing, uniformity, reproducibility of colors, and maximum dispersion and coverage of the products.

The principal technical developments of the past year were in the preparation of high-quality ferromagnetic materials or ferrites. In this field iron oxides are finding new uses in addition to the traditional pigment applications. A growing source of high-purity iron oxide was seen in the increased use of hydrochloric acid to replace sulfuric acid in the pickling lines of major steel companies. Regeneration of the hydrochloric acid (HCl) can be done more economically than sulfuric acid (H_2SO_4), and ferric oxide (Fe_2O_3) results as a byproduct. With recovery systems now in operation, the ferric oxide product contains only minor amounts of impurities and with minimal treatment can be used for pigment or ferrite production.

The use of high-purity iron oxide in solid propellants for better control of the burning rate was cited by the research director of one of the pigment manufacturers in discussing new applications of the high-purity material.

Iron oxide was given provisional approval for use as a color additive in certain animal foods. One company announced a line of synthetic iron oxides for use in cosmetics which met the Food and Drug requirements of less than 2 parts per million arsenic and 10 parts per million lead.

Kyanite and Related Minerals

By James D. Cooper [1]

Output of domestic kyanite concentrates reached a new high in 1967, increasing for the ninth consecutive year. The quantity sold or used however declined slightly. Although no new firms entered the field during the year, the established kyanite producers increased capacity at their processing facilities in preparation for generally growing demand, and one new synthetic mullite firm in Georgia reached the pilot plant stage. Demand for mullite brick and shapes declined along with demand for most other types of refractories, and as a consequence output of synthetic mullite was 19 percent lower than that of 1966.

Kyanite, sillimanite, andalusite, dumortierite, topaz and synthetic mullite are included in this chapter because all are aluminum silicates, have similar properties, and can be used to produce mullite refractories.

DOMESTIC PRODUCTION

Demand for kyanite was slow during the first half of 1967 following a return to normal of production of calcined refractory bauxite which had been in short supply. The demand for kyanite improved during the final 6 months, sparked by exceptionally high exports in the third quarter, followed by increased output by the domestic steel producers, the major refractories consuming industry, in the fourth quarter.

Total output of domestic kyanite concentrate in 1967 increased 4 percent while that sold or used by producers declined about 1 percent in quantity, but increased 1 percent in value. Crude ore production was up 6 percent in 1967, indicating a very slight decline in the concentrate-to-ore ratio. All kyanite production facilities were owned by two firms, therefore quantitative data are withheld to prevent disclosure of individual company data. The producers in 1967 were Kyanite Mining Corp., with mines near Farmville and Dillwyn, Va., and Combustion Engineering, Inc., with two kyanite mining subsidiaries—Commercialores, Inc., Clover, S. C. and Aluminum Silicates, Inc., Lincolnton, Ga.

Synthetic mullite output included high-purity products made from Bayer process alumina and silica sand, and others made from siliceous bauxite and bauxite-clay mixtures. Electrically fused mullite was made in electric arc furnaces, and sintered products were made in rotary, periodic, and tunnel kilns. The following firms reported production in 1967:

- 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.)
- General Abrasive Co., Inc., Niagara Falls, N.Y. (plant at Niagara Falls, N.Y.)
- Harbison-Walker Refractories Co., Pittsburgh, Pa. (plant at Eufaula, Ala.)
- Norton Co., Worcester, Mass. (plant at Huntsville, Ala.)
- H. K. Porter Co., Inc., Refractories Division, Pittsburgh, Pa. (plant at Shelton, Conn.)
- Remmey Division of A. P. Green Fire Brick Co., Philadelphia, Pa. (plant at the same address)
- The Chas. Taylor Sons Co., subsidiary of National Lead Co., Cincinnati, Ohio (plant at South Shore, Ky.)
- Tennessee Electro Minerals Co., Greeneville, Tenn. (plant at Greeneville, Tenn.)

[1] Commodity specialist, Division of Mineral Studies.

Mullite Corporation of America, Andersonville, Georgia, reached pilot plant stage by the end of 1967 and planned to start operating on a small scale with two periodic kilns early in 1968, producing synthetic mullite from bauxite and kaolin mined near Andersonville.

Table 1.—Synthetic mullite production in the United States

Year	Short tons	Value (thousands)
1963	29,588	$3,529
1964	36,108	4,450
1965	40,049	4,866
1966	49,551	5,961
1967	40,288	4,811

CONSUMPTION AND USES

All domestically produced kyanite was minus 35-mesh material, and although some was used as the fine fraction in mullite brick and shapes, most of it went into refractory mortars, ramming mixes, and plastic refractories. Synthetic mullite was used mostly for producing refractory brick and shapes, but significant quantities were used in other refractories and special ceramics.

Refractory applications accounted for most of the kyanite and mullite used in the United States, with the iron and steel industries getting the largest quantities. Large sections of iron blast furnace stoves and stacks were lined with mullite in preference to other refractories because of the longer service life, lower installed cost, or other operating advantages such as resistance to corrosion and spalling. Mullite was also used extensively in electric furnaces for ferrous and nonferrous metal and alloy production, in glass furnaces, and in auxilliary pouring and handling equipment. Mullite has advantages over all other types of refractories for lining steel degassing chambers. Other important uses include kiln linings and kiln furniture, and linings for frit and enameling furnaces.

Small quantities of kyanite and mullite were used in ceramic and glass mixes, foundry mold facings, lightweight aluminum silicate wool insulation, ceramic honeycomb, and other specialty items.

PRICES

Published prices for domestic and imported kyanite remained unchanged throughout 1967, according to Metals Week. They were as follows:

Domestic kyanite, short ton, f.o.b. Virginia and South Carolina:
- 35-mesh, carload lots, bulk . . $47
- 35-mesh, carload lots, bags . . 50
- 200-mesh, carload lots, bags . . 58

Imported kyanite, 60-percent grade, c.i.f. Atlantic ports $79–84

The f.o.b. prices for Georgia kyanite were approximately the same as those quoted for Virginia and South Carolina material. An extra charge of about $10 per ton was made by all domestic producers for conversion of kyanite to mullite.

FOREIGN TRADE

Exports of material classified as kyanite and allied minerals including mullite, increased 25 percent in quantity and value in 1967. Greatly increased kyanite exports in recent years have been due in large part to the decline in output of high-quality sillimanite in the Republic of South Africa. Imports of lump kyanite reached a peak in 1951 and have been declining since, due to development of synthetic mullite of equal or better quality than that made from Indian or African kyanite group minerals. In 1967, imports reached their lowest point in the 30-year period since kyanite import statistics first became available.

Table 2.—U.S. exports and imports for consumption of kyanite and related minerals

	1965		1966		1967	
	Short tons	Value	Short tons	Value	Short tons	Value
Exports:						
Argentina	115	$7,842	------	---------	24	$2,236
Australia	1,558	111,777	1,291	$96,036	393	28,328
Belgium-Luxembourg	144	8,537	234	19,842	582	52,448
Canada	2,117	127,968	4,270	316,619	5,012	337,954
France	168	15,754	92	8,675	291	51,037
Germany, West	1,349	78,185	1,072	60,144	1,492	87,958
Italy	431	26,824	587	39,934	1,564	120,887
Japan	1,127	134,134	5,150	327,335	7,143	427,477
Mexico	1,070	70,616	1,531	91,386	1,610	110,706
Netherlands	122	7,354	145	5,819	60	2,280
United Kingdom	1,150	85,802	2,205	121,608	2,414	111,498
Venezuela	594	32,893	365	18,702	291	15,816
Other countries	293	24,161	397	24,625	552	59,817
Total	10,238	731,847	17,339	1,130,725	21,428	1,408,442
Imports:						
India	3,815	$158,051	3,404	$140,145	1,821	$75,158
Other countries	232	8,877	1	660	------	---------
Total	4,047	166,928	3,405	140,805	1,821	75,158

WORLD REVIEW

Australia.—Sillimanite output in 1966 was 2,984 tons, a slight increase from the total of 2,860 tons produced in 1965.

India.—During the first half of 1967 kyanite production was 28,000 short tons and sillimanite production was 3,158 short tons. Exports for the 6-months period totaled 26,969 tons of kyanite and 1,597 tons of sillimanite.

For 1966, the last full year for which data are available, kyanite output was a record 70,183 tons, exceeding the previous high established in 1962 by more than 15,000 tons. Exports in 1966, mostly to European countries, were 39,381 tons and local use accounted for 8,000 tons, leaving a substantial carryover for future disposal. Sillimanite output was 11,388 tons in 1966 compared with 12,430 tons in 1965. Of this, exports totaled 6,980 tons, and most of the balance was used in domestic production of refractories.

The Lapsa Buru kyanite deposits, which cover a 10-square-mile area around the hill for which the deposits were named, were described together with information on mining, processing, and marketing methods, domestic consumption, and export trade.[2]

Republic of South Africa.—Sillimanite production in the first 9 months of 1967 was 28,484 short tons, down slightly from the same period in 1966 when 30,836 tons was produced. Andalusite production rose in the first 9 months of 1967 to 19,696 tons compared with 16,433 tons for the same period of 1966.

TECHNOLOGY

Bureau of Mines research on kyanite and related minerals included improvements in beneficiation methods, completion of sampling and testing of kyanite from the Woodrat Mountain deposit in Idaho, and initiation of a field and laboratory study of kyanite-sillimanite in Madison County, Ga. A kyanite-mullite marketing study for the Western States was underway. Important progress was made toward improving the recovery of kyanite from crude ore, and in extracting commercial-quality kyanite concentrates from the magnetic rejects presently wasted by producers. The Bureau also announced development of a patented process for synthesizing high-strength aluminum silicate whiskers suitable for reinforcement of metals and plastics.

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[2] Industrial Minerals (London). Lapso Buru, Principle (sic) Souce of India's Kyanite. No. 1, October 1967, pp. 15–17.

On the basis of overall economy and performance, mullite ranked among the highest of 18 types of refractories tested for use in lining chambers for vacuum degassing of steel. Zirconia and high-alumina products were more stable but considerably more expensive. High-magnesia products have higher thermal conductivity and tend to spall under operating conditions.[3]

New products included a ceramic honeycomb made of mullite, and blown aluminum silicate wool fibers produced from melted kyanite. The honeycomb was used as a catalyst support in fume abatement reactors and as a black body radiation emitter, while the silicate wool was used as lightweight high-temperature insulation in spacecraft, aircraft, and portable boilers.

[3] Osterholtz, C. E., J. E. Werner, and K. A. Baab. Stability of Refractories During Vacuum Deoxidization of Steel. Am. Ceram. Soc. Bull., v. 45, No. 12, December 1966, pp. 1067–1070.

Lead

By Donald E. Moulds [1]

The domestic lead industry in 1967 experienced a reversal of the upward trend in production of primary and secondary lead initiated in 1963 and in consumption since 1960. In the first 6 months of the year the upward trend in primary production was maintained, with a 7-percent increase in mine output and a 5-percent increase in primary metal compared with the first 6 months of 1966. However, the strike, beginning on July 1 and extending into 1968, at primary smelters and refineries operated by American Smelting and Refining Company and International Smelting & Refining Co., significantly reduced metal ouput in the latter half of 1967 and also output at many mines dependent on these smelters. Lead consumption held relatively stable during the first 6 months with only a 1-percent reduction compared with the first 6 months of 1966, but fell more severely in the second half to a total for the year of 1.26 million tons, some 5 percent below the record 1.32 million tons in 1966. Imports of metal were at a record high level especially in the last 2 months of the year. The 374,000 tons imported in 1967 represented a 29-percent increase over the record high total of 1966 and indicated a favorable domestic demand induced by curtailed domestic production. Sales of Government lead were, however, small in comparison with those in prior years.

Stocks of metal at yearend indicated a relatively balanced supply and demand with primary metal stocks only 800 tons above the abnormally low 22,600 tons at the opening of the year. Consumer stocks increased only 15,400 tons, principally as refined soft lead.

The free 1967 world market position was also one of relative balance. The indicated mine production of 2.39 million tons, some 1.7 percent above that of 1966, augmented by secondary metal, resulted in a refined metal output of 3.02 million tons, a 0.6 percent gain, and compares with a 3.05-million-ton consumption of metal from all sources including Communist exports and U.S. stockpile. Producer stocks in the free world were indicated to have reached a high of 233,000 tons in April and thereafter decreased gradually to end the year at 180,000 tons.

The price of lead in the United States remained stable at 14 cents per pound, New York, throughout the year. The London Metal Exchange price opened the year at approximately 10 cents per pound (U.S. equivalent), gradually climbed to an average of 10.51 cents for the month of August, and then declined within a narrow range to end the year at 10.12 cents per pound (U.S. equivalent of the devalued pound).

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient lead statistics

	1963	1964	1965	1966	1967
United States:					
Production:					
Domestic ores, recoverable lead content ---- short tons	253,369	286,010	301,147	327,368	316,931
Value ---- thousands	$54,727	$74,936	$93,959	$98,964	$88,741
Primary lead (refined):					
From domestic ores and base bullion ---- short tons	239,660	294,254	305,007	318,646	258,507
From foreign ores and base bullion ---- short tons	155,072	155,175	113,242	122,089	121,387
Antimonial lead (primary lead content) ---- short tons	9,256	8,607	6,612	11,182	9,083
Secondary lead (lead content) short tons	493,471	541,582	575,819	572,834	553,772
Exports of lead materials excluding scrap short tons	1,092	10,194	7,811	5,435	6,536
Imports, general:					
Lead in ores and matte ---- do	147,742	123,257	122,661	143,991	124,067
Lead in base bullion ---- do	5,437	4,838	566	2,012	752
Lead in pigs, bars, and old short tons	235,902	212,898	226,883	288,821	373,887
Stocks Dec. 31 (lead content):					
At primary smelters and refineries short tons	120,836	84,398	83,443	115,473	125,479
At consumer plants ---- do	119,930	113,444	109,195	90,306	105,786
Consumption of metal, primary and secondary ---- short tons	1,163,358	1,202,138	1,241,482	1,323,877	1,260,516
Price: New York, common lead, average, cents per pound	11.14	13.62	16.00	15.12	14.00
World:					
Production:					
Mine ---- short tons	2,775,267	2,789,317	2,977,461	3,131,095	3,132,887
Smelter ---- do	2,667,567	2,784,736	2,880,565	2,988,350	3,076,348
Price: London, common lead, average, cents per pound	7.93	12.59	14.37	11.87	10.28

Legislation and Government Programs.—The Lead and Zinc Mining Stabilization Program was reactivated in October 1966 when the price of lead dropped below 14.5 cents per pound. Since the rules and regulations were changed to meet the revisions of Public Law 89–239, 57 of the 138 applicants were certified as eligible for supplemental payments under provisions of the program. Payments made in 1967 on lead sales in the last quarter of 1966 and on sales in 1967 totaled $48,852 on 6,733 tons of lead. Total payments on lead and zinc since inception of the program in October 1961 through 1967 amounted to $2.28 million of which $1.2 million was paid to 29 presently active participants and $1.1 million to 57 inactive or presently ineligible participants.

Government participation in exploration projects, primarily for lead, was withdrawn at the end of June 1962. The desire to augment national resources of antimony, bismuth, copper, and silver has, however, resulted in exploration assistance through the Office of Minerals Exploration, U.S. Geological Survey, which indirectly benefits the domestic lead resource base.

Legislative proposals for a system of flexible import controls on lead and zinc ore, metal, and certain manufactured articles, based on the relationship of primary producer stocks to producer shipments of refined metal, submitted in the first session of the 89th Congress, was approved by the Interior and Insular Affairs Committee of the Senate but no further action was taken prior to adjournment. The proposed legislation would authorize the Secretary of the Interior to impose import restrictions on ores, metal, and certain manufactured articles containing lead and/or zinc under certain prescribed statistical determinations.

Sale of government stockpile surplus lead, under Public Law 89–9 enacted March 1965, was conducted by General Services Administration on an open-sale, shelf-item basis throughout the year. Total sales in 1967 were 16,800 tons of which 15,300 tons was for domestic commercial consumption and 1,500 tons for government use. Withdrawals from inventory amounted to 27,500 tons during the year, thus reducing the total government lead inventory to 1,193,280 tons valued at $334 million and an additional 10,500 tons of antimonial lead valued at $3.1 million. The lead remaining for sale at yearend under the present 200,000-ton authorization, amounted to 26,460 tons for commercial consumption and 46,900 tons for government use.

The 11th session of the International Lead and Zinc Study Group was held in Geneva, Switzerland, on October 6–12 and was preceded by meetings of the various committees of the Study Group. Representatives of 25 countries attended and reviewed world statistics and estimates of production and consumption of lead for 1967 and 1968. The review concluded that the relative balance indicated for 1967 could change to a supply surplus of 180,000 tons provided the forecast of expanded output in the various countries was achieved. Discussions of the Study Group on matters of concern to the various countries included liberalization of trade, orderly marketing, price stabilization, and promotion of consumption.

The International Lead-Zinc Research Organization, incorporated in 1965 by 25 sponsoring companies located in eight countries, continued a $1.5 million program of research and development related to the use of lead and zinc in all end-use areas.

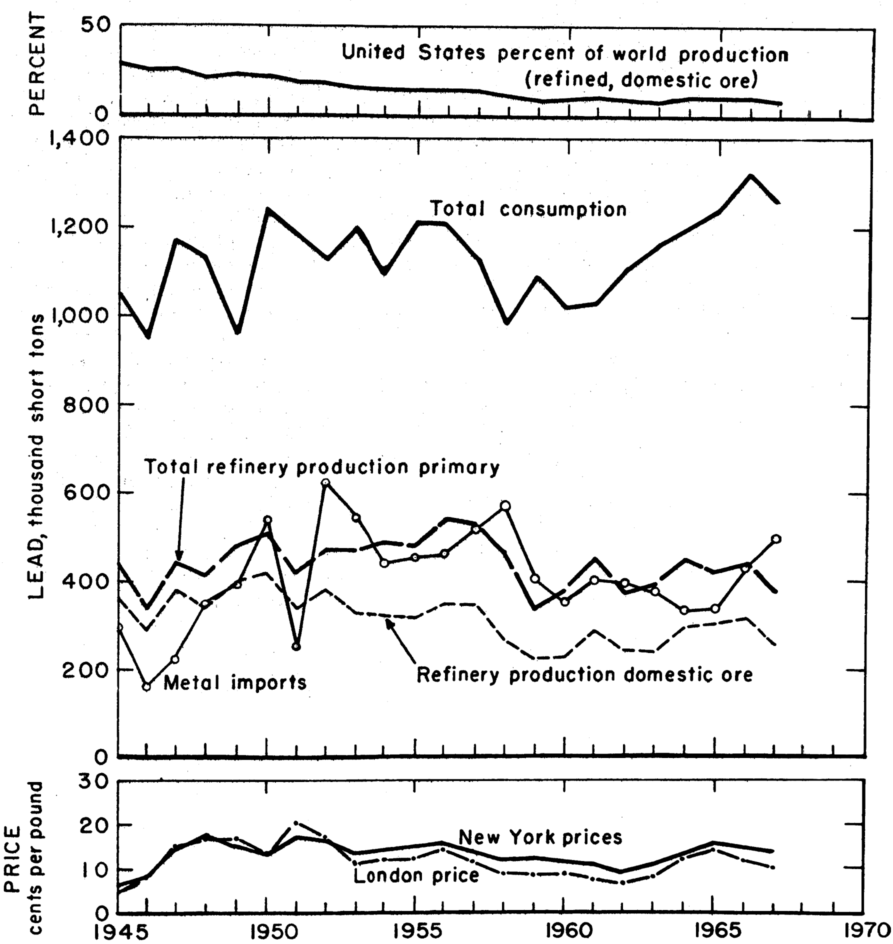

Figure 1.—Trends in the lead industry in the United States.

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic output of lead during the first 6 months of 1967 continued the upward trend initiated in 1963 and for the January-June period totaled some 8,000 tons (5 percent) above the like period in 1966. The total of 316,900 tons for the year, however, was 10,400 tons (3 percent) below that of the prior year and reflected curtailed operations in the Western States resulting from strike closure of several leading lead mines, inability of other mines to market concentrates, and the lack of byproduct lead from strike-closed copper and zinc mines and refining plants. December output of 21,900 tons of recoverable lead, also strike-curtailed, was the lowest since April 1963. The most severe tonnage reductions occurred in Idaho, Montana, Utah, and Washington. Output of lead in Montana was reduced primarily by the termination of operations at The Anaconda Company's zinc mines, which also recovered associated lead. Washington production declined due to the termination of output at the Van Stone mine on May 1 and to strike-curtailed output at the Pend Oreille mine. Strikes at the Lucky Friday and Galena mines in Idaho and United Park City and Tintic mines in Utah accounted for most of the decline in these States. Missouri contributed 48 percent of the domestic output in 1967 and posted a 15-percent gain over that of 1966 as new St. Joseph Lead Co. developments initiated production. Of the total domestic lead produced, four States produced 91 percent with Missouri contributing 48 percent; Idaho, 19 percent; Utah, 17 percent; and Colorado 7 percent.

Activity in the lead belt of Missouri continued at the high level of recent years as construction and development of new mines proceeded toward completion. St. Joseph Lead Co. continued lead concentrate production at the Federal, Indian Creek, and Viburnum mines and the new Fletcher mine and mill, producing 224,233 tons of lead concentrates in comparison with 189,225 tons in 1966. The Fletcher plant became operational in February and processed 509,163 tons of ore by yearend. Zinc is presently recovered from the ore and construction of a copper circuit was in progress. The new Goose Creek shaft to open ore reserves north of the Indian Creek mine was bottomed at 1,180 feet and surface facilities completed. First production from this mine is expected in the third quarter of 1968. A new rail connection from Keysville to Buck, Mo., was completed by the St. Louis–San Francisco Railway Co. in mid–1967. This connection will provide all rail haulage of concentrate from the Viburnum mine to Herculaneum smelter and reduce the truck haulage distance for Fletcher concentrates.[2]

Construction of the fully integrated lead mine, mill, and smelter complex of Missouri Lead Operating Co., a joint venture of American Metal Climax, Inc., and Homestake Mining Co., was nearing completion. Startup of the 50,000-ton annual lead capacity mine and mill and 100,000-ton-capacity smelter was expected in mid-1968.[3] Cominco American Inc., a joint venture of Cominco Inc. and Dresser Industries, Inc., continued development and construction at its Magmont mine-mill complex. The planned capacity of the plant is 50,000 tons of lead in concentrates annually and was expected to begin operations in mid-1968. The concentrates will be smelted at the Missouri Lead Operating Co. smelter.[4] Ozark Lead Co., a subsidiary of Kennecott Copper Corp., continued development and construction of the 60,000-ton annual lead capacity mine-mill complex at the Ellington mine with a scheduled startup in mid-1968. Sufficient ore had been stockpiled to more than meet requirements for the first year's operation.[5] Construction of the new lead smelter and refinery at Glover, Mo., by American Smelting and Refining Company, proceeded on schedule with startup expected in mid-1968. This smelter, with an initial monthly capacity of 5,500 tons of refined lead, will operate as a custom smelter handling concentrates from Ozark Lead Co. and other mines in the area.[6] The development of the Higdon ore body near Fredericktown, Mo., a joint venture of National Lead Co. and The Bunker

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[2] St. Joseph Lead Co. Annual Report. 1967, pp. 7–8.
[3] American Metal Climax, Inc. Annual Report. 1967, p. 10.
[4] Cominco Ltd. Annual Report. 1967, p. 8.
[5] Kennecott Copper Corp. Annual Report. 1967, p. 11.
[6] American Smelting and Refining Company. Annual Report. 1967, p. 7.

Hill Co., previously scheduled for completion in 1968, was indefinitely postponed during the year.

In other lead-producing areas, especially those producing silver, the search for new ore went forward at an accelerated rate throughout the year. Of special note was the joint venture projects in the Coeur d'Alene region in which unitization agreements have been completed to conduct deep exploration of adjacent properties. The Bunker Hill Co., Hecla Mining Co., and American Smelting and Refining Company have undertaken active exploration under this type of agreement. Operations along similar lines were undertaken in Colorado, Nevada, and Utah.

The Burgin mine of Kennecott Copper Corp., in the Tintic District, Utah, was closed by strike on July 15 for the remainder of the year. Production of lead in direct smelting ore, however, was 14,500 tons in comparison with 18,300 tons in 1966. Expansion programs were to be undertaken to increase the mining rate, and testing and design for a proposed 500-ton-per-day concentrator were completed. The Mayflower mine in the Park City District, Utah, operated by Hecla Mining Co., operated throughout the year as did the U.S. and Lark mine of United States Smelting, Refining and Mining Co. United Park City Mines were closed by strike on July 15, as was the Tooele, Utah, smelter of International Smelting and Refining Co. The smelter closure necessitated the storage of lead concentrates at various concentrating plants serving the operating mines throughout the last half of 1967.

Colorado output decreased slightly in 1967 although operations were essentially uninterrupted at the major mines—Idarado Mining Co., New Jersey Zinc Co., Standard Metals Mining Co., Federal Resources Corp., and Emperius Mining Co. Exploration and development activity was at a high level in 1967, especially in the areas of historic silver mines. In the Leadville, Creede, San Juan, Ouray, Clear Creek, and Gilpin districts plans were reportedly in process for concentration mills to treat the complex silver-bearing base-metal ores.

In Idaho, production at The Bunker Hill Co. mines was uninterrupted but the tonnage of ore mined at the Bunker Hill and Star Unit area mines was well below the 1966 level. However, as the ore was of higher grade, lead output was only 1,100 tons lower than in 1966. As a result of strike closure of the Lucky Friday mine on October 15 which continued through the remainder of the year, the Hecla Mining Co. produced significantly less lead from its Coeur d'Alene mines. The Galena mine of American Smelting and Refining Company was closed by strike on July 15.

The outlook for domestic lead production is exceptionally promising for 1968 after termination of the strike in the Western mining and smelting area. The expected addition of three major producing mines in Missouri, the initiation of production from reportedly high-grade deep-level developments in the Coeur d'Alene area, and new concentrating facilities in Utah and Colorado will significantly increase output in 1968 and again in 1969, as these new plants post the first full year of operation.

SMELTER AND REFINERY PRODUCTION

The production of lead metal from primary materials during the first half of 1967 was at a rate approximately 6 percent above that of the like period in 1966. The strike at smelters and refineries, beginning on July 1 at the Omaha plant and extending on July 15 to the remaining Selby, Calif., El Paso, Tex., and East Helena, Mont., plants of American Smelting and Refining Company and the Tooele, Utah, smelter of International Smelting and Refining Co., curtailed output throughout the rest of the year. Total production was thus 379,900 tons of refined lead and 9,100 tons of antimonial lead, a reduction of 63,900 tons or 14 percent in relation to the prior year. The November output of primary lead was the lowest recorded since November 1958, when strikes also curtailed production. The Herculaneum smelter of St. Joseph Lead Co. and smelters and refineries operated by Eagle-Picher Industries, Schuylkill Products Co., and United States Lead Refinery, Inc., operated throughout the year although primary material at the Schuylkill and United States Lead Refinery was supplemented by secondary materials. The value of primary refined lead again declined in average price per pound reflecting the usual 6-mill differential in respect to average quoted price at New York for common lead. The total value indicates a $26.9 million drop in comparison with that of 1966.

The expansion program increasing capacity at the Herculaneum, Mo., smelter of St. Joseph Lead Co. to over 200,000 tons of refined lead annually, was completed early in 1967 after a conversion shutdown period begun in December 1966. Herculaneum production from company concentrates in 1967 totaled 120,207 tons of lead metal in comparison with 90,729 tons in 1966. Output curtailed by equipment adjustments approached capacity during the closing months of the year.

Operations at the Tooele, Utah, smelter of International Smelting & Refining Co. were suspended on May 18 in the wake of an explosion in the air blower system, without employee injury, which necessitated extensive repairs prior to resumption of operations in late June.

The 50th anniversary of the blowing in of the Bunker Hill lead smelter was observed in July. In the period, starting July 5, 1917, the plant has produced over 3.3 million tons of lead and 368 million ounces of silver. The modernization and expansion program continued at the smelter with installation of a downdraft sintering machine and exhaust gas system underway to eliminate air pollution and increase sulfuric acid plant output.

Secondary lead output decreased about 19,100 tons to 553,800 tons from the high level of 1966. Primary plants reported an output of only 10,300 tons of secondary lead in comparison with 19,800 tons in 1966. The major demand continued in antimonial lead with a record output of 288,700 tons, 52 percent of the total secondary. The major decline was in other lead alloys, which decreased from 23 percent of the total in 1966 to 21 percent. Soft lead output continued at about the same level undoubtedly reflecting some demand resulting from the decreased domestic primary output of refined lead. Secondary lead in 1967 represented 59 percent of the domestic production of lead from all materials and 43 percent of total supply including metal imports for consumption. This compares with 56 percent and 44 percent, respectively, in 1966.

Raw Material Source.—The domestic component of smelter feed reversed the upward trend of recent years and represented 68 percent of the 389,000 tons of primary metal in comparison with 72 percent of the 451,900 tons in 1966. Imported ores and bullion supplied 125,000 tons of metal. The smelting of scrap at primary plants continued to decrease from the high of 1965 and in 1967 contributed only 10,300 tons, principally as antimonial lead. Raw materials and material in process at primary plants at the beginning of the year totaled 136,200 tons, lead content, of which 94,900 tons was primary and secondary materials for smelting and 41,300 tons was in the process of smelting and refining. Stocks of materials were gradually built up to a high of 164,900 tons at the end of October and then drawn down to end the year at 150,300 tons, of which 105,000 tons was available for smelting and 45,300 tons was in the process of smelting.

Consumption of scrap materials during the year was 726,300 tons, gross weight, in comparison with 741,000 tons in 1966 and 748,300 tons in 1965. Receipts of scrap at consuming plants were essentially in balance with consumption, with stocks ranging from 52,800 tons at the beginning of the year to lows of 47,200 tons in March and September, and ending the year at 58,000 tons. Battery plates supplied 73 percent of the old scrap consumed in comparison with 70 percent in 1966, and drosses and residues from manufacturing and foundry sources accounted for all of the new scrap processed amounting to 101,100 tons in comparison with 112,000 tons in 1966.

CONSUMPTION AND USES

Consumption of lead declined in 1967 after five successive years of growth culminating in the record high of 1.32 million tons in 1966. Total consumption of 1.26 million tons in 1967 represented a decrease of 63,400 tons or 4.8 percent. Industry requirements again exceeded 100,000 tons monthly except for February and the vacation month of July. Consumption in each month except January and April, however, was well below that of the corresponding month in 1966. The daily average was 3,453 tons in comparison with the 3,627–ton average in 1966. The decrease in consumption was distributed over all types of lead—soft lead, antimonial lead, and lead alloys—and over all product categories except chemicals. The two major uses of lead—batteries and gasoline antiknock compounds—held up well, however, with battery requirements down only 5,800 tons (1 percent) and antiknock compounds slightly increased. These two major end products required almost 57 percent of the total lead consumed and ammunition moved into third place in 1967 supplanting red lead and litharge.

The requirements for ammunition have increased 29,000 tons since 1963, influenced by increased military needs as well as the use of sporting ammunition. The relatively unchanged requirements for collapsible tubes, foil, plumbing, white lead, and pigments was noteworthy. A significantly lower consumption in calking lead accelerated the downward trend in this use area and solder requirements, after a slight gain in 1966, were much lower in 1967. The use of lead in red lead and litharge, after an abnormally high level in 1966, decreased to approximately the level existing in 1964–65 and requirements for type metal and terne metal continued to decline.

The manufacture of storage batteries, the largest use of lead, consumed 245,200 tons of soft lead and 221,500 tons of lead in antimonial lead in comparison with 237,400 tons of soft lead and 234,600 tons of antimonial lead in 1966. Batteries are of two categories—starting-lighting-ignition (S.L.I.) batteries used in conjunction with internal combustion engines and the industrial batteries used for power, lighting, and communications. Industrial batteries over the past 8 years have required from 10 to 12 percent of the total lead used in batteries. Shipments of S.L.I. batteries both for original equipment and replacement, totaled 41.5 million units in 1967 in comparison with 43 million units in 1966. Shipments of replacement batteries, only slightly below the 1966 total, represented 77 percent of the total; original equipment batteries, down to 9.3 million from 10.7 million units in 1966, represented 22 percent; and export of 204,400 batteries accounted for the remaining 1 percent. Technological advances in battery manufacture and in improved charging equipment has materially reduced the weight of lead per battery unit to the present average of 18.8 pounds and has increased battery life from an average of 20 months in 1950 to 27 months in 1966. Greater emphasis on methods of combating air pollution has served to point up the dependability, material availability, low cost, and advanced engineering qualifications of the lead-acid battery for electric-powered transportation.

The use of lead in antiknock compounds posted a remarkable gain from the 168,900 tons used in 1962 to the 246,900 tons in 1966. The gain of only 291 tons in 1967 reflects, in part, the decreased lead content per gallon of gasoline and also a declining export market. New antiknock compound plants in Greece, Mexico, Canada, and Japan as well as expansion of plants in other countries has decreased the dependence of foreign areas on U.S. supplies. Future growth will be to a large extent dependent on increased domestic gasoline consumption and, also, the extent to which gasoline refining is extended toward higher octane ratings to combat air pollution.

Historic lead consumption in bearing metal, construction, type metal, solders, paints, and other miscellaneous uses does not appear to have a growth potential and in fact in many areas is being supplanted by other materials or processes. The emphasis of research and commercial application to increase lead usage appears currently to be in the area of sound attenuation, vibration dampening, corrosion-resistant coverings, and organolead chemicals.

Lead foil and sheet is presently available in gages and strength necessary for soundproofing of building partitions and the efficiency of lead has been well demonstrated. Methods for applying lead coverings to metal, plastics, and concrete have been worked out to utilize the noncorrosive quality of lead without excessive weight involvement. Improved paints and specialized soldering alloys are also available. The field of organolead compounds is promising in both quantity and scope and includes such uses as catalysts, cattle foods, pesticides, fungicides, and plastics.

LEAD PIGMENTS

The lead content of pigments produced in 1967 decreased for all items except black oxide. The total lead contained in the various pigments and oxides amounted to 317,600 tons in comparison with 331,300 tons in 1966, and reversed the growth trend of the previous 6 years. Black oxide for batteries consumed 61 percent of the total pig lead in comparison with 58 percent in 1966. Litharge, the other large item, consumed 28 percent in comparison with 30 percent in 1966.

Distribution of shipments of pigments and oxides reflected the dimishing requirements for white lead and red lead in the paint industry. The ceramic requirements for white lead, red lead, and litharge also decreased as did the use of litharge in oil refining, rubber processing, and varnish manufacture. Manufacturers' shipments not specificially defined as to end product represent a major tonnage of white lead, red lead, and litharge and a substantial decline was posted for the "Other" categories for each of these materials in comparison to the high requirements of 1966.

Prices.—The quoted price of lead pigments and oxides was unchanged during the year reflecting the stable price of lead. Basic carbonate white lead was quoted at 20.5 cents per pound in carload lots, freight allowed. Red lead, 95 percent Pb_3O_4, in carload lots, at works, was quoted at 16.75 cents per pound effective in mid-October 1966. The price of litharge was 16.25 cents per pound for commercial grade, powdered, in carload lots, at works, also effective in mid-October 1966.

Shipments of dry white lead declined in average value per ton from $412 to $407 while the average value of white lead in oil increased from $658 to $677 per ton. The total valuation of white lead shipments decreased about $1.3 million. Red lead shipments declined in average value from $361 to $342 per ton and litharge from $341 to $321 per ton and total value decreased $5.4 million. The total value of shipments of white lead, red lead, and litharge was $46.8 million, a decrease of 16 percent in comparison with the $56 million value in 1966.

Foreign Trade.—The export of lead oxides, pigment grade, including compounds of lead arsenate and others, decreased from 2,600 tons valued at $1.04 million in 1966 to 1,909 tons valued at $772,500 in 1967. Canada was the leading importer at 666 tons followed by the United Kingdom, 175 tons and South Viet-Nam, 115 tons. Twelve other countries received shipments ranging from 15 to 84 tons and small shipments aggregating 213 tons were consigned to various other countries.

Imports for consumption of lead pigments and compounds was slightly higher in tonnage but declined in value some $784,000. White lead was received, in order of importance, from West Germany, Canada, Netherlands, the United Kingdom, and Japan. Red lead was chiefly supplied by Mexico (45 percent), France (26 percent), and West Germany (25 percent), with Denmark, the United Kingdom, and Belgium-Luxembourg the other suppliers. Litharge, representing 80 percent of the lead pigments and compounds imports, was predominantly from Mexico, 98 percent, with France, West Germany, Belgium-Luxembourg, Netherlands, and Canada the other sources. Other pigments, including leaded zinc oxide, blue lead, orange mineral, and unspecified, aggregated 74 tons and came predominantly from West Germany and the United Kingdom. Lead nitrate imports of 220 tons from the United Kingdom and Republic of South Africa and 130 tons of unspecified lead compounds, mainly from Canada, made up the 350 tons of other lead compounds.

STOCKS

The stock position of all segments of the lead industry improved in 1967 although still well below normal levels. Primary producer stocks of refined lead at the beginning of the year amounted to 16,200 tons and antimonial lead stocks were 6,400 tons. The combined stocks gradually increased through May to 33,700 tons, declined to close the year at 18,200 tons of refined lead and 5,200 tons of lead in antimonial lead. The combined stocks of metal at primary plants has thus ranged from 25,200 tons in 1965 to 22,600 tons in 1966 and 23,400 tons in 1967. The total lead in primary materials, including ore, bullion, in process, in transit, and refined, as reported by the American Bureau of Metal Statistics at yearend 1967 was 189,900 tons in comparison with 177,100 tons at yearend 1966 and the low of 140,800 tons at yearend 1965.

Consumer and secondary stocks of lead in all forms opened the year at 90,300 tons and increased moderately to a peak of 114,200 tons in July and then declined to 105,800 tons at yearend. The major increase was in soft lead which comprised 57 percent of total stocks. Government inventory of lead was reduced 27,500 tons to about 1,193,300 tons.

PRICES

The domestic quoted price for common lead at New York, after two decreases of 1 cent per pound in 1966 from the December 1964 peak of 16 cents per pound, was unchanged at 14 cents per pound throughout the year. The foreign market, as illustrated by the London Metal Exchange, was relatively stable with daily fluctuations within a narrow range. The average monthly price in U.S. currency equivalent ranged from a low of slightly under 10 cents per pound in January to a high of 10.51 cents in August. The differential of 3.5 to 4 cents per pound between the domestic and foreign price was well above the generally accepted 2-cent additional cost of landing foreign metal at New York. The domestic market was thus a favorable market throughout the year.

The Government price for stockpile lead was at the industrial quoted price for equivalent grades at time of sale, f.o.b., the various General Services Administration storage areas.

FOREIGN TRADE

The foreign market for domestic raw materials and refined metal continued unfavorable during 1967. The 1,000-ton increase in refined exports resulted mainly from larger metal shipments to Japan and, also, increased small-lot shipments to other countries. Scrap shipments abroad continued to decline indicating the upward trend in lead raw material availability at the European smelters.

General imports of ore and bullion during the first 6 months of 1967 were 15,800 tons or 23 percent above the receipts during the like period in 1966. The strike closure of domestic smelters relying on foreign ores during the last half of the year resulted in a 15-percent decrease for the year. General imports of metal, however, posted a 38-percent increase for the first 6 months and 27 percent for the year in comparison with the like periods in 1966. A large tonnage of lead in ore was moved from bond into commercial channels in 1967 and imports for consumption exceeded general imports by over 20,000 tons. Metal deliveries were entered for duty payment as landed and general imports and imports for consumption were identical in 1967. General scrap receipts were about 900 tons above the amount entered for consumption. The value of ore and bullion imported for consumption was $30.3 million indicating an average value of $209 per ton in comparison with $220 in 1966. The value of metal was $88.7 million, an average of $244 per ton compared with $264 the previous year. Imports of fabricated lead as sheets, pipe, and shot increased about 300 tons to continue the upward trend.

Four countries—Australia, Bolivia, Canada, and Mexico—contributed 93 percent of the ore imports and all entered for consumption, duty paid, a larger tonnage than landed in 1967 indicating the drawdown of bonded stocks. Peru was the leading metal supplier with 19 percent of the total followed by Mexico, Australia, West Germany, Canada, and Yugoslavia. These six countries contributed 82 percent of the metal entered. Of special note was the 90,000 tons of metal received from European smelting centers—Belgium-Luxembourg, West Germany, and United Kingdom—in comparison with 21,100 tons in 1966. This reflects in part the movement of free world surplus stocks to compensate for the strike-curtailed domestic output.

WORLD REVIEW

Statistical summaries of world production and consumption of lead compiled by the Bureau of Mines, American Bureau of Metal Statistics (ABMS), and the International Lead and Zinc Study Group vary widely in reporting base, reporting sources, and estimating necessity. The Bureau of Mines reports, insofar as possible, production in ore on a recoverable content basis whereas the Lead and Zinc

Study Group reports on an ore content basis. Therefore, free world mine production totals range from the ABMS total of 2.28 million tons through the 2.372-million-ton estimate of the Bureau of Mines to the 2.385 million tons of the Lead and Zinc Study Group. Smelter output also varies widely with the Bureau of Mines presenting primary lead insofar as possible in contrast to the Lead and Zinc Study Group which reports metal production from both primary and secondary materials. Free world smelter output thus ranges from the Bureau of Mines total of 2.22 million tons through the ABMS total of 2.40 million tons to the Lead and Zinc Study Group total of 3.017 million tons. As the Lead and Zinc Study Group reports free world lead consumption on the same basis as smelter metal production, the Group's figures are used hereafter for comparative purposes.

The upward trend in lead production in many countries, initiated in 1962, continued in 1967 with an indicated free world output of 2.39 million tons of lead in ores, a 40,000-ton or 2-percent gain over 1966. A like gain in the Communist sphere in Europe and Asia would indicate a world production of 3.3 million tons in comparison with 3.15 million in 1966.

Major gains were registered from newly developed mines in Ireland and Canada. Expansion of production at mines in France, West Germany, Italy, Spain, and Sweden also assisted in the 31,000-ton increase in Western Europe. The increases in Canada, Peru, and Argentina more than offset the decreases in the United States and Mexico to post a North American increase for the year. The Asian increase of 6,000 tons was confined to Burma and Japan, and Australian production increased 8,000 tons as the labor troubles of 1966 eased. African production, however, declined about 16,000 tons, principally in South-West Africa and Morocco.

Metal production from primary and secondary materials in the free world gained about 18,000 tons to 3.017 million tons in 1967. The Communist area production of metal is estimated to be about 750,000 tons for a world total of 3.75 million tons in 1967 of which 600,000 tons was derived from secondary material. The increase of 68,000 tons in Europe, primarily in West Germany, and 34,600 tons in Japan more than offset the 76,000-ton decrease in the Americas and the small decrease in Africa and in Australia. Producer stocks in the free world opened the year at about 266,000 tons, mounted to a high of 372,000 tons in August, and thereafter were gradually drawn down to close the year at 285,000 tons.

The consumption of metal in the free world was indicated to be about 3.05 million tons in 1967, some 22,000 tons below the 1966 total and thus reversed the upward trend since 1958, the year reporting was initiated by the International Lead and Zinc Study Group. The consumption increase of 8,000 tons in Europe, 23,000 tons in Asia, and 3,000 tons in Australia, plus a small increase in Africa, did not compensate for the 57,000-ton decline in the Americas. A slight gain in consumption was indicated in Brazil, Canada, Mexico, and Peru. Consumption in Argentina and the United States, however, was substantially lower.

Argentina.—Compania Minera Aguilar, S.A., a subsidiary of St. Joseph Lead Co., increased production as a result of higher grade mill feed. Expansion of the mine and mill was underway for scheduled completion in 1968.

Australia.—New Broken Hill Consolidated Ltd. and North Broken Hill Ltd. reported increases in ore milled for the fiscal year 1966–67, and Broken Hill South Ltd., a slight decline in ore treated. The lead content of ores milled at all three companies declined from 0.2 to 0.5 percent. Reserves were increased for the Broken Hill area. A labor stoppage of one day and a slowdown period of 15 days occurred in the June–July period.

Mount Isa Mines Ltd. milled 1.06 million tons of lead-zinc ore in comparison to 1.2 million tons in the prior 1965–66 fiscal period. The lead grade, however, increased from 6.8 to 7.8 percent lead in 1967. Lead smelter production of 70,400 tons of lead bullion was the highest on record despite problems early in the period with the new updraft sintering machine commissioned in October 1966. Ore reserves were increased slightly.[7]

Lead bullion produced in Australia at the Broken Hill Associated Smelters Proprietary Ltd. smelter, which is converted to refined metal at the plant, and the Mount Isa Mines Ltd. smelter, which is

[7] Mount Isa Mines Ltd. Annual Report. 1967, pp. 18–19.

shipped abroad for refining, was a record high in 1967.

Brazil.—Lead concentrates for the 14,400-metric-ton-capacity smelter at Santo Amaro, Bahia, came from the Boquira mine in south-central Bahia, the largest mine in Brazil. Ore for the Panelas flotation plant and 9,000 metric ton capacity Paraná smelter is mined at Panelas and at three other properties in the Sao Paulo.

Canada.—A 5-percent increase in mine production to 339,700 tons of lead in ore lifted Canada to the position of the third largest producer, exceeded only by the U.S.S.R. and Australia. Production from two new mines that completed their first full year of operation accounted for most of the increase with the remainder from two new mines starting in 1967 and increased output at other mines. Cominco, Ltd., operated the Sullivan and Bluebell mines in British Columbia. Pine Point Mines, Ltd., a subsidiary of Cominco in the Northwest Territories, was the largest individual lead producer in Canada. Production from this operation in 1967 was 1.52 million tons of milling ore with a combined lead-zinc grade of 14.4 percent and 333,000 tons of direct-shipping ore of 45.9 percent lead-zinc. A new 3,000-ton-per-day addition to the present 5,000-ton-per-day concentrator was under construction. Scheduled for completion in late 1968 the addition will handle ore from the adjoining Pyramid ore bodies being stripped for open pit production. Production of refined lead at the Trail, British Columbia, smelter amounted to 187,600 tons in comparison to 184,900 tons in 1966.[8] Ecstall Mining, Ltd., a subsidiary of Texas Gulf Sulphur Co., operated the Kidd Creek mine near Timmins, Ontario, throughout the year with the mill reaching full operation in mid-February. Over 3 million tons of ore was mined and 43,000 tons of copper-lead concentrate shipped to smelters in the United States. The No. 6 mine of Brunswick Mining and Smelting Corp., Ltd., near Bathurst, New Brunswick, completed its first year of operation to substantially increase the output from the New Brunswick area. Early in 1967, East Coast Smelting and Chemical Co., Ltd., a subsidiary of Brunswick Mining and Smelting Corp., began production of lead metal at its Imperial Smelting type blast furnace at Belledune, New Brunswick.

Mineral exploration and development continued to be a major activity in Canada with perhaps the most significant development of the year being the announcement that Anvil Mining Corp., a subsidiary of Cyprus Mines Corp. (60 percent) and Dynasty Explorations, Ltd. (40 percent), would invest $60 million in a 5,500-ton-per-day lead-zinc facility in the Vangorda area of the central Yukon Territory. Annual production of 370,000 tons of lead and zinc concentrates, commencing in 1969, will be shipped mainly to Japan until the feasibility of a smelter is determined.

France.—Mine production was slightly above the 1966 level which reflected the expansion at the group of mines controlled by Société Minière et Métallurgique de Peñarroya, especially the newly developed Largentiers mine. Output of lead at the Noyelles-Godault refinery also increased. Expansion of metallic lead output from all of the European plants of Peñarroya in the first half of 1967 was reported to have exceeded 12 percent compared with that of the like period in 1966.

Ireland.—The Irish Base Metals, Ltd. operations at Tynagh, Galway, continued to expand output in the second year of operation. The 42,000 tons of lead in concentrates produced in 1966 increased to over 60,000 tons in 1967. The other major lead-zinc development, Consolidated Mogul Mines, Ltd., completed construction of concentrator and surface plant and development of the mine was approaching the 2,300-ton-per-day output required to start up the concentrator and achievement of the 3,000-ton-per-day capacity is expected within 3 months of initial production. Official ore reserves at this property were reported at 11.4 million tons in the main ore body averaging 8.16 percent zinc, 2.80 percent lead, and 0.81 ounce of silver.

Japan.—The output of lead in ore continued at essentially the same level as in the previous year, namely 70,000 tons. The 31-percent expansion in refined lead capacity in 1966, predominantly by the Harima Imperial Smelter of Sumitomo ISP Co., Ltd., and the Naoshima smelter of Mitsubishi Cominco Ltd. was, however, reflected in the record output of

[8] Cominco, Ltd. Annual Report. 1967, p. 6.

165,300 tons of lead in 1967, an increase of 34,600 tons. Six Japanese lead and zinc smelting companies initiated a joint venture to build an Imperial Smelting Process plant at Hachinohe, scheduled to be operating by October 1968 with a capacity of 5,000 tons of zinc and 2,500 tons of lead monthly.

Mexico.—Output of lead declined slightly owing to the generally declining content of ores mined. Expansion of production facilities was underway at many of the mines with substantial increases in ore and concentrate production anticipated when the modernization projects are completed. Cía. Minera Los Angeles, S.A., completed construction of a 100-ton-per-day lead oxide smelter in the Ocampo, Coahuila, area to smelt accumulated reserves of lower grade ore previously unprofitable for shipment to the Peñoles smelter in Torreon. Compañia Fresnillo, S.A. and Zimapán, S.A., 49 percent owned by The Fresnillo Co., Inc., produced 41,100 tons of lead in the 1966–67 fiscal year from the Fresnillo, Naica, and Zimapán units, slightly lower than in the prior year with reserves increased slightly. Substantial progress was made in development of the new Amaltea and Rubi mines near Talpa in the State of Jalisco with a 200-ton-per-day mill completed and about to commence production. Development of the Sombrerete mine was encouraging.[9] Asarco Mexicana, S.A., 49 percent owned by American Smelting and Refining Company, reported 77,700 tons of refined lead produced in 1967 compared with 83,900 tons in 1966.[10]

Peru.—Compania Minerales Santander, Inc., a St. Joseph Lead Co. subsidiary, continued with development of the underground mine with open pit production scheduled to be phased out in the fourth quarter of 1968. Production at the Cerro de Pasco Corp. complex of base-metal facilities in Peru was adversely affected by a 1-week strike at the mines and a 2-week strike at the metallurgical plants in 1967. Lead production amounted to 90,000 tons compared with 97,600 tons in the prior year. Forty-three percent of the lead came from purchased ores versus 48 percent in 1966.

U.S.S.R.—The lead-zinc industry was reported to be engaged in an expansion program that will result in a substantial increase in lead output, recently estimated at over 400,000 tons annually. Improvement of extraction processes, modernization of mining equipment, and techniques and development of new ore bodies is a major objective in the current 5-year plan.[11] New capacities and extensions to be carried out through 1969 have been reported to total 400,000 tons of lead and 600,000 tons of zinc for world markets.

Yugoslavia.—The lead-zinc industry continued to emphasize exploration and development in 1967. In recent years some 12 million tons of new reserves have been established in Serbia. A new lead-zinc mine was opened at Novi Pazar, in the Kosovska Metrovica deposits. The Ajvalija, Kiznica, mines were being modernized and open pit production developed. At the Podvirovi mine in Besna Kobila shafts were sunk in an ore deposit reported to contain 200,000 tons of ore analyzing 9.7 percent lead, 8.7 percent zinc, 2.2 percent copper, and 130 grams of silver per ton. Trepca Lead and Zinc Mines and Refineries obtained a $7 million loan from a group of London banks to expand production to an expected 150,000 tons of pig lead annually in relation to the 1967 rate of about 100,000 tons.

Other Countries.—Output in the African countries was indicated to be substantially below that of the prior year. An Algerian-Moroccan border dispute involving ore movement across the frontier was unresolved. The nationalization of Tunisian mines, under the Société Tunisienne d'Expansion Minière, was reported to have accelerated prospecting and the opening of two new lead-zinc mines. The Republic of South Africa output, centered in the operation of the Tsumeb and Kombat mines and smelter of Tsumeb Corp., Ltd., was below the 1966 level with a substantial drop in lead ore produced and a 7-percent decline in metal output.

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[9] The Fresnillo Company. Annual Report. 1967, p. 8.
[10] American Smelting and Refining Company. Annual Report. 1967, p. 8.
[11] Chumak, Z. V. The Lead-Zinc Industry During the Fifty Years' Existence of the Soviet State. Tsvetnyye Metally. (English Transl.), No. 8, August 1967, pp. 5–13.

TECHNOLOGY

The metallurgical, environmental, and end product areas of lead continued to attract major research interest.

The technical problems in concentration of the complex black ores of Japan and methods of solving these problems at various Japanese plants were discussed.[12] The combined effort of The Bunker Hill Co. and Sherritt Gordon Mines Ltd., in the successful pilot plant pressure leaching process for base metals resulted in a proposed construction of a commercial recovery plant at Kellogg, Idaho. The Outokumpu Oy Co., Helsinki, Finland, has devoted a major research effort to development of flash smelting of lead concentrates that would eliminate sintering. Pilot testing of the process indicates the favorable economics of the process for certain ores.[13]

The interest in use of oxygen in primary and secondary lead smelting continued as productivity increases were reported at blast furnaces incorporating supplemental oxygen in the fuel. An onsite oxygen plant has been built in East Helena, Mont., to supply oxygen requirements to The Anaconda Company and American Smelting and Refining Company. The Bureau of Mines reported on an extensive study of electric smelting of complex lead-zinc sinter and concluded that, while reduction of lead and zinc was satisfactory, the recovery of zinc metal was unsatisfactory, and that slag-resistance open-bath electric smelting of complex lead-zinc sinter was not considered feasible.[14] A process was developed on a laboratory scale for the recovery of lead, copper, and iron from secondary lead smelter matte by roasting and leaching to recover copper and lead and subsequent smelting to yield pig iron.[15]

The problems associated with utilization of low-sulfur stack gases from roasting of lead concentrates has often had an economic bearing on elimination of undesirable sulfur dioxide from lead smelter stack gases. Successful research in updraft roasting has resulted in a decision by The Bunker Hill Co. to revise the roasting plant at Kellogg, Idaho, and eventually divert all sulfur dioxide to the sulfuric acid plant operated in conjunction with the zinc plant.

Improvement of the mechanical properties of lead has long been a major research objective. A dispersion-strengthened lead alloy, placed on the market in development quantities, incorporates superior corrosion resistance, high strength, and good creep resistance without certain disadvantages inherent in the antimoy additive alloys. It has been found that the addition of a small amount of lead to copper-base alloys, especially beryllium-copper alloys, diminishes the problems associated with manufacture of bars and rods of beryllium-copper and also increases machinability. Permanent magnets were manufactured on a development scale at General Motors Research Laboratories from a powdered compound of iron and lead oxides in a process resulting in a hard ceramic permanent magnet.

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12 Yonezawa, Dr. Toshiaki. How Selective Flotation Recovers Four Minerals—Chalcopyrite, Galena, Sphalerite, and Pyrite. World Mining, v. 3, No. 4, April 1967, pp. 26–31.

13 Bryk, Petri, Rolf Malmstrom, and Erik Nyholm. Flash Smelting of Lead Concentrates. J. Metals, v. 18, No. 12, December 1966, pp. 1298–1302.

14 Spencer, Richard N., Seth C. Schaefer, and James E. Mauser. Electric Smelting of Complex Lead-Zinc Sinter. BuMines Rept. of Inv. 6999, 1967, 28 pp.

15 Wilson, D. A., and P. M. Sullivan. Recovery of Lead and Copper From Blast Furnace Matte. BuMines Rept. of Inv. 7042, 1967, 21 pp.

Table 2.—Mine production of recoverable lead in the United States, by States

(Short tons)

State	1963	1964	1965	1966	1967
Alaska	5	-------	(1)	14	-------
Arizona	5,815	6,147	5,913	5,211	4,771
California	823	1,546	1,810	1,976	1,735
Colorado	19,918	20,563	22,495	23,082	21,923
Idaho	75,759	71,312	66,606	72,334	61,387
Illinois	2,901	2,180	3,005	2,285	2,384
Kansas	1,027	1,185	1,644	1,109	1,031
Kentucky	831	858	756	484	845
Missouri	79,844	120,148	133,521	132,255	152,649
Montana	5,000	4,538	6,981	4,409	898
Nevada	1,126	809	2,277	3,581	1,500
New Mexico	1,014	1,626	3,387	1,596	1,827
New York	1,009	732	601	1,097	1,653
North Carolina	62	-------	-------	-------	-------
Oklahoma	3,192	2,781	2,813	2,999	2,727
Tennessee	-------	-------	-------	181	-------
Utah	45,028	40,249	37,700	64,124	53,813
Virginia	3,500	3,857	3,651	3,078	3,430
Washington	5,374	5,731	6,328	5,859	2,762
Wisconsin	1,116	1,742	1,645	1,694	1,596
Other States	25	6	14	-------	-------
Total	253,369	286,010	301,147	327,368	316,931

[1] Combined with "Other States" to avoid disclosing individual company confidential data.

Table 3.—Ore, old tailings, etc., yielding lead and zinc in the United States in 1967

(Short tons)

State	Lead ore			Zinc ore			Lead-zinc ore		
	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc
Arizona	1,163	58	4	69,686	149	2,926	274,621	4,527	10,382
California	3,360	1,283	77				7,860	345	363
Colorado	1,297	115	13	222,910	2,127	21,325	354,527	9,926	15,273
Idaho	239,424	19,752	3,306	26,178	736	2,242	676,355	33,875	42,955
Illinois				(2)	(2)	(2)			
Kansas				250,769	1,029	4,763	126	2	2
Kentucky				58,688		5,481			
Missouri	5,561,390	152,634	7,391	800	4	21	1,634	11	18
Montana	4,107	461	78	35,836	182	1,631	211	31	10
Nevada	252	28	5	904	69	217	228,509	1,397	2,807
New Jersey				152,880		26,041			
New Mexico	5	(4)		272,058	1,743	20,548	1,774	84	184
New York				178,848		16,807	629,901	1,653	53,748
Oklahoma	4,891	84	10	361,278	1,721	9,511	76,689	922	1,149
Pennsylvania				646,863		35,067			
Tennessee				3,862,508		102,865			
Utah	253	24	4				443,733	48,200	28,921
Virginia							640,530	3,430	18,846
Washington				583,809	973	16,121	292,628	1,788	5,419
Wisconsin				988,798	1,596	28,953			
Total	5,816,142	174,439	10,888	7,712,813	10,329	294,519	3,629,098	106,191	180,077

State	Copper-lead, copper-zinc, and copper-lead-zinc ores			All other sources [1]			Total		
	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc
Arizona	17,306	1	682	20,149,396	36	336	20,512,172	4,771	14,330
California				1,924	107	1	13,144	1,735	441
Colorado	437,700	9,654	15,733	154,778	101	98	1,171,212	21,923	52,442
Idaho				770,334	7,024	8,025	1,712,291	61,387	56,528
Illinois				[3] 704,547	2,384	20,416	704,547	2,384	20,416
Kansas							250,895	1,031	4,765
Kentucky				93,469	845	836	152,157	845	6,317
Missouri							5,563,824	152,649	7,430
Montana				31,364	224	1,622	71,518	898	3,341
Nevada				1,393	6	6	231,058	1,500	3,035
New Jersey							152,880		26,041
New Mexico	42,268		312	84,641	(4)	336	400,746	1,827	21,380
New York							808,749	1,653	70,555
Oklahoma							442,858	2,727	10,670
Pennsylvania							646,863		35,067
Tennessee	1,605,590		10,200				5,468,098		113,065
Utah	127,182	5,424	4,514	16,233	165	812	587,401	53,813	34,251
Virginia							640,530	3,430	18,846
Washington				15	1		876,452	2,762	21,540
Wisconsin							988,798	1,596	28,953
Total	2,230,046	15,079	31,441	22,008,094	10,893	32,488	41,396,193	316,931	549,413

[1] Lead and zinc recovered from other ores (copper, gold, silver, etc.) and from smelter slags, mill tailings, and miscellaneous cleanups.

[2] Zinc ore combined with "All other sources" to avoid disclosing individual company confidential data.

[3] Includes zinc ore.

[4] Less than ½ unit.

Table 4.—Mine production of recoverable lead in the United States, by months

(Short tons)

Month	1966	1967
January	26,206	25,622
February	24,734	25,428
March	30,650	30,065
April	26,945	29,368
May	27,399	32,051
June	26,453	28,032
July	25,465	24,383
August	28,547	24,730
September	27,811	22,839
October	28,521	25,366
November	27,154	24,225
December	27,483	24,822
Total	327,368	316,931

Table 5.—Twenty-five leading lead-producing mines in the United States in 1967 in order of output

Rank	Mine	State	County	Operator	Source of lead
1	Viburnum	Missouri	Crawford, Iron, and Washington	St. Joseph Lead Co	Lead ore.
2	Federal	do	St. Francois	do	Do.
3	Fletcher	do	Reynolds	do	Do.
4	U.S. and Lark	Utah	Salt Lake	United States Smelting Refining and Mining Co	Lead-zinc ore.
5	Bunker Hill	Idaho	Shoshone	The Bunker Hill Co	Do.
6	Lucky Friday	do	do	Hecla Mining Co	Lead ore.
7	Burgin	Utah	Utah	Kennecott Copper Corp	Lead-zinc ore.
8	Indian Creek	Missouri	Washington	St. Joseph Lead Co	Lead ore.
9	Star-Morning	Idaho	Shoshone	Hecla Mining Co	Lead-zinc ore.
10	Idarado	Colorado	Ouray and San Miguel	Idarado Mining Co	Copper-lead-zinc ore.
11	Mayflower	Utah	Wasatch	Hecla Mining Co	Do.
12	Iron King	Arizona	Yavapai	Shattuck Denn Mining Corp	Lead-zinc ore.
13	United Park City	Utah	Summit and Wasatch	United Park City Mines Co	Do.
14	Austinville and Ivanhoe	Virginia	Wythe	The New Jersey Zinc Co	Do.
15	Ophir	Utah	Tooele	United States Smelting Refining and Mining Co	Do.
16	Page	Idaho	Shoshone	American Smelting and Refining Co	Do.
17	Sunnyside	Colorado	San Juan	Standard Metals Corp	Do.
18	Eagle	do	Eagle	The New Jersey Zinc Co	Zinc, copper ores.
19	Silver Star-Queens	Idaho	Blaine	Federal Resources Corp	Lead ore.
20	Pend Oreille	Washington	Pend Oreille	Pend Oreille Mines & Metals Co	Lead-zinc ore.
21	Brenneman	Colorado	San Juan	Standard Metals Corp	Do.
22	Balmat	New York	St. Lawrence	St. Joseph Lead Co	Do.
23	Bunker Hill Slag Dump	Idaho	Shoshone	The Bunker Hill Co	Zinc slag.
24	Rico Argentine	Colorado	Dolores	Rico Argentine Mining Co	Lead-zinc ore.
25	Emperius	do	Mineral	Emperius Mining Co	Do.

Table 6.—Refined lead produced at primary refineries in the United States, by source material

(Short tons)

	1963	1964	1965	1966	1967
Refined lead:					
From primary sources:					
Domestic ores and base bullion	239,660	294,254	305,007	318,646	258,507
Foreign ores and base bullion	155,072	155,175	113,242	122,089	121,387
Total	394,732	449,429	418,249	440,735	379,894
From secondary sources	3,741	8,505	13,140	9,004	2,538
Grand total	398,473	457,934	431,389	449,739	382,432
Average sales price per pound	$0.108	$0.131	$0.156	$0.146	$0.134
Calculated value of primary refined lead (thousands) [1]	$85,262	$117,750	$130,494	$128,695	$101,812

[1] 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
1963	18,818	1,890	10.0	4,553	4,703	7,672	16,928
1964	24,023	1,995	8.3	4,522	4,085	13,421	22,028
1965	27,895	1,984	7.1	2,809	3,803	19,299	25,911
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

Table 8.—Stocks and consumption of new and old lead scrap in the United States in 1967

(Short tons, gross weight)

Class of consumers and type of scrap	Stocks Jan. 1 r	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks Dec. 31
Smelters and refiners:						
Soft lead	2,424	57,674	-------	57,498	57,498	2,600
Hard lead	1,035	18,931	-------	18,520	18,520	1,446
Cable lead	1,125	34,231	-------	34,413	34,413	943
Battery-lead plates	27,570	454,805	-------	453,640	453,640	28,735
Mixed common babbitt	214	3,656	-------	3,535	3,535	335
Solder and tinny lead	311	12,770	-------	12,802	12,802	279
Type metals	2,852	35,649	-------	34,898	34,898	3,603
Drosses and residues	16,823	104,075	101,131	-------	101,131	19,767
Total	52,354	721,791	101,131	615,306	716,437	57,708
Foundries and other manufacturers:						
Soft lead	34	171	-------	189	189	16
Hard lead	73	101	-------	150	150	24
Cable lead	43	33	-------	58	58	18
Battery-lead plates	28	19	-------	-------	-------	47
Mixed common babbitt	134	9,438	-------	9,490	9,490	82
Solder and tinny lead	-----	-------	-------	-------	-------	-------
Type metals	-----	-------	-------	-------	-------	-------
Drosses and residues	126	15	-------	-------	-------	141
Total	438	9,777	-------	9,887	9,887	328
All consumers:						
Soft lead	2,458	57,845	-------	57,687	57,687	2,616
Hard lead	1,108	19,032	-------	18,670	18,670	1,470
Cable lead	1,168	34,264	-------	34,471	34,471	961
Battery-lead plates	27,598	454,824	-------	453,640	453,640	28,782
Mixed common babbitt	348	13,094	-------	13,025	13,025	417
Solder and tinny lead	311	12,770	-------	12,802	12,802	279
Type metals	2,852	35,649	-------	34,898	34,898	3,603
Drosses and residues	16,949	104,090	101,131	-------	101,131	19,908
Grand total	52,792	731,568	101,131	625,193	726,324	58,036

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Table 9.—Secondary metal recovered [1] from lead and tin scrap in the United States in 1967, by type of products

(Short tons, gross weight)

	Lead	Tin	Antimony	Other	Total
Refined pig lead	127,466	------	------	-----	127,466
Remelt lead	22,878	------	------	-----	22,878
Total	150,344	------	------	-----	150,344
Refined pig tin	------	3,294	------	-----	3,294
Remelt tin	------	263	------	-----	263
Total	------	3,557	------	-----	3,557
Lead and tin alloys:					
Antimonial lead	288,719	432	16,783	418	306,352
Common babbitt	15,276	833	1,622	116	17,847
Genuine babbitt	30	188	16	9	243
Solder	31,705	5,348	430	93	37,576
Type metals	30,149	1,797	4,576	4	36,526
Cable lead	19,531	------	190	-----	19,721
Miscellaneous alloys	1,297	433	47	123	1,900
Total	386,707	9,031	23,664	763	420,165
Tin content of chemical products	------	567	------	-----	567
Grand total	537,051	13,155	23,664	763	574,633

[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)

	1963	1964	1965	1966	1967
As metal:					
At primary plants	3,741	8,505	13,140	9,004	2,538
At other plants	130,788	140,702	168,774	147,215	147,806
Total	134,529	149,207	181,914	156,219	150,344
In antimonial lead:					
At primary plants	7,672	13,421	19,299	10,758	7,808
At other plants	237,125	257,101	251,354	272,977	280,911
Total	244,797	270,522	270,653	283,735	288,719
In other alloys	114,145	121,853	123,252	132,880	114,709
Grand total:					
Quantity	493,471	541,582	575,819	572,834	553,772
Value (thousands)	$106,590	$141,894	$179,656	$167,268	$148,411

Table 11.—Lead recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1966	1967	Form of recovery	1966	1967
New scrap:			As soft lead:		
Lead-base	79,573	71,829	At primary plants	9,004	2,538
Copper-base	7,424	4,500	At other plants	147,215	147,806
Tin-base	508	578	Total	156,219	150,344
Total	87,505	76,907	In antimonial lead [1]	283,735	288,719
			In other lead alloys	108,264	96,884
Old scrap:			In copper-base alloys	24,566	17,795
Battery-lead plates	285,489	303,258	In tin-base alloys	50	30
All other lead-base	179,502	155,892			
Copper-base	20,334	17,711	Total	416,615	403,428
Tin-base	4	4			
			Grand total	572,834	553,772
Total	485,329	476,865			
Grand total	572,834	553,772			

[1] Includes 10,758 tons of lead recovered in antimonial lead from secondary sources at primary plants in 1966 and 7,808 tons in 1967.

Table 12.—Lead consumption in the United States, by products

(Short tons)

Product	1966	1967
Metal products:		
Ammunition	78,435	78,766
Bearing metals	21,588	19,561
Brass and bronze	25,447	20,467
Cable covering	66,491	63,037
Calking lead	63,250	48,789
Casting metals	6,671	10,083
Collapsible tubes	11,987	11,299
Foil	6,041	6,148
Pipes, traps, and bends	19,984	20,184
Sheet lead	28,938	26,763
Solder	78,898	68,833
Storage batteries:		
Battery grids, posts, etc	240,535	229,287
Battery oxides	231,957	237,378
Terne metal	1,966	1,620
Type metal	30,421	28,554
Total	912,609	870,769
Pigments:		
White lead	8,131	8,087
Red lead and litharge	89,500	76,589
Pigments—Continued		
Pigment colors	13,695	13,041
Other [1]	8,562	5,473
Total	119,888	103,190
Chemicals:		
Gasoline antiknock additives	246,879	247,170
Miscellaneous: chemicals	614	609
Total	247,493	247,779
Miscellaneous uses:		
Annealing	5,441	4,202
Galvanizing	1,639	1,854
Lead plating	428	532
Weights and ballast	18,090	15,794
Total	25,598	22,382
Other, unclassified uses	18,289	16,396
Grand total [2]	1,323,877	1,260,516

[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	1966	1967
January	104,651	107,431
February	101,506	99,789
March	114,570	112,912
April	106,834	106,964
May	113,649	110,808
June	110,555	106,011
July	93,236	84,161
August	114,046	104,406
September	110,951	102,553
October	120,575	111,920
November	118,641	107,967
December	114,663	105,594
Total [1]	1,323,877	1,260,516

[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 1967, 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	195,869	103,378	49,817	15,527	364,591
Storage batteries	245,208	221,457	-------	-------	466,665
Pigments	100,967	189	-------	-------	101,156
Chemicals	247,779	-------	-------	-------	247,779
Miscellaneous	10,676	11,602	104	-------	22,382
Unclassified	13,928	1,697	771	-------	16,396
Total	814,427	338,323	50,692	15,527	[1] 1,218,969

[1] Excludes 39,513 tons of lead which went directly from scrap to fabricated products and 2,034 tons of lead contained in leaded zinc oxide and other nonspecified pigments.

Table 15.—Lead consumption in the United States in 1967, by States [1]

(Short tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	88,663	31,097	5,204	905	125,869
Colorado	1,070	2,714	72	--------	3,856
Connecticut	16,233	15,112	124	1,169	32,638
District of Columbia	154	--------	--------	--------	154
Florida	5,255	4,914	--------	--------	10,169
Georgia	35,545	11,729	2,019	--------	49,293
Illinois	85,431	51,679	8,936	2,067	148,113
Indiana	74,835	42,175	1,282	742	119,034
Kansas	10,784	9,141	41	312	20,278
Kentucky	2,546	6,290	3	--------	8,839
Maryland	3,454	18,562	212	--------	22,228
Massachusetts	3,706	1,700	500	162	6,068
Michigan	13,256	14,542	1,837	598	30,233
Missouri	35,425	10,923	159	499	47,006
Nebraska	2,806	1,017	68	660	4,551
New Jersey	123,239	19,414	8,751	497	151,901
New York	38,239	2,905	13,314	778	55,236
Ohio	13,360	3,186	3,159	1,049	20,754
Pennsylvania	50,935	29,830	1,180	2,587	84,532
Rhode Island	1,351	409	41	--------	1,801
Tennessee	189	10,714	286	310	11,499
Virginia	1,973	995	790	1,379	5,137
Washington	6,837	499	307	--------	7,643
West Virginia	17,036	3,259	--------	--------	20,295
Wisconsin	2,997	2,461	106	116	5,680
Alabama and Mississippi	874	2,380	--------	652	3,906
Arkansas and Oklahoma	4,453	3,734	79	--------	8,266
Hawaii and Oregon	1,071	2,650	2	35	3,758
Iowa and Minnesota	3,807	7,691	128	439	12,065
Louisiana and Texas	157,270	17,973	2,082	381	177,706
Montana and Idaho	5,472	--------	--------	--------	5,472
New Hampshire, Maine, Vermont, Delaware	4,612	5,909	10	190	10,721
North and South Carolina	1,445	2,719	--------	--------	4,164
Utah, Nevada, Arizona	104	--------	--------	--------	104
Total	814,427	338,323	50,692	15,527	1,218,969

[1] Excludes 39,513 tons of lead which went directly from scrap to fabricated products and 2,034 tons of lead contained in leaded zinc oxide and other non-specified pigments.

Table 16.—Production and shipments of lead pigments [1] and oxides in the United States

Pigment	1966				1967			
	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	9,680	10,909	$4,492,202	$412	7,316	8,871	$3,609,808	$407
In oil [3]	2,619	3,967	2,610,603	658	2,807	3,257	2,205,973	677
Total	12,299	14,876	7,102,805	477	10,123	12,128	5,815,781	480
Red lead	31,080	31,270	11,302,545	361	26,869	25,741	8,814,995	342
Litharge	108,098	110,303	37,580,505	341	95,581	99,982	32,135,289	321
Black oxide	198,941	-------	----------	----	203,571	------	----------	----

[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)

Pigment	1966				1967			
	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	-----	-----	9,839	9,839	-----	-----	8,098	8,098
Red lead	-----	-----	28,174	28,174	-----	-----	24,357	24,357
Litharge	-----	-----	100,531	100,531	-----	-----	88,890	88,890
Black oxide	-----	-----	190,931	190,931	-----	-----	194,909	194,909
Leaded zinc oxide	1,247	528	-------	1,775	798	512	---------	1,310
Total	1,247	528	329,475	331,250	798	512	316,254	317,564

[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	1963	1964	1965	1966	1967
Paints	11,358	10,534	9,185	8,260	6,968
Ceramics	138	143	133	130	96
Other	3,906	4,769	5,355	6,486	5,064
Total	15,402	15,446	14,673	14,876	12,128

[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	1963	1964	1965	1966	1967
Paints	13,213	14,133	13,725	14,480	13,318
Storage batteries	W	W	W	W	W
Ceramics	W	W	W	W	W
Other	13,032	13,957	15,938	16,790	12,423
Total	26,245	28,090	29,663	31,270	25,741

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

Table 20.—Distribution of litharge shipments, by industries

(Short tons)

Industry	1963	1964	1965	1966	1967
Ceramics	17,762	20,508	21,013	23,476	19,491
Chrome pigments	5,763	6,426	W	W	W
Floor covering	W	W	W	W	W
Insecticides	W	W	1,161	1,166	W
Oil refining	1,973	2,142	2,886	1,991	1,835
Rubber	1,702	1,978	2,153	2,296	1,928
Storage batteries	W	W	W	W	W
Varnish	4,240	4,004	3,763	1,620	1,228
Other	72,394	64,335	74,916	79,754	75,500
Total	103,834	99,393	105,892	110,303	99,982

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	1966 Short tons	1966 Value (thousands)	1967 Short tons	1967 Value (thousands)
White lead	1,915	$668	2,293	$672
Red lead	2,130	591	3,296	761
Litharge	25,638	5,685	24,632	4,969
Other lead pigments	78	19	74	22
Other lead compounds	736	390	350	145
Total	30,497	7,353	30,645	6,569

Table 22.—Stocks of lead at primary smelters and refineries in the United States, Dec. 31

(Short tons)

Stocks	1963	1964	1965	1966	1967
Refined pig lead	48,780	34,100	17,524	16,175	18,243
Lead in antimonial lead	7,890	4,012	7,680	6,396	5,119
Lead in base bullion	14,947	13,218	10,735	15,606	16,622
Lead in ore and matte	49,219	33,068	47,504	77,296	85,495
Total	120,836	84,398	83,443	115,473	125,479

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
1963	71,558	40,606	6,558	1,208	119,930
1964	69,361	35,163	7,933	987	113,444
1965	61,586	36,190	10,406	1,013	109,195
1966	44,490	34,704	10,071	1,041	90,306
1967	59,837	35,879	8,919	1,151	105,786

Table 24.—Average monthly and yearly quoted prices of lead at St. Louis, New York and London [1]

(Cents per pound)

Month	1966 St. Louis	1966 New York	1966 London [2]	1967 St. Louis	1967 New York	1967 London [2]
January	15.80	16.00	13.68	13.80	14.00	9.96
February	15.80	16.00	13.23	13.80	14.00	10.04
March	15.80	16.00	13.26	13.80	14.00	10.34
April	15.80	16.00	12.69	13.80	14.00	10.28
May	14.94	15.14	11.84	13.80	14.00	10.35
June	14.80	15.00	11.71	13.80	14.00	10.31
July	14.80	15.00	11.90	13.80	14.00	10.44
August	14.80	15.00	11.93	13.80	14.00	10.51
September	14.80	15.00	11.41	13.80	14.00	10.23
October	14.04	14.24	10.57	13.80	14.00	10.18
November	13.80	14.00	10.07	13.80	14.00	10.44
December	13.80	14.00	10.14	13.80	14.00	10.12
Average	14.92	15.12	11.87	13.80	14.00	10.28

[1] St. Louis: Metal Statistics, 1968. New York: Metal Statistics, 1968. London: Metals Week.
[2] Based on monthly rates of exchange by Federal Reserve Board.

Table 25.—U.S. exports of lead, by countries [1]

(Short tons)

Destination	1965	1966	1967
Pigs, bars and anodes:			
Belgium-Luxembourg	691	1,115	13
Brazil	1	799	558
Canada	213	299	353
Colombia	428	530	237
Italy	259	12	42
Japan	585	15	1,402
Mexico	128	156	200
Netherlands	336	118	156
Philippines	129	68	119
Spain	348	11	1
Switzerland	289	1	(2)
Taiwan	73	233	190
United Kingdom	1,928	200	321
Venezuela	363	346	206
Viet-Nam, South	639	521	19
Other	1,401	1,011	2,719
Total	7,811	5,435	6,536
Scrap:			
Belgium-Luxembourg	------	101	35
Canada	243	-----	56
Germany, West	161	-----	-----
Italy	2,348	5	-----
Japan	12	-----	16
Netherlands	235	238	139
United Kingdom	83	138	120
Yugoslavia	584	-----	-----
Other	127	16	28
Total	3,793	498	394
Grand total	11,604	5,933	6,930

[1] In addition foreign lead was reexported as follows: pigs, bars and anodes, 1965, 659 tons; 1966, 7 tons; 1967, 162 tons. Scrap, 1965, 99 tons; 1966–67, none.
[2] Less than ½ unit.

Table 26.—U.S. imports [1] of lead, by countries

(Short tons)

Country	1965	1966	1967
Ore, flue dust, and matte (lead content):			
Australia	26,658	22,614	25,553
Bolivia	5,096	11,136	13,764
Canada	43,622	52,707	33,474
Colombia	677	445	561
Guatemala	18	35	197
Honduras	8,712	11,132	6,513
Mexico	760	624	314
Peru	26,419	41,610	36,734
Philippines	106	164	37
South Africa, Republic of	10,570	1,394	359
Other	23	2,130	6,561
Total	122,661	143,991	124,067

Table 26.—U.S. imports [1] of lead, by countries—Continued

Country	1965	1966	1967
Base bullion (lead content):			
Australia	448	1,283	-------
Belgium-Luxembourg	--------	-------	442
Canada	50	62	23
France	--------	-------	55
Germany, West	-------	56	-------
Mexico	43	547	95
Peru	25	64	66
United Kingdom	-------	-------	71
Total base bullion	566	2,012	752
Pigs and bars (lead content):			
Australia	51,105	44,187	53,156
Belgium-Luxembourg	197	2,535	23,281
Burma	-------	5,532	2,548
Canada	31,697	34,283	37,238
Denmark	514	672	423
Germany, West	1,653	15,499	49,077
Japan	4,638	1,719	-------
Mexico	73,546	75,294	57,271
Peru	26,132	51,593	70,377
South Africa, Republic of	3,165	11,986	6,989
Spain	243	-------	-------
United Kingdom	514	3,101	17,680
Yugoslavia	28,640	31,322	30,478
Zambia	-------	1,148	-------
Other	569	6,518	15,080
Total	222,613	285,389	363,598
Reclaimed scrap, etc. (lead content):			
Australia	978	43	1,086
Canada	2,919	2,543	6,431
Dominican Republic	-------	179	248
Germany, West	-------	-------	1,472
Japan	42	-------	13
Mexico	315	314	278
Netherlands Antilles	-------	188	187
New Zealand	-------	50	77
Panama	-------	80	374
Other	16	35	123
Total	4,270	3,432	10,289
Grand total	350,110	434,824	498,706

[1] Data are "general imports"; that is they include lead imported for immediate consumption plus material entering the country under bond.

Table 27.—U.S. imports for consumption [1] of lead, by countries

(Short tons)

Country	1965	1966	1967
Ore, flue dust, and matte (lead content):			
Australia	23,408	21,460	37,879
Bolivia	3,885	1,454	14,707
Canada	33,637	23,617	41,416
Colombia	439	228	892
Honduras	7,406	3,506	5,350
Mexico	577	425	409
Peru	30,732	10,177	40,321
Philippines	96	-------	264
South Africa, Republic of	28,712	2,963	478
Sweden	-------	-------	2,377
Other	41	20	63
Total	128,933	63,850	144,156
Base bullion (lead content):			
Australia	448	1,272	-------
Belgium-Luxembourg	-------	-------	442
Canada	50	62	23
Germany, West	-------	56	-------
Mexico	43	474	20
Peru	25	64	66
United Kingdom	-------	-------	71
Other	(2)	-------	55
Total	566	1,928	677
Pigs and bars (lead content):			
Australia	50,484	44,160	53,156
Belgium-Luxembourg	422	2,535	23,281
Burma	-------	5,532	2,548
Canada	31,697	34,283	37,236
Denmark	514	672	423
Germany, West	2,161	15,499	49,077
Japan	4,363	2,106	-------
Mexico	73,386	75,394	57,271
Morocco	112	-------	2,413
Netherlands	224	5,137	878
Peru	27,484	51,593	70,377
South Africa, Republic of	3,002	11,925	6,989
United Kingdom	425	3,101	17,680
Yugoslavia	28,639	31,322	30,478
Other	548	2,529	11,789
Total	223,461	285,788	363,596
Reclaimed scrap, etc. (lead content):			
Australia	23	61	67
Canada	3,127	2,807	6,340
Dominican Republic	-------	179	248
Germany, West	1	-------	1,568
Japan	42	-------	13
Mexico	328	314	278
Netherlands Antilles	-------	188	167
New Zealand	-------	50	80
Panama	45	80	374
Peru	-------	150	-------
Other	46	127	233
Total	3,612	3,956	9,368
Sheets, pipe, and shot:			
Belgium-Luxembourg	121	219	513
Canada	83	30	99
Germany, West	5	134	2
Mexico	265	-------	-------
Netherlands	377	514	402
Other	29	22	196
Total	880	919	1,212
Grand total	357,452	356,441	519,009

[1] Excludes imports for manufacture in bond and export, classified as "imports for consumption" by the Bureau of the Census.
[2] Less than ½ unit.

Table 28.—U.S. imports for consumption of lead, by 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		
1965	129	$26,923	1	$380	223	$60,924	4	$793	1	$273	$329	$89,622
1966	64	13,871	2	575	285	75,312	4	886	1	283	r 563	91,490
1967	144	29,111	1	1,224	364	88,697	9	1,951	1	322	542	121,847

r Revised.
[1] Excludes imports for consumption in bond and export, classified as "imports for consumption" by the Bureau of the Census.

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)
1965	3,299	986	$8,129
1966	1,589	731	3,203
1967	775	413	1,423

Table 30.—World mine production of lead (content of ore) by countries [1] [2]

(Short tons)

Country	1963	1964	1965	1966	1967 [p]
North America:					
Canada	198,988	206,359	302,952	[r] 323,175	339,701
Guatemala [3]	825	[e] 550	[e] 550	[e] 660	[e] 660
Honduras	[r] 10,913	8,250	10,642	12,207	12,879
Mexico	209,425	192,710	187,494	[e] 197,000	[e] 188,500
United States [3]	253,369	286,010	301,147	327,368	316,931
South America:					
Argentina	29,173	28,576	35,534	34,884	35,595
Bolivia	20,989	18,180	[r] 17,981	[r] 21,484	21,755
Brazil [e]	19,200	16,200	[r] 25,000	24,700	21,000
Chile	1,199	1,230	[r] 863	[r] 912	445
Colombia	331	534	507	658	NA
Ecuador	179	183	126	76	NA
Peru [3]	164,461	166,089	170,135	159,570	174,378
Europe:					
Austria [3]	5,504	5,727	5,553	5,336	5,295
Bulgaria	97,995	100,641	[e] 110,200	[e] 110,200	[e] 112,000
Czechoslovakia [e]	14,900	14,900	15,400	15,400	15,400
Finland	1,262	2,083	6,952	5,107	[e] 4,600
France	9,255	13,437	19,898	[r] 29,491	30,000
Germany:					
East [e]	11,000	11,000	11,000	[r] 13,000	NA
West	58,243	53,944	54,727	61,099	65,535
Greece	[r] 9,755	[r] 8,962	[r] 10,626	10,748	[e] 10,400
Hungary	1,102	1,323	1,543	[e] 1,540	NA
Ireland	----------	1,323	2,853	[r] 44,092	[e] 68,700
Italy	[r] 36,231	[r] 36,737	[r] 39,098	[r] 40,456	[e] 43,000
Norway	3,297	3,945	[r] 3,860	[r] 3,887	[e] 3,700
Poland	42,659	42,218	45,415	[r] 49,714	[e] 50,000
Portugal	247	216	168	[r] 1,890	1,653
Rumania [e] [4]	13,800	14,000	[r] 17,000	[r] 44,000	44,000
Spain	68,557	64,356	[r] 62,435	68,774	69,040
Sweden	78,293	74,373	[r] 76,004	76,280	[e] 78,000
U.S.S.R. [e]	[r] 347,000	[r] 364,000	[r] 386,000	[r] 413,000	440,000
United Kingdom	276	198	101	----------	----------
Yugoslavia	125,535	124,677	117,122	[r] 113,097	[e] 113,500
Africa:					
Algeria	9,039	10,525	11,514	[e] [r] 4,400	[e] 4,400
Congo (Brazzaville)	364	2,391	[e] 3,100	[e] 3,900	[e] 3,900
Congo (Kinshasa)	1,306	1,152	1,709	NA	NA
Morocco	81,540	78,584	85,000	85,536	57,707
Nigeria	----------	----------	[e] 770	[e] 1,760	[e] 2,200
South Africa, Republic of	16	----------	53	20	26
South-West Africa, Territory of [3]	83,220	104,023	96,789	93,745	[e] 77,000
Tunisia	15,697	13,944	17,494	17,561	13,720
United Arab Republic [e]	550	----------	----------	17	NA
Zambia [4]	21,615	14,508	23,529	20,679	21,055
Asia:					
Burma	22,064	20,723	[r] 21,385	NA	[e] 10,800
China, mainland [e]	110,000	110,000	110,000	110,000	99,000
India	4,758	4,966	4,388	4,116	2,607
Iran [e] [5]	11,000	16,500	18,700	22,000	NA
Japan	58,110	59,604	60,550	[r] 69,551	70,110
Korea:					
North [e]	55,000	60,000	65,000	65,000	72,000
South	2,113	3,691	4,878	[r] 6,126	10,670
Philippines	78	114	116	101	105
Thailand	2,496	4,030	6,152	[r] 7,023	3,833
Turkey	2,811	1,792	1,854	1,031	2,599
Oceania: Australia	459,527	419,839	405,594	[r] 408,724	416,888
Total [6]	[r] 2,775,267	[r] 2,789,317	[r] 2,977,461	[r] 3,131,095	3,132,887

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

[1] Data derived in part from International Lead and Zinc Study Group Monthly Bulletin, United Nations Statistical Yearbook, Yearbook of the American Bureau of Metal Statistics, annual issues of the Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London), and Metal Statistics (Metallgesellschaft), Germany.

[2] Compiled mostly from data available June 1968.

[3] Recoverable.

[4] Smelter production.

[5] Year ended March 21 of year following that stated.

[6] Total is of listed figures only; no undisclosed data included.

Table 31.—World smelter production of lead by countries [1] [2]

(Short tons)

Country	1963	1964	1965	1966	1967 p
North America:					
Canada (refined)	155,001	151,372	186,484	184,871	190,279
Guatemala	52	83	126	237	78
Mexico	205,217	183,758	181,117	189,757	e 182,000
United States (refined) [3]	394,732	449,429	418,249	440,726	379,894
South America:					
Argentina	26,500	25,400	35,300	24,300	e 40,000
Bolivia (refined metal and solder)	280	508	1,032	r 1,246	261
Brazil	r 17,629	r 14,417	r 10,654	r 10,955	18,997
Chile	243	----	----	----	----
Peru	89,427	98,904	95,688	97,843	90,185
Europe:					
Austria	7,083	9,365	8,481	7,907	8,586
Belgium [4]	108,504	91,840	122,089	102,139	e 116,000
Bulgaria	56,584	96,451	102,979	e 100,200	e 108,000
Czechoslovakia e	15,400	15,400	16,000	16,000	16,000
France	85,569	98,976	108,419	119,753	e 128,000
Germany:					
East e [4]	27,600	27,600	27,600	27,600	e 27,600
West	121,515	118,502	114,674	120,841	150,250
Greece (base bullion from ores)	r 4,400	5,500	5,700	6,063	e 4,000
Hungary	440	220	220	e 220	NA
Italy	46,228	41,792	r 50,067	r 59,269	66,689
Poland	42,895	45,747	45,620	47,936	48,832
Portugal	1,232	1,506	1,442	1,160	e 1,200
Rumania e	13,800	14,000	17,000	44,000	44,000
Spain	68,436	63,927	r 59,321	60,775	e 60,600
Sweden (refined)	r 44,933	r 44,482	r 44,346	48,171	e 44,000
U.S.S.R. e	r 347,000	r 364,000	r 386,000	r 413,000	441,000
United Kingdom	297	195	99	----	----
Yugoslavia (refined)	114,832	111,427	111,889	107,503	103,452
Africa:					
Morocco	20,679	20,766	18,995	20,696	23,544
South-West Africa, Territory of	1,997	52,685	72,791	82,976	e 80,500
Tunisia [5]	13,898	13,331	15,627	15,403	14,600
Zambia	21,615	14,508	23,529	20,679	21,055
Asia:					
Burma	19,553	19,900	e r 17,600	e r 15,400	e 14,300
China, mainland e	99,000	110,000	110,000	110,000	99,000
India	3,899	3,995	3,202	2,733	2,610
Iran [6]	e 550	413	e 440	e 440	NA
Japan	101,575	106,962	119,433	130,715	165,316
Korea:					
North e	45,000	50,000	55,000	55,000	60,000
South	----	e 40	e 900	1,772	3,293
Turkey	2,073	2,161	r 1,012	r 550	e 1,300
Oceania: Australia:					
Refined lead	251,558	227,473	216,504	r 216,304	213,881
Pb content of lead bullion (for export)	90,341	87,701	74,936	r 83,210	107,046
Total [7]	r 2,667,567	r 2,784,736	r 2,880,565	r 2,988,350	3,076,348

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

1 Data derived in part from International Lead and Zinc Study Group Monthly Bulletin, United Nations Statistical Yearbook, Yearbook of the American Bureau of Metal Statistics, annual issues of Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London), and Metal Statistics (Metallgesellschaft), Germany.

2 Compiled mostly from data available June 1968.

3 Figures cover lead refined from domestic and foreign ores; refined lead produced from foreign base bullion not included.

4 Includes recovery from scrap.

5 Lead bars only; does not include lead contained in antimonial lead or solder.

6 Year ended March 21 of year following that stated.

7 Total is of listed figures only; no undisclosed data included.

Lime

By Paul L. Allsman [1]

DOMESTIC PRODUCTION

Production of quicklime increased 2 percent in 1967 due to its growing use in basic-oxygen-furnace (BOF) steelmaking. Production of hydrated lime remained at the same level, while production of dead-burned dolomite declined 14 percent. Total sales of open-market and captive lime remained about the same as in 1966. Growth in capacity continued as steel plants readied fluxing-lime units for operation.

Huron Lime Co. put into operation a new 800-ton-per-day lime plant in Huron, Ohio; production was scheduled for the basic-oxygen-furnaces of Weirton Steel Co., in Weirton, W. Va.

The Anaconda Company remodeled the old Domestic Manganese and Development Co. plant in Butte, Mont.; milk of lime production was to be used in copper concentration. Morrison and Weatherly Chemical Products Co. leased the Kennecott Copper Corp. lime quarry at McGill, Nev.; a new lime plant was put into operation for copper concentrating and smelting.[2]

Table 1.—Salient lime statistics in the United States

(Thousand short tons and thousand dollars)

	1963	1964	1965	1966	1967
Number of primary plants	208	210	212	208	209
Sold or used by producers:					
Quicklime	10,128	11,370	12,009	13,195	13,438
Hydrated lime	2,444	2,551	2,609	2,669	2,656
Dead-burned dolomite	1,949	2,168	2,176	2,193	1,880
Total [1]	14,521	16,089	16,794	18,057	17,974
Value [2]	$199,389	$223,149	$232,939	$239,588	$241,137
Average value per ton	$13.73	$13.87	$13.87	$13.27	$13.42
Open-market	8,889	9,802	10,449	11,451	11,461
Captive	5,632	6,287	6,345	6,606	6,513
Imports for consumption	101	123	276	196	123
Exports	17	30	40	60	52

[1] Data may not add to totals shown because of rounding.
[2] Selling value, f.o.b. plant, excluding cost of containers.

Port Landing, Inc. began production at its new $2.5 million lime plant near Lovell, Wyo.; production was scheduled for highway base stabilization. Spreckles Sugar Co. reported a new lime plant for sugar beet refining at Spreckles, Ariz., was put into operation during 1967.

Big Horn Calcium Co. built a $1 million, 250-ton-per-day lime plant at its Warren, Mont., limestone quarry; the plant will produce quicklime, hydrated lime, pebble lime, and sugar refining materials. Sierra Lime Products Corp. put its new 140-ton-per-day lime plant at Cool, Calif., into operation; undersize materials are processed to produce calcium oxide and calcium hydroxide.

[1] Commodity specialist, Division of Mineral Studies.
[2] Utley, Harry F. Copper Concentrator is Primary Market for New Lime Plant. Pit and Quarry, v. 60, No. 6, December 1967, pp. 100–104.

Clifstone Chemical Lime Co., Inc., put a new 200-ton-per-day lime plant into operation at Clifton, Tex.; the chemical lime will be used for water and paper processing, and steel, aluminum, and magnesium manufacture. W. S. Frey Co. began production at a new high-calcium, rotary kiln lime plant at Clearbrook, Va.; fluxstone, agricultural lime, and quicklime are produced in the 300-ton-per-day plant.[3]

A new lime kiln was installed by Paul Lime Plant, Inc., Paul Spur, Ariz., increasing capacity to 480 tons per day. Pete Lien & Sons, Rapid City, S. Dak., added a 200-ton vertical kiln; and Bethlehem Mines Corp., Annville, Pa., constructed a large rotary kiln at its Millard quarry. U.S. Gypsum Co. added a 300-ton rotary kiln at its New Braunfels, Tex., plant, increasing capacity to 800 tons; and also planned to add a 400-ton rotary kiln at its Montevallo, Ala. plant. National Gypsum Co. put into operation a 600-ton rotary kiln at its Kimballton, Va., plant, and also announced plans to expand its Gibsonburg, Ohio plant to supply lime to the metallurgical and glass industries. Ohio Lime Co. installed a 250-ton Parsons' calciner, the first production model of this vertical shaft kiln, at its Woodville, Ohio plant. Olin-Mathieson Chemical Corp. replaced old vertical kilns with rotary kilns at its Saltville, Va., plant. St. Regis Paper Co. added the world's largest lime sludge kiln at its Ferguson, Miss. plant; the 420 ton kiln is 13½ by 375 feet.

[3] Levine, Sidney. The W. S. Frey Co., Cultivates Four-State Market. Rock Prod., v. 70, No. 7, July 1967, pp. 56–59.

Table 2.—Lime, primary, sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	1966								
	Sold			Used			Total		
	Active plants	Quantity	Value	Active plants	Quantity	Value	Active plants	Quantity	Value
Alabama	5	W	W	4	W	W	7	699	$8,442
Arizona	4	121	$1,928	3	97	$1,793	6	218	3,721
Arkansas	1	W	W	4	W	W	5	207	3,004
California	6	183	3,300	12	368	5,464	17	552	8,764
Colorado	2	W	W	13	W	W	15	126	2,327
Florida	2	W	W	1	W	W	3	135	1,966
Hawaii	2	W	W	1	W	W	2	10	320
Louisiana	2	W	W	2	W	W	4	835	9,274
Maryland	3	29	386	---	-----	------	3	29	386
Massachusetts	3	W	W	2	W	W	3	182	2,712
Michigan	4	721	8,503	8	980	11,513	11	1,701	20,016
Mississippi	1	W	W	1	W	W	1	W	W
Missouri	4	W	W	1	W	W	4	1,494	17,910
Montana	---	------	------	4	225	2,116	4	225	2,116
New Mexico	---	------	------	1	34	472	1	34	472
New York	1	W	W	3	W	W	3	1,096	9,870
Ohio	15	2,535	36,075	8	1,322	14,921	19	3,858	50,997
Oklahoma	1	W	W	---	-----	------	1	W	W
Oregon	2	W	W	2	W	W	4	116	2,283
Pennsylvania	15	W	W	1	W	W	16	1,585	22,816
Tennessee	2	W	W	---	-----	------	2	W	W
Texas	9	763	8,826	6	710	9,870	14	1,473	18,696
Utah	3	W	W	4	W	W	7	200	3,640
Virginia	8	W	W	2	W	W	9	840	10,486
West Virginia	3	W	W	1	W	W	3	240	3,492
Wisconsin	5	W	W	1	W	W	6	204	3,186
Connecticut, New Jersey, Vermont	4	W	W	1	W	W	4	50	901
Illinois, Indiana, Iowa, Minnesota, Nebraska, North Dakota, South Dakota, Wyoming	11	1,219	17,961	13	112	2,435	24	1,331	20,396
Idaho, Nevada, Washington	4	W	W	6	W	W	10	378	6,164
Undistributed [1]	---	5,878	80,443	---	2,757	33,582	---	238	5,231
Total [2]	122	11,451	157,422	105	6,606	82,166	208	18,057	239,588
Puerto Rico	1	30	960	---	-----	------	1	30	960

W Withheld to avoid disclosing individual company confidential data.
[1] Includes items indicated by symbol W.
[2] Data may not add to totals shown because of rounding.

Table 2.—Lime, primary, sold or used by producers in the United States, by States—Continued

(Thousand short tons and thousand dollars)

State	1967								
	Sold			Used			Total		
	Active plants	Quantity	Value	Active plants	Quantity	Value	Active plants	Quantity	Value
Alabama	5	504	$5,836	4	120	$1,883	7	624	$7,719
Arizona	3	W	W	4	W	W	7	186	3,142
Arkansas	1	W	W	4	W	W	5	187	2,723
California	6	209	3,735	12	330	4,961	18	539	8,696
Colorado	2	W	W	11	W	W	13	118	2,028
Florida	2	W	W	1	W	W	3	155	2,425
Hawaii	2	W	W	1	W	W	2	8	265
Louisiana	2	W	W	2	W	W	4	758	9,891
Maryland	3	W	W	---	-----	------	3	W	W
Massachusetts	3	W	W	1	W	W	3	195	3,044
Michigan	4	810	9,617	8	977	11,965	11	1,787	21,582
Missouri	4	W	W	1	W	W	4	1,434	16,371
Montana	---	------	-------	4	143	1,765	4	143	1,765
New Mexico	---	------	-------	1	17	243	1	17	243
New York	1	W	W	3	W	W	3	1,139	10,570
Ohio	15	W	W	8	W	W	19	3,636	48,817
Oregon	2	W	W	2	W	W	4	99	2,059
Pennsylvania	14	W	W	2	W	W	16	1,719	24,715
Texas	9	843	10,552	6	722	10,161	14	1,564	20,713
Utah	3	W	W	4	W	W	7	169	3,182
Virginia	9	W	W	2	W	W	10	829	10,345
West Virginia	3	W	W	1	W	W	3	217	3,099
Wisconsin	5	211	3,407	1	1	7	6	212	3,414
Connecticut, New Jersey, Vermont	3	W	W	---	-----	------	3	W	W
Illinois, Indiana, Iowa, Minnesota, Mississippi, Nebraska, North Dakota, Oklahoma, South Dakota, Tennessee, Wyoming	14	1,641	22,999	15	143	4,044	28	1,784	27,042
Idaho, Nevada, Washington	5	W	W	6	W	W	11	383	6,117
Undistributed [1]	---	7,244	100,642	---	4,059	49,321	---	70	1,167
Total [2]	120	11,461	156,787	104	6,513	84,350	209	17,974	241,137
Puerto Rico	1	35	1,106	---	-----	------	1	35	1,106

W Withheld to avoid disclosing individual company confidential data.
[1] Includes items indicated by symbol W.
[2] Data may not add to totals shown because of rounding.

Table 3.—Regenerated quicklime produced in the United States

(Thousand short tons and thousand dollars)

State	1966		1967	
	Quantity	Value	Quantity	Value
Alabama	399	$5,762	381	$5,405
Arkansas	167	3,248	178	3,488
California	47	1,136	118	2,525
Florida	462	7,496	467	7,625
Georgia	367	7,100	355	6,653
Idaho	75	W	73	1,962
Kentucky	237	2,240	242	2,544
Louisiana [1]	451	8,934	457	9,734
Maryland	30	449	W	W
Michigan [1]	40	508	W	W
Montana	67	W	W	W
North Carolina	337	3,767	353	3,653
Ohio	98	1,175	92	W
Oregon	190	4,628	187	4,546
Pennsylvania	23	378	23	400
South Carolina	307	3,175	314	3,184
Tennessee	127	2,098	122	1,920
Virginia	123	1,721	W	W
Washington [1]	446	10,322	414	9,596
Wisconsin [1]	33	584	W	W
Undistributed [2]	406	10,004	581	11,496
Total [3]	4,432	74,726	4,357	74,731

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Includes hydrated lime to avoid disclosing individual company confidential data.
[2] Includes Maine, Mississippi, New York, Texas, and States indicated by symbol W.
[3] Data may not add to totals shown because of rounding.

Table 4.—Number and production of domestic lime plants, by size of operation [1]

Annual production (short tons)	1966 [r]			1967		
	Number of plants	Production (thousand short tons)	Percent of total	Number of plants	Production (thousand short tons)	Percent of total
Less than 10,000	53	248	1	56	284	2
10,000 to less than 25,000	40	673	4	37	604	3
25,000 to less than 50,000	29	1,054	6	29	1,020	6
50,000 to less than 100,000	35	2,459	14	29	1,890	10
100,000 to less than 200,000	22	3,063	17	25	2,810	16
200,000 and over	29	10,560	58	33	11,366	63
Total	208	18,057	100	209	17,974	100

[r] Revised.
[1] Includes captive tonnage.

Descriptions of quarries, equipment, and products at several important plants were published. Dixie Lime & Stone Co.'s new 200-ton calcimatic rotary hearth plant near Sumterville, Fla., produces pebble lime.[4] Bethlehem Steel Company's new 600-ton, circular refractory hearth plant at Hanover quarry, Pa., produces BOF steelmaking lime flux for its Sparrows Point, Md., steelworks.[5] Marblehead Lime Company's new 1,000-ton plant at Buffington, Ind., furnishes BOF fluxing lime for the Gary, Ind., steel industry.[6] Warner Company's Bell-Mine pebble lime plant at Bellefonte, Pa., has a capacity of 1,500 ton per day; stone is mined from the 960-foot level.[7]

[4] Trauffer, Walter E. Dixie's New Lime Plant Uses Rotary Hearth Calciner. Pit and Quarry, v. 59, No. 11, May 1967, pp. 100–115.
[5] Levine, Sidney. Bethlehem's New Lime Plant Provides 600 tpd BOF Flux. Rock Products, v. 70, No. 7, July 1967, pp. 63–67.
[6] Herod, Buren C. Marblehead Lime On Stream With New Indiana Plant. Pit and Quarry, v. 59, No. 11, May 1967, pp. 116–125.
[7] Levine, Sidney. Fifth Lime Kiln Boosts Warner Co.'s Capacity. Rock Prod., v. 70, No. 7, July 1967, pp. 60–62.

Table 5.—Lime sold or used by producers in the United States by uses

(Thousand short tons)

Use	1966			1967		
	Open market	Captive	Total	Open market	Captive	Total
Agriculture	199	(1)	199	174	-------	174
Construction:						
Finishing lime	263	W	263	231	-------	231
Mason's lime	499	W	499	518	(2)	518
Soil stabilization	573	-------	573	669	-------	669
Other	74	-------	74	14	-------	14
Undistributed [3]	------	103	103	--------	-------	------
Total [4]	1,409	103	1,512	1,433	(2)	1,433
Chemical and other industrial:						
Alkalies (ammonium, potassium, and sodium compounds)	15	3,274	3,290	50	3,092	3,142
Brick, sand-lime, slag, and silica	20	-------	20	16	-------	16
Calcium carbide	455	W	455	19	W	419
Glass	435	-------	435	437	-------	437
Other chemical uses [5]	687	1,238	1,925	671	1,277	1,949
Metallurgical uses:						
Aluminum	135	W	135	143	W	143
Copper smelting	117	307	424	127	170	296
Magnesium	W	W	128	W	W	128
Ore concentration [6]	60	-------	60	63	-------	63
Steel flux	3,657	384	4,041	4,005	676	4,681
Metallurgy (other) [7]	55	282	209	114	302	288
Paper and pulp	896	98	994	878	92	970
Sewage and trade-wastes treatment	310	54	365	322	49	371
Sugar	30	545	575	27	536	563
Water softening and treatment	1,095	-------	1,095	1,019	4	1,023
Total [4]	7,970	6,182	14,152	8,290	6,198	14,488
Refractory lime (dead-burned dolomite)	1,872	321	2,193	1,565	315	1,880
Grand total [4]	11,451	6,606	18,057	11,461	6,513	17,974

W Withheld to avoid disclosing individual company confidentiality.
[1] Included with open-market agricultural lime to avoid disclosing confidential data.
[2] Included with "Other chemical uses" to avoid disclosing confidential data.
[3] Includes finishing, mason's, soil stabilization, and other.
[4] Data may not add to totals shown because of rounding.
[5] Includes alcohol, calcium carbonate (precipitated), coke and gas, food and food byproducts, insecticides medicine, and drugs, explosives, oil-well drilling, paint, petrochemicals, petroleum refining, rubber, tanning, salt, miscellaneous unspecified uses, mason's lime, and items indicated by symbol W.
[6] Includes flotation, cyanidation, and bauxite purification.
[7] Includes wire drawing and various metallurgical uses, and items indicated by symbol W.

CONSUMPTION AND USES

Basic Oxygen Furnace (BOF) steelmaking was again the leading lime consumer, with a further 50-percent increase in lime use by this industry predicted within the next decade. The amount of lime produced by captive plants was expected to reach one-fifth of the total used for fluxing purposes by 1975.[8] Also forecast was the growth of steel fluxing lime to 40 percent of the commercial lime market by 1975. It was estimated that by 1975 BOF steelmaking alone would use at least 6 million tons.[9]

While lime usage in agriculture in 1967 declined, aglime showed signs of increasing importance in this area. Laboratory work proved that liming enhances the action of fertilizers, and can be used in conjunction with them. Lime corrects high acidity created by fertilizers, and adds elements removed by high crop yields.[10]

Subgrade and soil stabilization with lime continued to expand, as special equipment was adapted to this use. A pulverizing mixer used on the new Kansas City airport was described.[11] Overall lime stabilization tonnage was predicted

[8] Grancher, Roy A. BOP Steelmaking Will Revamp the Lime Industry. Rock Prod. v. 70, No. 4, April 1967, pp. 85–87, 114.
[9] Grancher, Roy A. Steel Flux Dominates Market for Lime. Rock Prod., v. 70, No. 3, March 1967, pp. 84–86, 110–112.
[10] Eastern Potash Newsletter. Lime: Profit-Making Foreman. No. E-130, 1967, 3 pp.
[11] Roads and Streets. Lime Bolsters Poor Airfield Subgrade, Speeds Paving Schedule. V. 110, No. 8, August 1967, pp. 60–62.

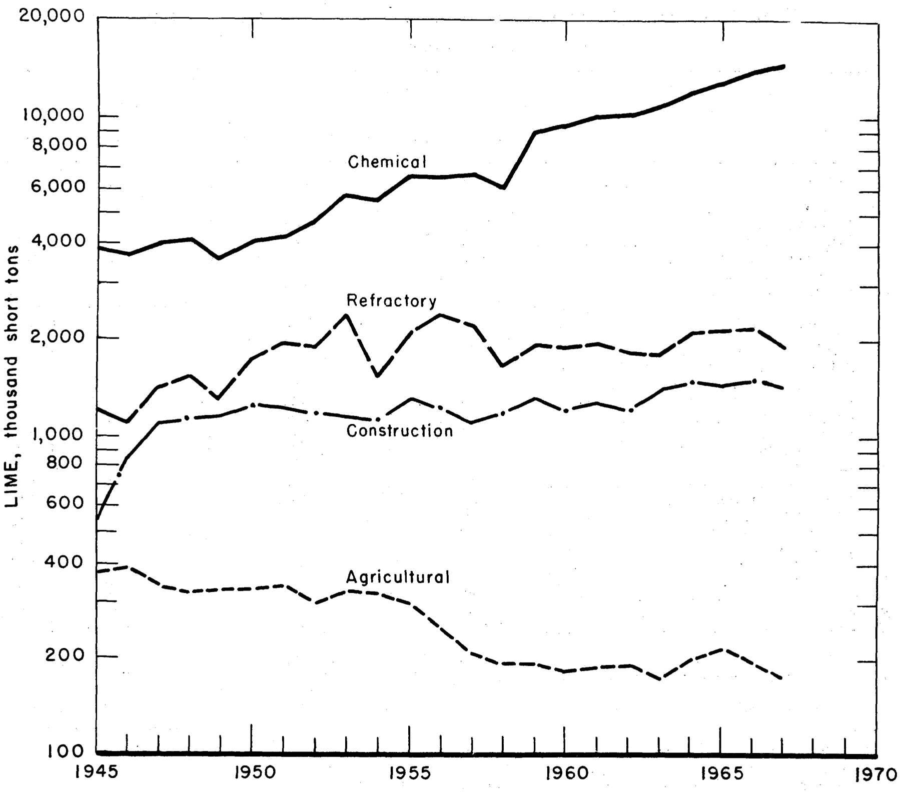

Figure 1.—Trends in major uses of lime.

to grow at a steady rate of 15 percent per year.

Other growing uses for lime, outlined at the National Lime Association convention, included building foundations, masonry lime, agriculture, water treatment, waste treatment, and drill lime stabilization. A great future for the lime industry was predicted.[12]

Dead-burned dolomite, which dropped in tonnage in 1967 due to lowered use by the steel industry where it is used as a furnace-lining refractory, may find new use in treating furnace gases. Combustion Engineering, Inc. announced a successful new process using calcined dolomitic limestone which will remove 99 percent of the sulfurous fumes from plant stack gases.[13]

[12] Rock Products. More Change Predicted for Lime Industry. V. 70, No. 7, July 1967, pp. 84, 98.

[13] National Lime Association. Limeographs. V. 34, July-August 1967, p. 5.

Table 6.—Destination of shipments of primary open-market lime sold in the United States

(Thousand short tons)

State	1966			1967		
	Quicklime	Hydrated lime	Total	Quicklime	Hydrated lime	Total
Alabama	309	15	324	265	17	282
Alaska	W	W	1	W	W	1
Arizona	W	W	114	W	W	95
Arkansas	16	19	34	12	19	31
California	263	111	374	292	118	409
Colorado	66	26	92	81	25	107
Connecticut	70	27	96	76	24	100
Delaware	34	11	44	27	10	37
District of Columbia	W	W	6	W	W	3
Florida	172	68	240	134	56	190
Georgia	105	19	124	86	17	103
Hawaii	W	W	W	W	W	W
Idaho	W	W	12	W	W	13
Illinois	606	159	765	607	161	768
Indiana	925	64	989	1,084	65	1,149
Iowa	87	19	106	71	25	96
Kansas	40	20	60	40	18	58
Kentucky	418	18	436	495	18	513
Louisiana	167	52	220	151	64	215
Maine	43	11	54	50	11	61
Maryland	323	18	341	331	16	348
Massachusetts	W	W	39	W	W	37
Michigan	911	64	975	866	59	925
Minnesota	110	17	127	112	15	127
Mississippi	78	46	124	76	15	91
Missouri	125	51	176	144	34	178
Montana	4	2	5	11	2	13
Nebraska	W	W	20	W	W	18
Nevada	W	W	36	W	W	29
New Hampshire	W	W	10	W	W	11
New Jersey	75	88	164	59	80	139
New Mexico	1	24	26	1	25	25
New York	234	168	402	233	166	398
North Carolina	70	30	100	78	31	110
North Dakota	1,257	W	12	W	W	27
Ohio	1,257	140	1,397	1,331	136	1,466
Oklahoma	W	W	W	W	W	W
Oregon	56	15	72	46	16	62
Pennsylvania	1,351	178	1,528	1,137	165	1,303
Rhode Island	7	6	13	7	7	14
South Carolina	36	8	44	54	8	62
South Dakota	13	23	36	20	26	46
Tennessee	69	51	120	73	52	125
Texas	327	451	778	391	510	901
Utah	W	W	84	W	W	81
Vermont	W	W	2	W	W	2
Virginia	129	37	166	86	33	120
Washington	69	16	85	60	15	75
West Virginia	94	22	116	96	16	112
Wisconsin	89	53	143	86	62	147
Wyoming	W	W	8	W	W	8
Undistributed [1]	281	170	107	278	173	125
Total United States [2]	9,030	2,317	11,346	9,046	2,312	11,357

W Withheld to avoid disclosing individual company confidentiality.
[1] Includes States indicated by symbol W.
[2] Data may not add to totals shown because of rounding.

PRICES

Quotations in the Engineering News–Record for delivered hydrated finishing lime in 1967 ranged from $60 per ton in Seattle to $27 per ton in Los Angeles. The average price reported for 17 major cities was $38.10 per ton. Prices for pulverized quicklime ranged from $54 per ton in Denver to $26 per ton in Dallas, and averaged $34.96 per ton for 10 cities. The average delivered price for common hydrated lime, as reported from 16 selected cities, was $33.38 per ton.

The average value of lime sold or used by producers, f.o.b. plant, excluding the cost of containers, was $13.42 per ton, compared with $13.27 in 1966.

FOREIGN TRADE

In 1967, Canada received 61 percent of U.S. lime exports and Mexico received 23 percent.

Imports from Canada represented virtually all of the combined import total for all types of lime in 1967.

WORLD REVIEW

Canada.—The 235-ton, rotary hearth lime kiln of Algoma Steel Corp., Ltd., at Sault Ste. Marie, Ontario, was described. Producing flux for BOF steel making, the modern, fully automated plant can be operated by just one man.[14]

Jamacia.—Alcan Jamaica, Ltd., announced plans for a $1.3 million expansion of the lime producing facilities at its Kirkvine Works, 80 miles north of Kingston. Production will be used for processing of alumina from bauxite at Alcan's Kirkvine and Ewarton plants.

Panama.—Empresas Asociadas, S. A., announced plans for a limestone quarry and lime plant, to produce hydrated lime and quicklime.

Puerto Rico.—Puerto Rican Cement Co. Inc., was completing a $2.3 million, 250,000 barrel white lime plant at Ponce, P. R.

Table 7.—U.S. exports of lime

Year	Short tons	Value (thousands)
1965	40,036	$942
1966	59,848	1,195
1967	52,143	1,099

Table 8.—U.S. imports for consumption of lime

Year	Hydrated lime		Other lime		Dead-burned dolomite [1]		Total	
	Short tons [2]	Value (thousands)	Short tons [2]	Value (thousands)	Short tons [2]	Value (thousands)	Short tons [2]	Value (thousands)
1965	532	$10	215,816	$2,590	59,519	$2,385	275,867	$4,985
1966	203	5	151,703	1,772	43,637	2,038	195,543	3,815
1967	545	12	79,983	961	42,413	1,832	122,941	2,805

[1] Dead-burned basic refractory material consisting chiefly of magnesia and lime.
[2] Includes weight of immediate container.

TECHNOLOGY

Research on new applications for lime took the spotlight in 1967, with important new techniques announced for agricultural liming, acid mine drainage control, lime kiln design and efficiency, soil mixing and pulverizing, and calcining. The Bureau of Mines published results of a study of the oxygen-converter steelmaking process.[15]

Lime producers presented results of agliming studies in tropical soils at the annual meeting of the National Lime Association in San Juan, P. R. It is believed that liming to tropical soils will revive a lagging soil fertility more effectively than fertilizers.[16]

A new lime neutralization process for treating acid mine water was developed by Heyl & Patterson Co. of Pittsburgh. Capital costs are $150 to $250 per gallon per minute of capacity; operating costs are 10¢ to 15¢ per 1,000 gallons, most of which is for lime materials.[17]

Two important papers on lime kiln design were published during the year. The metallurgical calculations and production results to be expected from a

[14] Mac Namara, John. Lime Plant at Algoma. Iron and Steel Eng., v. 44, No. 10, October 1967, pp. 126–130.
[15] Tartaran, F. X., and J. D. Ruschak. Effect of Lime Structure in Oxygen Steelmaking. BuMines Rept. of Inv. 6901, 1967, 41 pp.
[16] Geigel, Antonio R. Importance of Hydrated Lime in Tropical Agriculture. Pit & Quarry, v. 59, No. 11, May 1967, pp. 126–130.
[17] National Lime Association. Limeographs. V. 34, July August, 1967, p. 4.

standard-sized 500 ton-per-day rotary kiln were summarized.[18] The operating characteristics of the new Ultimos vertical kiln were listed. Calcination is controlled in a reducing atmosphere, and drawbacks of earlier vertical kilns are eliminated.[19]

[18] Azbe, Victor J. Azbe Summarizes Design Requirements for Super Rotary Lime Kiln. Rock Prod., v. 70, No. 2, February 1967, pp. 73–79, 112–113.

[19] Azbe, Victor J. The Ultimos Kiln in Performance. Rock Prod., v. 70, No. 7, July 1967, pp. 74–77, 98.

Table 9.—World production of quicklime and hydrated lime, including dead-burned dolomite, sold or used [1] [2]

(Thousand short tons)

Country	1963	1964	1965	1966	1967 p
North America:					
Canada	1,451	1,541	1,620	r 1,573	1,393
Costa Rica	e 6	e 7	e 13	e 13	9
Guatemala	NA	NA	r 20	19	NA
Nicaragua	31	29	29	30	NA
Puerto Rico	4	18	27	30	35
United States (sold or used by producers)	14,521	16,089	16,794	18,057	17,974
South America:					
Brazil	1,332	r 1,586	1,344	1,400	NA
Colombia	107	110	r 119	56	NA
Paraguay	19	20	20	19	19
Uruguay e	33	46	66	66	NA
Venezuela	55	75	71	49	NA
Europe:[3]					
Austria	759	805	763	r 765	751
Belgium	2,223	2,534	2,526	2,460	NA
Bulgaria	830	919	938	NA	NA
Czechoslovakia	2,485	2,587	2,743	2,716	NA
Denmark	167	176	179	165	NA
Finland	229	265	270	250	e 255
France	2,919	3,216	3,113	r 3,208	3,009
Germany:					
East	3,811	4,049	3,793	e 3,900	NA
West	10,775	11,920	11,714	11,465	11,227
Hungary	698	811	782	852	NA
Ireland	36	44	e 46	e 45	NA
Italy	6,283	5,622	5,622	5,622	e 5,620
Malta	18	NA	41	40	NA
Norway	125	r 114	r 251	r 259	e 260
Poland	2,209	2,395	2,491	r 2,647	NA
Rumania	r 1,329	r 1,146	r 1,132	r 1,154	1,157
Spain	234	283	278	NA	NA
Sweden	r 856	r 948	r 967	1,063	e 990
Switzerland	203	221	195	184	NA
U.S.S.R.	17,651	17,855	19,495	e 19,800	e 19,800
Yugoslavia	947	999	1,226	1,255	1,322
Africa:					
Congo (Kinshasa)	74	75	72	e 67	NA
Ethiopia (including Eritrea)	5	e 7	e 4	21	25
South Africa, Republic of (sales)	719	771	823	812	964
South-West Africa, Territory of	3	4	4	3	NA
Tanzania (sales and exports)	1	2	2	10	6
Tunisia	146	193	e 192	190	187
Uganda	12	13	22	4	204
Zambia	NA	NA	85	NA	NA
Asia:					
Cyprus	65	e 44	81	NA	NA
Japan	1,527	1,798	1,865	2,219	3,397
Kuwait	------	13	1	1	1
Lebanon	e 39	e 29	e 44	e 72	55
Mongolia e	28	33	39	39	44
Philippines	35	32	26	26	93
Ryukyu Islands	e 1	NA	NA	23	1
Saudi Arabia	7	NA	33	22	9
Taiwan	88	101	113	118	102
Oceania:					
Australia [4]	117	113	178	167	NA
Fiji Islands	6	4	r 4	3	3
Total [5]	75,219	79,662	82,276	82,959	NA

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

[1] Lime is produced in many other countries of the world besides those listed. India and Mexico are among the more important countries for which official data are unavailable.

[2] Compiled mostly from data available June 1968.

[3] For Europe the data includes lime only and in the case of France, high grade lime only. France's total lime production is much larger than that shown.

[4] Year ended June 30 of year stated.

[5] Total is of listed figures only; no undisclosed data included.

Magnesium

By Robert F. Griffith [1]

Expansion of domestic production capacity to meet increased demands, and research directed toward developing new markets, and improving the strength of magnesium alloys dominated the industry in 1967. Apparent consumption of primary magnesium, reached 100,000 tons.

Legislation and Government Programs.—The national stockpile objective for magnesium was lowered on January 1, 1967, from 145,000 to 90,000 short tons. Inventory at yearend was 145,300 tons, and legislation was pending on the orderly disposal of the 55,000 ton surplus created by the lowering of the objective. Stockpile sales since March 1962 have totaled about 33,500 tons, including 5,100 tons sold on a competitive bid basis in 1966–67, and 17,650 tons sold on a negotiated basis during the same period. Reflecting the strong demand for magnesium, bids exceeded the 586 tons of primary and alloy magnesium, offered for sale from the stockpile in March 1967.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient magnesium statistics

(Short tons)

	1963	1964	1965	1966	1967
United States:					
Production:					
Primary magnesium	75,845	79,488	81,361	79,794	97,406
Secondary magnesium	9,225	11,790	13,617	15,129	e 13,235
Shipments: Primary	72,255	74,580	85,796	96,443	100,743
Imports for consumption	1,850	2,227	2,551	3,265	9,213
Exports	15,484	15,949	17,836	14,869	11,989
Consumption	51,240	54,748	69,622	82,678	98,230
Price per pound ... cents	35.25	35.25	35.25	35.25	35.25
World: Primary production	157,156	165,927	178,318	179,844	202,608

e Estimate.

DOMESTIC PRODUCTION

The 22 percent increase in primary magnesium production to 97,400 tons, the highest since 1952, represented domestic capacity. To meet increasing demand, through plant expansions and process improvements the two primary magnesium producers increased annual domestic capacity to 103,750 tons at yearend. The Dow Chemical Co., operating electrolytic plants at Freeport and Velasco, Tex., increased annual capacity to 95,000 tons and announced plans for an additional increase to 120,000 tons by mid-1968. Alamet Division of Calumet and Hecla, Inc., producer of magnesium by the silicothermic process at Selma, Ala., increased annual capacity from 7,200 to 9,000 tons. In 1966, this company put on stream an automated plant for producing the ferrosilicon that is used for reduction in its process for producing primary magnesium. Production by Chas. Pfizer & Co., Inc., was discontinued in 1966.

Table 2.—Magnesium recovered from scrap processed in the United States, by kinds of scrap and forms of recovery

(Short tons)

	1963	1964	1965	1966	1967
Kind of scrap:					
New scrap:					
Magnesium-base	4,183	4,505	6,306	6,462	5,062
Aluminum-base	2,848	3,177	3,643	4,127	e 4,150
Total	7,031	7,682	9,949	10,589	e 9,212
Old scrap:					
Magnesium-base	1,150	2,998	2,232	3,321	2,973
Aluminum-base	1,044	1,110	1,436	1,219	e 1,050
Total	2,194	4,108	3,668	4,540	e 4,023
Grand total	9,225	11,790	13,617	15,129	e 13,235
Form of recovery:					
Magnesium alloy ingot [1]	2,227	2,875	2,138	5,202	3,760
Magnesium alloy castings (gross weight)	404	37	14	24	39
Magnesium alloy shapes	75	50	58	70	103
Aluminum alloys	3,839	4,468	7,947	6,336	e 5,948
Zinc and other alloys	435	23	23	17	18
Chemical and other dissipative uses	754	588	542	281	25
Cathodic protection	1,491	3,749	2,895	3,199	3,342
Total	9,225	11,790	13,617	15,129	e 13,235

e Estimate.
[1] Figures include secondary magnesium content of both secondary and primary magnesium alloy ingot.

Construction was completed on the first phase of a project to extract magnesium chloride and other salts from the Great Salt Lake by Great Salt Lake Minerals & Chemicals Corp., a joint venture of Lithium Corporation of America, Inc., and Salzdetfurth, A.G., of Hanover, West Germany. Initial capacity is estimated at 300,000 tons of magnesium chloride per year. The Dow Chemical Co. has an agreement to purchase a substantial quantity of this production, and announced plans to construct a magnesium production plant in the Pacific Northwest with startup timed for 1971. Four other companies were considering plans for magnesium plants in the Pacific Northwest because low-cost electrical energy is available and because the paper industry provides a market for byproduct chlorine.

Plans were also made to construct a 30,000-ton-per-year electrolytic magnesium plant near Snyder, Tex. Slated to be on stream by May 1969, the plant will be operated by American Mangesium Co. of Tulsa, Okla., owned one-third by Pullman, Inc., of Chicago. Magnesium will be produced from area brine wells that contain up to 11 percent magnesium chloride. A power contract was made with the Texas Electric Service Co.

CONSUMPTION AND USES

Increased use of magnesium in structural applications offers the best opportunities for the industry's growth. However, in 1967, sacrificial and distributive uses, in which magnesium is desired for its chemical properties, accounted for 70 percent of total consumption; only 30 percent was used for structural purposes. Using cost versus unit volume as a determining factor, magnesium is competitive with aluminum in structural applications. The cost of primary magnesium ingot is about 40 percent higher than aluminum, but magnesium is 50 percent lighter. With present technology, however, the cost of extruding aluminum ingot is about 10 cents per pound compared with 30 to 35 cents per pound for magnesium.

Magnesium's attractive structural properties include low specific weight, good machinability, hot formability, and high strength. The principal structural applications are in industries involving aircraft and missiles, automobiles, materials handling, and power tools, such as powersaws and lawnmowers. Magnesium sand-casting foundries operated at peak capacity to supply the components of military and commercial aircraft. Most airplane wheels are made of magnesium. One-fourth of the weight of Mariner 4, was magnesium, 134 pounds out of 572.

Foreign and domestic enterprises are finding increased need for the desirable qualities of magnesium in their manufactures. Italy's Fiat Motor Company in a new production model, the Dino, uses 59 pounds of magnesium per vehicle in 18 parts, including the wheels. Mass production of magnesium wheels for the domestic automotive industry is a large potential market that is being investigated.

Aluminum alloys accounted for 32 percent of magnesium consumption in 1967. Although production of titanium and zirconium metals increased, a corresponding increase in use of magnesium as a reducing agent, was not reported probably because of the practice of recycling magnesium at a plant of a major producer of titanium.

Table 3.—Consumption of primary magnesium (ingot equivalent and magnesium content of magnesium-base alloys), in the United States by uses

(Short tons)

Use	1963	1964	1965	1966	1967
For structural products:					
Castings:					
Sand	3,280	2,229	2,959	3,961	5,420
Die [1]	5,580	4,757	5,599	4,980	9,080
Permanent mold	1,400	732	814	632	770
Wrought products:					
Sheet and plate	5,650	4,897	4,937	6,075	W
Extrusions (structural shapes, tubing)	3,370	4,419	[2] 5,995	[2] 7,100	[3] 14,520
Forgings	220	293	W	W	W
Total	19,500	17,327	20,304	22,748	29,790
For distributive or sacrificial purposes:					
Powder	1,175	W	W	W	W
Aluminum alloys	21,780	21,880	26,266	30,862	31,244
Zinc alloys	70	99	136	100	53
Other alloys	1,420	1,705	2,216	1,975	2,370
Scavenger and deoxidizer	150	141	170	195	W
Chemical	470	2,684	3,806	4,604	5,214
Cathodic protection (anodes)	2,985	4,983	4,597	4,670	5,100
Reducing agent for titanium, zirconium, hafnium, uranium, and beryllium [4]	3,070	3,764	8,467	8,429	6,704
Other [5]	620	2,165	3,660	9,095	17,755
Total	31,740	37,421	49,318	59,930	68,440
Grand total	51,240	54,748	69,622	82,678	98,230

W Withheld to avoid disclosing individual company confidential data.
[1] Includes primary metal to produce small quantities of investment castings.
[2] Includes "Forgings."
[3] Includes "Sheet and plate" and "Forgings."
[4] Quantity used for reduction of uranium not included in 1964.
[5] Includes primary metal for experimental purposes, debismuthizing lead, and producing nodular iron, secondary magnesium alloys, and powder.

PRICES

The quoted base price of primary magnesium, in 10,000-pound lots, 42-pound slabs, 99.80-percent magnesium remained at 35.25 cents per pound f.o.b. U.S. plants. Sales were made to aluminum smelters and alloyers for 32.25 cents per pound. GSA accepted bids for grade A magnesium (minimum 99.80 percent) in minimum lots of 10,000 pounds at prices ranging from 32.33 to 32.65 cents per pound, and for grade 2 magnesium alloy containing 3.5 to 5.0 percent aluminum, 0.2 to 0.5 percent zinc, 0.15 to 0.4 percent manganese, and minimum 93.8 percent magnesium at prices ranging from 28 to 28.05 cents per pound.

The quoted price for magnesium alloy ingots (AZ63A, AZ91C, and AZ92A) containing aluminum, zinc, and manganese was 40.75 cents per pound at yearend.

Magnesium sold during the year in Canada for 31.0 cents per pound, in West Germany for about 25 cents, in France for 34.0 cents, and in Italy for 35.56 cents.

STOCKS

On December 31, 1967, producer and consumer stocks were 10,751 short tons of primary magnesium and 2,122 tons of primary magnesium alloy ingot, an increase of 1,251 tons of primary magnesium and 328 tons of primary magnesium alloy ingot from stocks at the beginning of the year.

Table 4.—Stocks and consumption of new and old magnesium scrap in the United States in 1967

(Short tons)

Scrap item	Stocks, Jan. 1 r	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Cast scrap	621	3,718	151	3,631	3,782	557
Solid wrought scrap [1]	2,441	6,200	6,031	-----	6,031	2,610
Total	3,062	9,918	6,182	3,631	9,813	3,167

r Revised.
[1] Includes borings, turnings, drosses, etc.

FOREIGN TRADE

Exports of primary metal to West Germany, principally for use in the Volkswagen, declined almost 14 percent. The decline reflected Volkswagen's reduced output but still accounted for nearly 60 percent of the total export.

Imports for consumption of magnesium in all forms increased sharply over those for 1966, while exports declined 15 percent, reflecting the strong domestic demand. About 7,250 short tons of primary magnesium were imported from three countries: Norway, 51 percent; Canada, 26 percent; and the U.S.S.R., 23 percent.

In late 1966 and early 1967, The Dow Chemical Co. bought 2,200 tons of primary magnesium on the European Market from the U.S.S.R. to meet short-term requirements caused by the Viet-Nam situation and increasing consumer demand.[2] The reported price was about 25 cents per pound.

[2] Chemical & Engineering News. V. 45, No. 8, Feb. 20, 1967, p. 27.

Table 5.—U.S. exports of magnesium, by classes and countries

(Short tons)

Destination	1966		1967	
	Primary metal, alloys, and scrap	Semifabricated forms, n.e.c., including powder	Primary metal, alloys, and scrap	Semifabricated forms, n.e.c., including powder
Argentina	96	13	124	12
Australia	433	10	45	28
Belgium-Luxembourg	84	13	8	26
Brazil	1,372	--------	868	550
Canada	1,930	319	1,465	203
France	43	26	97	23
Germany, West	8,099	19	6,999	4
India	153	--------	128	--------
Italy	62	22	310	23
Japan	291	14	95	69
Mexico	689	32	353	59
Spain	210	1	222	1
United Kingdom	1,064	10	718	21
Venezuela	54	16	149	45
Other	289	84	408	120
Total	14,869	579	11,989	1,184

Table 6.—Exports and imports for consumption of magnesium

Year	Exports			
	Metal and alloys in crude form and scrap		Semifabricated forms, n.e.c.	
	Short tons	Value (thousands)	Short tons	Value (thousands)
1965	17,836	$10,265	484	$1,260
1966	14,869	8,853	579	1,387
1967	11,989	7,132	1,184	1.983

	Imports					
	Metallic and scrap		Alloys (magnesium content)		Powder, sheets, tubing, ribbons, wire, and other forms (magnesium content)	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1965	2,551	$1,101	327	$ 760	103	$128
1966	3,265	1,613	689	1,656	5	36
1967	9,213	4,909	354	1,529	153	433

The duty on magnesium and scrap remained at 40 percent ad valorem; alloys were 16 cents per pound of magnesium content plus 8 percent ad valorem; and wrought magnesium was 13.5 cents per pound plus 7 percent ad valorem. Duty on metal waste and scrap was temporarily suspended through June 30, 1969. Presidental Proclamation 3822, authorizing reductions in tariffs in accordance with the Kennedy Round trade agreements, was signed in December 1967. The first stage of tariff reductions, applying to calendar year 1968 and becoming effective January 1, 1968, included magnesium.

WORLD REVIEW

The United States accounted for almost 50 percent of the estimated world production of 203,000 tons of primary magnesium in 1967. Total world planned capacity, to be completed in 1969, is estimated at 285,000 tons.

Import quotas for member countries of the European Economic Community were established for the first 7 months of 1967, by the EEC commission as follows: West

Table 7.—World production of primary magnesium, by countries [1]

(Short tons)

Country	1963	1964	1965	1966	1967 [p]
Canada	8,907	9,353	10,108	[r] 6,723	8,685
China [2]	1,000	1,000	1,000	1,000	1,000
France	1,921	1,090	[r] 3,132	[r] 3,770	4,597
Germany, West [3]	550	550	550	[r] 220	[e] 220
Italy	6,092	6,645	6,959	[r] 7,165	[e] 7,300
Japan	[4] 2,689	[4] 3,237	[4] 4,172	[r] [4] 5,832	[e] 7,000
Norway	[r] 20,000	24,300	[r] 29,100	[r] 31,195	[e] 31,400
U.S.S.R.[e]	35,000	35,000	36,000	40,000	45,000
United Kingdom [5]	[r] 5,152	[r] 5,264	[r] 5,936	[r] 4,145	([6])
United States	75,845	79,488	81,361	79,794	97,406
Total [7]	157,156	165,927	178,318	179,844	202,608

[e] Estimate. [p] Preliminary. [r] Revised.
[1] Compiled mostly from data available March 1968.
[2] Conjectural, denoting an order of magnitude.
[3] Estimate according to the 54th annual issue of Metal Statistics (Metallgesellschaft), except for 1967.
[4] In addition, the following amounts of secondary magnesium were produced: 1963, 1,556; 1964, 2,478; 1965, 4,590; and 1966, 5,757 short tons.
[5] Primary metal and remelt alloys.
[6] Primary production suspended June 1966. Remelt alloy production in 1967 estimated to be 4,200 short tons.
[7] Total is of listed figures only; no undisclosed data included.

Germany, whose annual consumption is about 42,000 tons, was allowed to import 9,450 tons at the low duty of 1.5 percent; Belgium, 291 tons; and the Netherlands, 262 tons.

Canada.—Dominion Magnesium Ltd., the only Canadian producer, operated at about 75 percent of its 11,500-ton-per-year capacity, producing 8,685 tons, valued at nearly $5 million. At the beginning of the year, all 15 furnaces were in operation, producing high-purity magnesium by treating 350 tons of dolomite per day by reduction with ferrosilicon. Two furnaces were shut down in early June because of decreased requirements from the United Kingdom.

Italy.—Negotiations were held between The Compagnia Generale del Magnesio and officials of the Syracuse, Sicily, industrial area for construction of a magnesium plant there.[3]

Japan.—Two Japanese companies use ferrosilicon reduction in processing magnesium. Ube Kosan KK, which began production in the second half of 1966, announced plans to increase annual capacity from 2,200 to 5,500 tons. The older producer, Furukawa Magnesium Co. Ltd., operated its 5,500-ton plant at near capacity. Furukawa also has a remelt production capacity of about 3,800 tons. The principal market for both companies is the Japanese titanium industry.[4]

Norway.—Norsk-Hydro Elektrisk A/S, the sole producer of magnesium in Norway, continued its expansion program to attain an annual capacity of 40,000 tons by the end of 1967.[5] Exports to West Germany dropped from 30,400 tons in 1966 to 24,500 tons in 1967, reflecting Volkswagen's reduced requirements.

Saudi Arabia.—The State-owned oil company, Petromin, solicited bids for a plant to produce 20,000 tons of magnesium per year, 56,000 tons of chlorine, 20,000 tons of hydrochloric acid, 15,000 tons of magnesium oxide and 500,000 tons of salts. The plant would utilize solar evaporation to recover magnesia from Arabian Gulf marshes.[6]

United Kingdom.—Production of magnesium by Magnesium Elektron Ltd., the only producer, was suspended in June 1966. The company's Clifton Junction factory continued to process and sell primary magnesium imported from Norway.[7] Imports from Norway more than doubled during the first 6 months in 1967 compared with the same period in 1966, increasing from 684 to 1,543 tons.

TECHNOLOGY

The relatively high price of magnesium is a major factor in limiting its use, accordingly, research was directed toward lowering production costs. The second in a series of cost analyses of production methods was published.[8]

Great Salt Lake contains the largest reserve of high-grade brine in the United States. At current market prices the dissolved salts have an estimated value of $50 billion, about half of which is represented by magnesium chloride. There has been no commercial recovery of salts other than sodium chloride from this resource, primarily because the high sulfate content presented formidable technical problems. A report was published describing a process for removing sulfate from natural brines, including sea water, in which sodium carbonate and sulfur or sulfuric acid are recovered as byproducts in sufficient quantities to more than defray the cost of desulfation.[9]

The entire field of magnesium technology, from metal extraction to the finished component, was reviewed. Special reference was made to the chemical and metallurgical principles involved.[10]

A paper was presented at the annual meeting of the Magnesium Association,

[3] Metal Bulletin (London). No. 5248, Nov. 14, 1967, p. 26.

[4] Metal Bulletin (London). Ube Expanding Magnesium Output. No. 5191, Apr. 24, 1967, p. 30.

[5] Mining & Minerals Engineering (London). V. 3, No. 8, August 1967, p. 284.

[6] Metal Bulletin (London). No. 5245, Nov. 3, 1967, p. 17.

[7] Light Metal Age. Magnesium Production Stopped. V. 24, No. 5–6, June 1966, p. 18.

[8] Elkins, D. A., P. L. Placek, and K. C. Dean. An Economic and Technical Evaluation of Magnesium Production Methods, BuMines Rept. of Inv. 6946, 1967, 74 pp.

[9] George, D'Arcy R., J. M. Riley, and Laird Crocker. Preliminary Process Development Studies for Desulfating Great Salt Lake Brines and Sea Water. BuMines Rept. of Inv. 6928, 1967, 34 pp.

[10] Emley, E. F. Principles of Magnesium Technology. Pergamon Press, New York, 1966, 1013 pp.

summarizing the problems of corrosion of magnesium and enumerating solutions to these problems. It includes a discussion of protective coating materials developed to combat magnesium corrosion.[11] Recognizing that marketing strategy cannot be based on light weight alone, magnesium industry research placed emphasis on developing high-strength alloys, studying magnesium corrosion problems, and perfecting magnesium batteries.

Magnesium rare-earth alloys are used in moderate temperature applications where a lightweight alloy with good creep resistance is required. They may be strengthened by age hardening and heat treatment in a hydrogen atmosphere for use in aircraft and missiles. A report on the magnesium-cerium system was published,[12] and results of studies on magnesium-heavy rare-earth alloys were released.[13]

Magnesium-lithium alloys, the lightest metals commercially available today, are also used in aircraft, missile, and space applications. Sound investment castings, from commercially available forms, can be made by techniques developed at Frankford Arsenal, Philadelphia, Pa. Research continued on development foundry techniques for the production of lightweight castings.[14]

Magnesium-lithium alloys can compete on a strength basis with many commercially wrought and cast light metal alloys.[15]

A high-strength, wrought magnesium-base alloy, the strength of which can be significantly improved by heat treatment, was developed by Birmetals Ltd. of Woodgate, Birmingham, England. The alloy, having a nominal composition of 6 percent zinc, 1.2 percent manganese, and 92.8 percent magnesium, is designated as ZM61. It has been mainly developed for use in extruded and forged forms.[16]

A battery using replaceable magnesium plates as the anode, oxygen from the air as the cathode, and salt water as the electrolyte was developed by General Electric for the U.S. Marine Corps. This lightweight portable battery has an energy density per pound of about five times that of the average lead acid battery, and is easier to recharge.[17] About 1.5 pounds of magnesium is used per battery, therefore, a significant increase in magnesium consumption would result if large production is attained.

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[11] McFarland, R. Light Metal Age. V. 25, No. 5-6, June 1967, pp. 12–14.

[12] Crosby, R. L., and J. L. Holman. Intermediate Phases in the Magnesium-Cerium System Between Magnesium and Mg_3Ce. BuMines Rept. of Inv. 6866, 1966, 18 pp.

[13] London, R. V., R. E. Edleman, and H. Marcus. Development of A Wrought High-Strength Magnesium-Yttrium Alloy. Frankford Arsenal (Philadelphia, Pa.), Rpt, A66-13, June 1966, 16 pp.

Ogren, J. R., N. J. Magnani, and J. F. Smith. Thermodynamics of Formation of Binary Rare Earth-Magnesium Phases With CsCl-Type Structures. Trans. AIME, v. 239, No. 6, June 1967, pp. 766–771.

[14] Saia, A., R. E. Edleman, and H. L. Gilmore. The Gating and Risering of Counter-Gravity Poured Magnesium-Lithium Castings. Modern Casting, v. 50, No. 1, July 1967, pp. 105–114.

[15] Materials Engineering. Magnesium-Lithium Alloys: Lightest Commercial Metals. V. 66, No. 1, July 1967, pp. 35–41.

[16] Magnesium News Letter. February 1967, 4 pp.

[17] American Metal Market. V. 74, No. 116, June 19, 1967, p. 4A.

Magnesium Compounds

By Robert F. Griffith [1]

World production of magnesite remained about the same as that of 1966. The Soviet Union continued as the principal producer and accounted for 30 percent of the estimated world total. Production of magnesite in the United States decreased 18 percent from the high set in 1966. U.S. exports of dead-burned magnesite and magnesia decreased 12 percent from those of 1966. The value of exported caustic-calcined magnesia increased 29 percent due in part to an increase in unit value from $228 to $269 per short ton.

Table 1.—Salient magnesium compounds statistics
(Thousand short tons and thousand dollars)

	1963	1964	1965	1966	1967
United States:					
Caustic-calcined and specified magnesias: [1]					
Shipments:					
Quantity	80	84	90	99	114
Value	$7,655	$8,562	$9,163	$9,686	$11,250
Imports for consumption: [2]					
Value	$500	$493	$592	$743	$585
Exports: [2]					
Value	$678	$1,654	$1,637	$1,627	$2,095
Refractory magnesia:					
Sold and used by producers:					
Quantity	713	842	897	852	688
Value	$44,378	$49,220	$56,100	$52,290	$42,679
Imports:					
Value	$4,593	$3,180	$4,214	$8,139	$5,171
Exports:					
Value	$5,620	$5,554	$5,912	$6,208	$5,889
Dead-burned dolomite:					
Sold and used by producers:					
Quantity	1,949	2,168	2,176	2,193	1,880
Value	$33,058	$37,961	$39,606	$39,725	$34,083
Imports:					
Value	$455	$1,165	$2,385	$2,038	$1,832
World: Crude magnesite: Production:					
Quantity	9,901	10,516	11,060	11,008	[e] 11,050

[e] Estimate.
[1] Excludes caustic-calcined magnesia used in production of refractory magnesia.
[2] Caustic-calcined magnesia only.

DOMESTIC PRODUCTION

Nevada and Washington supplied all of the crude magnesite produced in 1967. Basic, Inc., the sole producer in Nevada, also reported declining production of brucite from its Gabbs, Nev., property; 25 percent of that in 1966. Harbison-Walker Refractories Co., parent company of Northwest Magnesite Co., the sole producer of crude magnesite in Washington, merged with Dresser Industries, Inc., of Dallas, Tex. It was announced that all operations at this Chewelah, Wash., complex would be shut down by mid-1968, because of the availability of lower cost, imported magnesite for the Eastern U.S. markets.

Approximately 88 percent of the dead-burned dolomite was produced in Ohio,

[1] Commodity specialist, Division of Mineral Studies.

Illinois, Louisiana, Pennsylvania, and West Virginia. Crude olivine was produced in Washington and North Carolina, increasing 6 percent over 1966.

Michigan led in the production of refractory magnesia from well brines, sea water or dolomite. Refractory magnesia from the same sources was also produced in California, Florida, Mississippi, New Jersey, and Texas. Nevada led in the production of refractory magnesia from magnesite and brucite; Washington was second. Producers sold 415,987 tons of refractory magnesia in 1967 and consumed 271,718 in their own plants for a total of 687,705 tons valued at $42.7 million compared with 852,129 tons in 1966 valued at $52.3 million. The unit value of shipments was applied to producers' consumption to calculate a total value.

Kaiser Refractories, a division of Kaiser Aluminum & Chemical Corp., installed new facilities at its Moss Landing, Calif., plant to increase production of high-purity periclase (refractory magnesia).

Production of hydrous magnesium sulfate declined 8 percent and magnesium trisilicate 9 percent.

Small quantities of magnesium nitrate, magnesium phosphate, magnesium acetate, and anhydrous magnesium sulfate were also produced.

CONSUMPTION AND USES

Consumption of olivine increased over that of 1966 while consumption of crude magnesite decreased.

Consumption of hydrous magnesium sulfate decreased 6 percent; that of magnesium trisilicate decreased 7 percent. Consumption of anhydrous magnesium chloride, principally for the production of magnesium metal, increased 24 percent, and hydrous magnesium chloride increased 66 percent.

About 1.5 million short tons of magnesuim hydroxide was produced and consumed in processing of other magnesium compounds, including magnesium chloride used in the production of magnesium metal. It was either used in the originating plant or transported to another plant to continue the process. About 65,000 tons of magnesium hydroxide was shipped outside the industry, a decrease of 12 percent below that of 1966.

Consumption of refractory magnesia, both single-burned and dead-burned, decreased 20 percent to 683,700 tons. The rate of construction of basic oxygen steel furnaces (BOF) apparently declined in 1967, causing a drop in the demand for refractory magnesia used in the initial installation. Although the BOF process requires better refractory material than other processes, replacement is less frequent. More than 150,000 tons of steel was poured from one 300-ton BOF before it was necessary to replace the lining of impregnated magnesite brick. Less than 6 pounds of refractory was consumed per ton of steel produced.

About 114,000 tons of caustic-calcined magnesia, an increase of 13 percent, was consumed for uses excluding consumption as an intermediate material in processing of refractory magnesia.

Table 2.—Dead-burned dolomite sold in and imported into the United States

(Thousand short tons and thousand dollars)

Year	Sales of domestic product		Imports [1]	
	Quantity	Value	Quantity [2]	Value
1963	1,949	$33,058	9	$455
1964	2,168	37,961	29	1,165
1965	2,176	39,606	55	2,385
1966	2,193	39,725	44	2,038
1967	1,880	34,083	42	1,832

[1] Dead-burned basic-refractory material comprising chiefly magnesium and lime.
[2] Includes weight of immediate container.

Table 3.—Magnesium compounds produced and shipped in the United States

Year and product	Plants	Produced (short tons)	Shipped and used: Short tons	Shipped and used: Value (thousands)
1966:				
Refractory magnesia [1]	11	-------	852,129	$52,290
Caustic-calcined [2] and Specified (U.S.P. and technical) magnesias	10	-------	99,369	9,686
Magnesium hydroxide (100 percent Mg $(OH)_2$) [2]	8	-------	74,632	3,138
Magnesium chlorides [3]	7	306,231	305,471	21,385
Precipitated magnesium carbonate [2]	5	-------	9,407	------
1967:				
Refactory magnesia [1]	12	-------	687,705	42,679
Caustic-calcined [2] and Specified (U.S.P. and technical) magnesias	10	-------	114,247	11,250
Magnesium hydroxide (100 percent Mg $(OH)_2$) [2]	7	-------	65,463	2,688
Magnesium chlorides [3]	6	389,636	382,929	26,396
Precipitated magnesium carbonate [2]	5	-------	8,543	------

[1] Includes both single-burned and double-burned.
[2] Excludes material produced as an intermediate step in the manufacture of other magnesium compounds.
[3] Includes magnesium chloride used in production of magnesium metal.

Table 4.—Domestic consumption of caustic-calcined magnesia and specified magnesias by uses

(Percent)

Use	1966	1967
Chemical processing	4	10
Fertilizer	9	4
85-percent MgO insulation	5	1
Oxychloride and oxysulfate cements	17	10
Pulp and paper	20	13
Rayon	13	12
Rubber	8	11
Other: Electrical, medicinal, flux, ceramic, glass, sugar, animal feed, fuel additive, water treatment, and uranium processing	24	39

PRICES

Except for magnesia, technical, synthetic, rubber grade, light, which increased from 23–27.5 to 28.75–30 cents per pound (bags, carlot, freight equalized), prices remained the same for all grades of magnesia and dead-burned magnesite, according to the Oil, Paint and Drug Reporter. U.S.P. grade magnesium carbonate in carlots, freight equalized, increased from 14.5 to 16 cents per pound. The price of magnesium silicofluoride in drums increased from 12–13.5 to 15 cents per pound. Magnesium sulfate, technical, carlots, works, increased from $2.22 to $2.45 per 100–pound bag. Less than carlots increased from $2.97–$3.22 to $3.20–$3.45, and U.S.P. crystalline grade in carlots increased from $2.42 to $2.65.

FOREIGN TRADE

Exports of dead-burned magnesite and magnesia decreased about 12 percent. Increased deliveries to Canada were more than offset by decreases in deliveries to Argentina, Australia, and Mexico.

All categories of processed magnesite imports for consumption showed decreases in 1967. Imports of lump or ground caustic-calcined magnesia decreased 31 percent from the record high of 13,300 tons set in 1966.

Imports for consumption of dead-burned grain magnesia and periclase decreased 41 percent; magnesium carbonate (precipitated) decreased 17 percent; and magnesium sulfate (epsom salt) decreased about 30 percent.

Presidential Proclamation 3822 authorizing reductions in tariffs in accordance with the Kennedy Round Trade Agreement was signed in December 1967. The first stage of tariff reductions applying to calendar year 1968 and becoming effective January 1, 1968, included calcined magnesia, and magnesium carbonate, chloride, and sulfate.

Table 5.—U.S. exports of magnesite and magnesia, by countires

Destination	Magnesite and magnesia, dead-burned				Magnesite n.e.c. including crude, caustic calcined, lump or ground			
	1966		1967		1966		1967	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Valu (thousands)
Argentina	3,806	$263	278	$22	72	$19	33	$15
Australia	6,338	356	2,908	174	308	162	946	236
Belgium-Luxembourg	28	4	80	10	30	11	37	13
Canada	14,858	1,696	19,688	2,121	1,913	185	1,987	136
Chile	1,158	85	711	55	11	3	26	7
Colombia	10	6	19	4	651	47	133	29
Congo (Kinshasa)	------	-----	------	-----	331	29	-----	-----
Costa Rica	398	24	200	12	201	15	396	28
Denmark	------	-----	------	-----	52	27	52	32
El Salvador	255	16	450	27	28	2	-----	-----
France	3	1	------	-----	105	47	188	79
Germany, West	231	103	126	67	405	191	650	386
Honduras	------	-----	------	-----	52	5	265	31
India	------	-----	1	1	20	10	16	7
Israel	------	-----	------	-----	15	3	10	5
Italy	1,165	102	31	3	209	90	240	91
Japan	1	1	68	31	3	2	11	5
Malagasy Republic	------	-----	------	-----	193	26	39	6
Mexico	34,040	2,557	31,776	2,525	364	41	684	65
Netherlands	1,007	70	100	9	60	24	97	38
New Zealand	------	-----	------	-----	83	51	86	53
Peru	2,940	196	1,870	127	5	1	10	1
Philippines	18	5	3	(1)	43	9	62	17
South Africa, Republic of	77	41	88	51	51	27	82	43
Spain	------	-----	2	1	31	14	30	15
Sweden	100	43	225	63	37	18	93	51
Switzerland	------	-----	------	-----	52	23	54	24
United Kingdom	942	232	555	232	1,129	437	1,018	583
Venezuela	5,709	382	5,084	334	406	50	296	40
Viet-Nam, South	11	5	------	-----	83	9	-----	-----
Other countries	175	20	106	20	179	49	247	59
Total	73,270	6,208	64,369	5,889	7,122	1,627	7,788	2,095

[1] Less than ½ unit.

Table 6.—U.S. imports for consumption of crude and processed magnesite, by countries

Country	1966 Short tons	1966 Value (thousands)	1967 Short tons	1967 Value (thousands)
Crude magnestie: India	311	$21	327	$24
Lump or ground caustic-calcined magnesia:				
Australia	778	78	1,220	110
Austria	931	34	948	35
Belgium-Luxembourg	55	4	-------	-----
Greece	82	6	55	3
India	9,036	466	4,462	278
Laos	-------	------	56	4
Netherlands	161	11	99	7
New Zealand	-------	------	50	5
Turkey	1,395	95	1,949	128
United Kingdom	218	19	-------	-----
Yugoslavia	645	30	330	15
Total	13,301	743	9,169	585
Dead-burned and grain magnesia and periclase:				
Not containing lime or not over 4 percent:				
Austria	38,271	2,261	10,834	612
Canada	138	9	116	18
Germany, West	1,131	92	-------	-----
Greece	24,810	1,868	31,254	2,405
India	1	1	-------	-----
Italy	-------	------	822	54
Japan	64,599	3,907	22,639	1,403
Netherlands	-------	------	33	11
Turkey	-------	------	6,938	501
United Kingdom	1	1	(1)	2
Yugoslavia	-------	------	3,410	165
Total	128,951	8,139	76,046	5,171
Containing over 4 percent of lime:				
Austria	22,030	935	25,911	1,040
Canada	2,332	136	830	48
Greece	664	43	-------	-----
Italy	-------	------	577	41
Netherlands	-------	------	33	11
Yugoslavia	18,611	924	15,062	692
Total	43,637	2,038	42,413	1,832
Grand total	172,588	10,177	118,459	7,003

[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 salt) [1] [2]		Magnesium salts and compounds		Manufactures of carbonate of magnesia	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1965	148	$47	1,250	$225	366	$11	6,640	$127	3,599	$134	5	$2
1966	76	35	1,090	213	176	29	9,266	186	1,256	79	--	--
1967	64	31	900	173	451	81	6,524	135	3,354	127	--	--

[1] Not specifically provided for.
[2] Includes magnesium silicofluoride or fluosilicate and calcined magnesia.

WORLD REVIEW

Data on the world production of magnesite were revised upward by about 1 million tons per year for 1963–66 as a result of an increase of about 6 million tons reported from Czechoslovakia for this period. In order to compare world production on the same basis as in preceding years, magnesite production in 1967, excluding that from North America but including non-reporting countries, is estimated at 11.1 million tons.

Table 8.—World production of magnesite, by countries [1] [2]

(Short tons)

Country [1]	1963	1964	1965	1966	1967 [p]
North America: United States	527,655	W	W	W	W
South America:					
Brazil	99,598	103,331	137,394	[e] 220,000	NA
Colombia	276	243	209	[e] 210	NA
Europe:					
Austria	1,447,099	1,826,058	2,001,363	1,779,829	1,692,386
Czechoslovakia	[r] 1,632,635	[r] 1,858,047	[r] 2,029,154	[r] 2,095,291	2,322,331
Greece	[r] 294,558	[r] 397,054	[r] 347,453	413,366	NA
Italy	7,512	6,954	3,898	2,867	NA
Poland	29,321	[r] 41,888	[r] 46,297	[e] 46,000	NA
Spain	93,315	102,874	[r] 110,944	NA	NA
U.S.S.R. [e]	2,980,000	3,090,000	3,200,000	3,200,000	3,300,000
Yugoslavia	454,107	548,311	579,750	580,570	468,219
Africa:					
Kenya	288	187	74	747	NA
Rhodesia, Southern	12,067	42,410	39,242	[e] 33,000	NA
South Africa, Republic of	108,309	93,443	95,789	102,847	[e] 90,000
Sudan	---------	---------	---------	3,307	NA
Tanzania	94	546	1,260	5,270	NA
Asia:					
China, mainland [e]	990,000	1,100,000	1,100,000	1,100,000	880,000
India	[r] 259,116	[r] 229,210	263,128	255,736	NA
Iran	NA	6,033	NA	NA	NA
Korea, North [e]	880,000	990,000	990,000	1,100,000	1,100,000
Pakistan	968	680	577	[r] 812	NA
Turkey	19,750	43,065	83,320	45,903	93,651
Oceania:					
Australia	63,780	35,001	[r] 29,525	[r] 21,903	NA
New Zealand	875	676	937	624	NA
Total [1] [3]	[r] 9,901,323	[r] 10,516,011	[r] 11,060,314	[r] 11,008,282	9,946,587

[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 and Canada, but data on production are not available.

[2] Compiled mostly from data available April 1968.

[3] Total is of listed figures only; no undisclosed data included.

Table 9.—Austria: Exports of magnesia and magnesite brick by countries

(Short tons)

Destination	Magnesia				Magnesite brick	
	Caustic-calcined		Refractory			
	1966	1967	1966	1967	1966	1967
North America: United States	733	960	r 64,673	27,265	r 168	6
South America:						
Argentina	68	63	3,032	2,205	1,506	767
Chile	-------	-------	1,419	719	2,787	2,883
Venezuela	138	127	562	------	-------	-------
Europe:						
Belgium-Luxembourg	219	312	819	734	5,535	8,314
Denmark	3,525	1,609	r 103	51	4,084	3,460
Czechoslovakia	359	418	41	8	196	140
Finland	116	99	1,349	1,206	3,181	2,446
France	2,212	2,875	17,829	14,351	r 21,614	23,036
Germany:						
East	44	285	3	-------	-------	-------
West	r 80,317	65,080	99,896	113,272	r 22,821	23,604
Greece	-------	-------	570	385	2,060	2,458
Hungary	r 3,045	5,312	13,857	13,842	-------	7
Italy	r 4,173	5,328	14,968	12,844	6,439	6,415
Netherlands	439	326	98	3,544	1,543	706
Norway	33	-------	r 556	158	r 2,378	2,539
Poland	-------	-------	230	2,227	r 5,790	6,369
Portugal	-------	-------	592	35	1,057	1,104
Rumania	-------	-------	r 71	70	1,321	3,432
Spain	245	57	3,315	2,408	5,162	4,097
Sweden	849	1,015	r 5,886	1,231	21,173	21,782
Switzerland	3,588	3,087	1,370	279	r 1,621	2,015
United Kingdom	186	181	12,289	2,603	r 18,740	12,906
Africa:						
Rhodesia, Southern	-------	-------	16	5	366	372
South Africa, Republic of	-------	-------	r 90	20	4,117	2,525
Tunisia	-------	-------	84	32	1,443	172
Zambia	-------	-------	113	-------	r 4,777	5,268
Asia:						
India	-------	-------	540	-------	-------	173
Israel	487	550	687	588	298	173
Turkey	r 71	-------	r 727	1,072	2,037	1,573
Oceania:						
Australia	-------	-------	87	11	2,447	2,313
New Calendonia	-------	-------	r 45	13	r 1,417	2,353
Other countries	47	85	967	887	4,661	5,184
Total	100,894	87,769	246,884	202,065	r 150,739	148,592

r Revised.

Canada.—The Aluminum Company of Canada, Ltd., announced the closing of its magnesite-lime mine and plant at Wakefield, Quebec, with phasing out to begin in early 1968. Production has been about 20,000 tons per year of calcined magnesia and magnesium hydroxide, and about 100,000 tons per year of lime from a brucitic limestone deposit. Markets for the magnesia product have been —pulp and paper, 10,000 tons per year; refractories, 7,000; and agriculture, 3,000. Reportedly, poor recovery from low–grade ore has made the operation uneconomical.

The sole Canadian producer of magnesite, Canadian Refractories Ltd., continued the underground mining of magnesite-dolomite at Kilmar, Argenteuil County, Quebec, at a rate of 600 short tons per day for the production of dead-burned magnesia consumed chiefly in the manufacture of basic refractories.

The other producers of high-magnesia refractories, General Refractories Co. of Canada, Ltd., Smithville, Ontario; Norton Co., Chippawa, Ontario; and Refractories Engineering and Supplies Ltd., Bronte, Ontario, depended on imported magnesia. The value of magnesia produced from magnesite and brucite decreased from $3.9 million in 1966 to an estimated $3.4 million.

Exploration continued on a deposit in Deluro Township, near Timmins, Ontario, reported to contain over 50 million tons of high-iron magnesite.

The Sea Mining Corp., Ltd., of Newfoundland began construction of a $4.5

million plant at Aguathuna, about 10 miles from Stephenville, Newfoundland, on the island's west coast to produce magnesium hydroxide by the sea-water slaked lime process for the pulp and paper industry. The plant is scheduled for completion by mid-1968, and will have an annual capacity of 33,000 tons. Limestone will be mined and calcined onsite.

Greece.—General Refractories Co., Philadelphia, Pa., and a Dutch firm, Van Mannekus, announced plans to invest $868,000 to develop magnesite mines at Chalkidiki, in northern Greece.

The Skalistira mining group placed in operation a third kiln to produce dead–burned magnesite at its Mandoudi mine and plant. Annual capacity was increased to 100,000 tons.

Hungary.—Magnesite was included in a group of commodities that was permitted to be exported directly to Western countries instead of through national foreign trading organizations.

Mexico.—Near Tampico Latin America's first sea water magnesium oxide plant (annual capacity 50,000 metric tons) was placed in full operation by General Refractories Co.'s Mexican affiliate Quimica del Mar S. A. (Quimar). Prior to the opening of this plant practically all of Mexico's requirements for basic refractory raw materials and chemically active magnesia was imported; the rest of Latin America will still have to import.

Table 10.—Netherlands: Exports of refractory magnesia, by countries

(Short tons)

Destination	1966	1967
Belgium-Luxembourg	1,460	1,349
France	719	1,275
Germany, West	10,000	7,584
Italy	82	82
Other countries	18,164	8,571
Total	30,425	18,861

Netherlands.—A plant for producing magnesium oxide (MgO) at a rate of 5,500 metric tons per year was opened near Rotterdam by a subsidiary of Climax Molybdenum Co.

Turkey.—Continental Manyezit Limited Sirketi (COMAG), a Turkish subsidiary of Continental Ore Corp., operated three mines producing annually about 20,000 tons of crude magnesite. Most of the magnesite was calcined to caustic magnesite in a shaft furnace near the rail line at Taxsanli. Some almost pure hand-sorted ore was shipped as premium grade material. The company imported a 2- by 30- with a 12-meter cooling section to expand meter Kloeckner-Humboldt rotary kiln annual production of caustic grade magnesite by yearend 1967. By 1969 the firm plans to reach an annual capacity of 28,000 tons of caustic magnesite and 30,000 tons of dead-burned magnesite for export.

Manyezit Anonim Sirketi, a Turkish subsidiary of Veitscher of Austria, is producing 8,000 to 10,000 tons per year of dead-burned magnesite for export. Crude magnesite is purchased from private operators near Orhaneli and Eskisehir as feed for its rotary kiln at the latter site. The company plans to expand its capacity to 20,000 tons per year of dead-burned magnesite. Sumerbank, the state enterprise concerned with brick, tile, and refractories, plans to build a 26,500-ton-per-year plant at Meram, near Konya to produce sintered magnesite which will be used to produce chrome-magnesite refractories for the Turkish metallurgical industry. On the basis of present plans, the Turkish magnesite industry by 1968 should have capacity to produce as follows:

	Capacity (metric tons)			
	1966		1968	
	Caustic	Dead-burned	Caustic	Dead-burned
Sumerbank	-----	-----	------	26,500
COMAG	8,000	-----	28,000	30,000
Magnezit A.S.	-----	9,000	------	20,000
Totals	8,000	9,000	28,000	76,500

	Ore reserves		
Districts	No. of deposits	Indicated reserves (metric tons)	Source of information
Tavsanli, Dagardi, Orhaneli	14	3 million	COMAG
Eskishir	6	1–2 million	Planning Assistance Committee
Meram	1	1 million	MTA [1]
Total, all districts	21	+5 million	

[1] Mining Exploration and Research Institute.

Magnesite deposits in Eskisehir Province were reported to occur in serpentinized country rock as irregular masses 8 to 10 meters wide and 500 to 600 meters long, averaging 46 to 65 percent MgO.

U.S.S.R.—It was reported that the best source of magnesite for the Satka mill in the South Urals, which is claimed to be the world's largest for producing refractory magnesia, lies directly under the factory and can be mined only by removing the buildings.

Brucite deposits were discovered in the Maly Khingan Mountains of the Soviet Far East, not far from the Trans-Siberian railway.

Venezuela.—Magnesite reserves on Margarita Island were estimated at 5 million metric tons, and plans were made to develop the deposits and to construct a processing plant. Under Venezuelean law magnesite belongs to the surface owner, whereas most minerals below the surface belong to the State.

TECHNOLOGY

Research was directed toward development of methods to produce various types of magnesia refractories and methods of application of the refractory to furnace walls.

A ramming-casting product mix developed particularly for bottom installations in open hearth and electric furnaces was developed.[2] A dense, strong, monolithic structure, the density of which increases when fired, can be obtained.

High-temperature properties of periclase refractories were compared in the purity range of 95 to 99+ percent MgO. High strength, creep resistance, and resistance to steelmaking slag erosion were obtained with periclase containing more than 98 percent MgO.[3]

The acid treatment method for producing refractory magnesia from sea water, developed by Steetley Magnesite Co., Ltd., England, was installed at the Pascagoula, Miss., plant of H. K. Porter Co., Inc., and has improved the quality of its high-purity periclase (double-burned refractory magnesia). The former water softening system required a complicated arrangement of equipment that was sensitive to changes in the operating rate, causing inefficiency and an approximate 12 percent loss in magnesia values. Excess lime also was needed to convert the bicarbonate ion to calcium carbonate, causing lime contamination in the magnesia. With conversion to acid treatment the bicarbonate was decomposed into carbon dioxide and water, less equipment was needed, controls were simplified, and lime requirements were reduced. Magnesia losses were

[2] American Metal Market. V. 74, No. 90, May 11, 1967, p. 17.
[3] Van Dreser, M. L. Developments With High-Purity Periclase. Am. Ceram. Soc. Bull., v. 64, No. 2, February 1967, pp. 196–201.

corrected and lime content in the periclase product was reduced from 1.2 percent to 0.8 percent.[4]

Calrod heating elements become hazardous in ungrounded equipment if moisture is absorbed by the hygroscopic MgO which is used as an electric insulating material to position the nickel-chromium heater coil inside the metal sheath. Dry MgO has high electrical resistance and high thermal conductivity. To keep the MgO dry, General Electric Co. seals the tubes after cooling in air-conditioned dry rooms at 78° F and 15 percent relative humidity to avoid forming a vacuum in the tube which would occur if sealed at higher temperatures. A vacuum would reduce the dielectric efficiency of the finished product.[5]

An article was published describing the feasibility of recovering magnesium compounds from oilfield brines. The article included tables showing the content of magnesium and other minerals in sea water and oilfield brines.[6]

High-purity magnesia and calcia crystals and recrystallized block-form magnesia were available from Electronic Space Products, Inc., Los Angeles, Calif., for research in solid-state physics.[7]

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[4] Engineering and Mining Journal. Acid Treatment of Sea Water Improves Quality of Periclase Yield. V. 167, No. 10, October 1966, pp. 94–95.

[5] American Metal Market. Sheathed Calrod Heating Units Demoisturized. V. 73, No. 183, Sept. 21, 1966, p. 18.

[6] Oil and Gas Journal. Here's How Producers Can Turn Brine Disposal Into Profit. V. 64, No. 27, July 4, 1966, p. 112.

[7] Chemical & Engineering News. V. 45, No. 21, May 15, 1967, p. 64.

Manganese

By Gilbert L. DeHuff [1]

Manganese ore imports dropped back a bit from the pace of the last 2 years to the more normal level of 1964. Prices eased, and consumption and imports of manganese ferroalloys were also down. Shipments of domestic manganese ore—that is, ore, concentrate, and nodules, containing 35 percent or more manganese—were somewhat lower than the small quantity of 1966.

Table 1.—Salient manganese statistics in the United States

(Short tons)

	1963	1964	1965	1966	1967
Manganese ore (35 percent or more Mn):					
Production (shipments):					
Metallurgical	7,402	19,126	22,871	W	W
Battery	3,220	6,932	6,387	W	W
Total	10,622	26,058	29,258	14,406	12,585
Imports, general	2,093,473	2,064,990	2,575,229	2,553,704	2,064,158
Consumption	1,841,725	2,241,756	2,872,720	r 2,370,516	2,382,984
Manganiferous ore (5 to 35 percent Mn): Production (shipments)	543,125	238,776	332,763	324,926	289,160
Ferromanganese:					
Production	751,198	929,486	1,148,011	946,210	940,927
Exports	678	3,903	3,273	545	1,861
Imports for consumption	148,630	212,629	257,339	251,972	215,779
Consumption	892,884	1,007,623	1,040,502	1,048,429	982,130

r Revised.
W Withheld to avoid disclosing individual company confidential data.

Legislation and Government Programs.—An offer by General Services Administration (GSA) in January for the sale of 84,000 short tons of surplus Government stocks of metallurgical-grade manganese resulted in no acceptable bids. No further sealed-bid offerings of Government stocks were made in 1967, but approximately 450,000 tons were sold during the year on a negotiated basis—a large part for long-term delivery. These actions followed enactment August 19, 1966, of Public Law 539 authorizing disposal of 1.9 million tons of metallurgical-grade manganese ore held surplus in the national and supplemental stockpiles. This was in addition to the 1.8 million tons held in Defense Production Act (DPA) inventory for which GSA had previously made disposal plans. An offer in January 1966 of 100,000 tons of this DPA surplus metallurgical-grade manganese ore sold 69,000 tons, but 56,000 tons offered in March produced no acceptable bids. Offerings in September 1966, and again in November, of 56,000 tons from the combined disposable surplus stocks resulted in the sale of 48,000 and 20,000 tons, respectively. In November 1966, Public Law 726 was enacted authorizing disposal of surplus synthetic manganese dioxide.

The $215,000 Agency for International Development barter contract of the U.S. Department of Agriculture for natural manganese dioxide ore for delivery to

[1] Commodity specialist, Division of Mineral Studies.

South Viet-Nam, reported in the Manganese chapter of the 1965 Minerals Yearbook, was signed with Minerals & Chemicals Philipp Corp., New York. The approximate contract period was through October 1966.

DOMESTIC PRODUCTION

Taylor-Knapp Co., mining at Philipsburg, Mont., continued to be the only domestic producer of natural battery-grade ore. Shipments were made of Montana metallurgical oxide nodules made previously from Montana carbonate ore, and manganese ore containing more than 35 percent manganese continued to be produced in New Mexico.

Low-grade manganese ores (ferruginous manganese ores, middlings, and concentrates) containing 10 to 35 percent manganese were shipped from Colorado, Minnesota, Montana, and New Mexico. All Minnesota shipments were from the Cuyuna range. Manganiferous zinc residum was produced from New Jersey zinc ores.

Table 2.—Manganese and manganiferous ore shipped [1] in the United States, by States

(Short tons)

Type and State	1966 Gross weight	1966 Manganese content	1967 Gross weight	1967 Manganese content
Manganese ore (35 percent or more Mn, natural):				
Montana and New Mexico	14,406	6,486	12,585	6,084
Manganiferous ore:				
Ferruginous managanese ore (10 to 35 percent Mn, natural):				
Colorado	----------	--------	321	64
Minnesota	271,062	36,684	236,753	34,475
Montana	1,755	464	2,763	456
New Mexico	47,590	5,606	49,323	5,529
Total	320,407	42,754	289,160	40,524
Manganiferous iron ore (5 to 10 percent Mn, natural):				
Minnesota	4,519	388	------------	--------
Total manganiferous ore	324,926	43,142	289,160	40,524
Value manganese and mangniferous ore	$3,094,034	--------	$2,629,421	--------

[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., but not including castings), consumption of manganese as ferroalloys, metal, and direct-charged ore per short ton of raw steel produced was 13.2 pounds in both 1966 and 1967. This total consumption in each year comprised approximately 11.5 pounds ferromanganese, 1.4 pounds silicomanganese, 0.05 pound spiegeleisen, and 0.25 pound manganese metal.

After being closed by labor difficulties for much of the last half of 1966, the Alloy, W. Va., Ashtabula and Marietta, Ohio, and Portland, Oreg., plants of Union Carbide Corp. had resumed normal operations by mid-1967. The company's Sheffield, Ala., plant was closed by a wildcat strike in November and December 1966. Vanadium Corporation of America merged with Foote Mineral Co. on August 31, 1967, to become the latter's Vancoram Operations. Its Keoukuk Electro-Metals division became Foote's Kemco Operations. A merger of E. J. Lavino & Co. into International Minerals & Chemical Corp. became effective at the end of 1966. This included Lavino's ferromanganese plants and its Covington, Tenn., synthetic dioxide plant.

Table 3.—Consumption and stocks of manganese ore [1] in the United States

(Short tons)

Use and ore source	Consumption 1966	Consumption 1967	Stocks Dec. 31, 1967 [2] (including bonded warehouses)
Manganese alloys and manganese metal:			
Domestic ore	30,043	4,367	1,294
Foreign ore	2,133,925	2,182,997	1,810,814
Total	2,163,968	2,187,364	1,812,108
Steel ingots: Foreign ore	---------	1,122	----------
Steel castings: Foreign ore	39	13	2
Pig iron:			
Domestic ore	195	3,296	----------
Foreign ore	42,746	38,957	36,934
Total	42,941	42,253	36,934
Dry cells:			
Domestic ore	3,549	2,470	306
Foreign ore	30,651	27,170	18,947
Total	34,200	29,640	19,253
Chemicals and miscellaneous:			
Domestic ore	12,372	18,276	13,391
Foreign ore	r 116,996	104,316	59,868
Total	r 129,368	122,592	73,259
Grand total:			
Domestic ore	46,159	28,409	14,991
Foreign ore	r 2,324,357	2,354,575	1,926,565
Total	r 2,370,516	2,382,984	[3] 1,941,556

r Revised.
1 Containing 35 percent or more manganese (natural).
2 Excluding Government stocks.
3 Excludes small tonnages of dealers' stocks.

Electrolytic Manganese and Manganese Metal.—It can be assumed that virtually all of the manganese metal consumed, produced, and imported was electrolytic metal. American Potash & Chemical Corp. at Hamilton (Aberdeen), Miss.; Foote Mineral Co., with two plants at Knoxville, Tenn.; and Union Carbide Corp. at Marietta, Ohio, continued to be the only domestic producers. On December 29, 1967, American Potash & Chemical Corp. became a wholly owned subsidiary of Kerr-McGee Corp. Union Carbide Corp., Mining and Metals Division, completed expansion of its Marietta facility to permit production of 10,000-plus tons per year of electrolytic manganese metal. Foote Mineral Co. proceeded with construction of its large new electrolytic manganese plant at New Johnsonville, Tenn., with completion scheduled for 1968. The plant will incorporate the latest automatic analytical and control instrumentation.

Ferromanganese. — The Manganese Chemicals Co. Division, Pickands Mather & Co., continued to produce low-carbon ferromanganese by fused-salt electrolysis at Kingwood, W. Va. E. J. Lavino & Co. shut down its Lynchburg (Reusens), Va., blast-furnace ferromanganese plant in August for an indefinite period, citing reduced steel production and increased ferromanganese imports as factors. U.S. shipments of ferromanganese totaled 870,781 tons valued at $128 million, compared with 986,000 tons valued at $146 million in 1966. The quantity of ferromanganese made in blast furnaces was more than twice that made in electric furnaces.

Silicomanganese.—Production of silicomanganese in the United States was 246,000 tons, compared with 253,000 tons in 1966. Shipments from furnaces were 240,000 tons ($38 million), compared with 282,000 tons ($41 million) in 1966.

The ratio of consumption of silicomanganese to that of ferromanganese appears to have leveled off in 1966 and 1967 at 16 to 17 percent. New grades and sizings of silicomanganese were made available.

Spiegeleisen.—The New Jersey Zinc Co. continued to produce spiegeleisen, solely by electric furnaces, at Palmerton, Pa.

Table 4.—Consumption and stocks of manganese ferroalloys and metal in the United States

(Short tons, gross weight)

Material	Consumption 1966	Consumption 1967	Total industry stocks [1] Dec. 31, 1967
Ferromanganese, high carbon	942,270	851,249	274,785
Ferromanganese, medium and low carbon	106,159	130,881	34,944
Silicomanganese	174,157	159,905	28,772
Spiegeleisen	31,792	29,369	34,740
Manganese metal	24,838	24,043	5,298

[1] Industry stocks held by producers and consumers, including those in bonded warehouses.

Table 5.—Ferromanganese produced in the United States and metalliferous materials [1] consumed in its manufacture

Year	Ferromanganese produced: Gross weight (short tons)	Ferromanganese produced: Manganese content Percent	Ferromanganese produced: Manganese content Short tons	Materials consumed: Manganese ore (35 percent or more Mn natural) Foreign (short tons)	Materials consumed: Manganese ore (35 percent or more Mn natural) Domestic (short tons)	Materials consumed: Manganese ore used per ton of ferromanganese [2] made (short tons)
1963	751,198	77.2	579,852	[2] 1,617,112	------	2.2
1964	929,486	77.8	722,752	[3] 2,082,074	10,371	2.2
1965	1,148,011	77.8	892,725	[3] 2,692,290	12,067	2.3
1966	946,210	78.7	744,359	[3] 2,133,925	30,043	2.2
1967	940,927	78.2	735,177	[3] 2,182,997	4,367	2.3

[1] Excluding scrap and other secondary materials.
[2] Includes ore used in producing silicomanganese.
[3] Includes ore used in producing silicomanganese and metal.

Table 6.—Manganese ore used in producing ferromanganese, silicomanganese, and manganese metal in the United States, by source of ore

Source	1966 Gross weight (short tons)	1966 Mn content, natural (percent)	1967 Gross weight (short tons)	1967 Mn content, natural (percent)
Domestic	30,043	44.3	4,367	46.5
Foreign:				
Africa	1,100,164	45.8	1,183,865	45.8
Australia	(1)	(1)	13,343	49.0
Brazil	532,237	47.1	377,761	45.9
Chile	3,129	48.8	3,703	44.1
Cuba	194	49.3	(1)	(1)
Guyana	68,222	38.8	79,275	36.1
India	151,975	45.7	240,291	45.7
Mexico	50,535	44.0	30,963	40.0
New Hebrides	(1)	(1)	6,273	50.5
Turkey	(1)	(1)	18,031	38.5
Other or unidentified	227,469	-----	229,492	-----
Total	2,163,968	46.1	2,187,364	45.4

[1] Included in "Other or unidentified."

Pig Iron.—In producing pig iron, 536,000 tons of manganese-bearing ores containing over 5 percent manganese (natural) were consumed, compared with 609,000 tons in 1966. This was broken down as follows (1966 figures in parentheses): Domestic sources supplied 468,000 (378,000) tons, of which 346,000 (251,000) tons were manganiferous iron ore containing 5 to 10 percent manganese, 119,000 (127,000) tons were ferruginous manganese ore containing 10 to 35 percent manganese, and 3,000 (200) tons were manganese ore containing more than 35 percent manganese; foreign sources supplied 68,000 (230,000) tons, of which 29,000 (188,000) tons were manganiferous iron ore, none (100) tons were ferruginous manganese ore, and 39,000 (43,000) tons contained more than 35 percent manganese.

Battery and Miscellaneous Industries.—The ore reported in table 3 as consumed in the manufacture of dry cells continued to include that used by producers of dry cells in their manufacture of synthetic manganese dioxide, but did not include that used by noncaptive plants to make synthetic dioxide. The latter was reported under "Chemicals and miscellaneous" and included ore of various grades. The reported ore consumption of table 3 does not include consumption of synthetic manganese dioxide as such. Hence, there is no duplication. The trend was toward use of a higher ratio of synthetic to natural dioxide in the manufacture of dry cells. American Potash & Chemical Corp. began expansion of its Henderson, Nev., synthetic manganese dioxide plant to 10,000 tons per year from 6,000. Completion was scheduled for the fourth quarter of 1968. Union Carbide Corp. was building an entirely new synthetic manganese dioxide plant at Marietta, Ohio. Manganese Chemicals Co. Division, Pickands Mather & Co., brought its new hydroquinone plant to its rated capacity at Baltimore, Md., and added manganese sulfate to its product line of various manganese chemicals which includes synthetic dioxide.

The domestic ore and much of the foreign ore used for chemical and miscellaneous purposes did not meet National Stockpile Specification P-81-R for chemical-grade ore.

PRICES

Manganese Ore.—All manganese ore prices are negotiated, being dependent in part on character and quantity of ore offered, delivery terms, and fluctuating shipping rates. After holding steady for the first 10 months of 1966 at 73 to 78 cents, nominal, per long ton unit of manganese, c.i.f. eastern seaboard and gulf ports, American Metal Market quotations for ore containing 46 to 48 percent manganese began to drop and by the end of 1967 were down to 60 to 64 cents, nominal. The nominal quote at the beginning of 1967 was 73 to 74 cents; in August, 70 to 73 cents; and in October, 68 to 70 cents.

Manganese Alloys.—The average value at furnaces for ferromanganese shipped by domestic producers was $147.41 per short ton, compared with $147.98 in 1966. Prices for standard high carbon ferromanganese continued to be essentially on a "price on request" basis. Domestically produced material was quoted by the American Metal Market through the last 5 months of the year at $164.50, nominal, per long ton, generally f.o.b. producer's plant, freight equalized to nearest competitive producing point. It was stated in August, however, that "it can be bought in the open market for at least $5 a ton less" and "many deals have been made recently at even lower figures." Imported alloy continued to be quoted "in the area of $157" per long ton, but indications were that it could be purchased for less. In the last 3 months of the year, Metals Week was quoting imported alloy at $144 to $150, delivered in Pittsburgh and Chicago. The price of spiegeleisen containing 19 to 21 percent manganese continued unchanged at $89 per long ton, f.o.b. Palmerton, Pa.

Manganese Metal.—In December, all three producers of electrolytic manganese metal announced an increase in price of the standard grade, bulk carlots, to 29.85 cents per pound, f.o.b. producer's plant, freight equalized, effective the beginning of January. The previous price of 28.85 cents had prevailed through 1966 and 1967. The premium for hydrogen-removed metal remained unchanged at 0.75 cent.

FOREIGN TRADE

Ferromanganese exports totaled 1,861 short tons valued at $759,955, compared with 545 tons at $228,395 in 1966. Canada took approximately 75 percent of the quantity in both years. Exports classified as "manganese and manganese alloys, wrought or unwrought, and waste and scrap" were 1,388 tons valued at $857,603 in 1967, and 1,901 tons at $1,442,472 in 1966. Exports of ore and concentrate containing more than 10 percent manganese totaled 15,375 tons with a value of $1,502,044 in 1967, and 16,487 tons at $1,491,017 in 1966. They were believed to consist almost entirely of imported manganese dioxide ore exported after grinding, blending, or otherwise classifying.

The average grade of imported manganese ore was essentially unchanged at 47.3 percent manganese, having been 47.4 percent in 1966. Gabon and Brazil continued as the largest individual sources of supply but a large drop was registered in the receipts from Brazil. The Republic of South Africa, India, and Ghana were other suppliers of large quantities. Actual imports from Congo (Kinshasa) in 1967 were considerably less than the quantity reported and adjustments have been made by footnotes to table 7.

Table 7.—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				Value (thousands)	
	Gross weight		Mn content		Gross weight		Mn content			
	1966	1967	1966	1967	1966	1967	1966	1967	1966	1967
Angola	29,270	11,088	14,327	5,322	29,270	11,088	14,327	5,322	$895	$264
Brazil	682,921	271,530	321,501	128,176	780,297	271,530	371,269	128,176	22,491	7,286
British Western Pacific Islands [3]	------	9,118	------	4,559	------	9,118	------	4,559	------	252
Canada	(4)	------	(4)	------	(4)	------	(4)	------	(4)	------
Chile	683	3,360	321	1,612	683	3,360	321	1,613	13	125
Congo (Kinshasa) [5]	221,128	417,849	109,244	201,089	221,554	418,178	109,470	201,246	6,764	10,883
Gabon [6]	376,534	398,166	188,558	192,620	376,534	399,230	188,558	193,170	10,688	10,285
Ghana	287,367	173,089	143,324	91,688	287,448	173,127	143,371	91,707	12,456	7,892
Greece	7,235	11,506	3,504	5,501	7,235	11,506	3,504	5,501	397	656
Guatemala	272	------	139	------	272	------	139	------	10	------
Guyana [7]	50,579	95,412	19,500	39,479	50,654	95,412	19,538	39,479	1,035	1,888
India	320,723	198,562	144,385	90,282	320,926	198,562	144,484	90,282	8,268	3,971
Iran	8,900	1,680	3,560	789	8,900	1,680	3,560	789	182	36
Ivory Coast [8]	72,847	80,349	33,435	34,898	72,847	80,349	33,435	34,898	1,630	1,643
Japan	138	------	56	------	138	------	56	------	17	------
Mexico	44,008	11,641	19,985	4,999	44,064	11,698	20,011	5,022	1,251	393
Morocco	43,337	61,512	22,447	32,053	43,337	61,512	22,447	32,053	2,022	3,228
Mozambique	------	9,976	------	5,654	------	9,976	------	5,654	------	202
South Africa, Republic of	260,679	249,081	116,275	108,705	260,679	249,328	116,275	108,806	5,081	5,075
Turkey	1,140	5,625	433	2,700	1,140	5,625	433	2,700	15	125
Western Africa, n.e.c [9]	138,100	47,896	66,643	22,903	138,100	47,896	66,643	22,903	3,621	1,376
Western Portuguese Africa, n.e.c.	6,720	4,480	3,030	2,113	6,720	4,480	3,030	2,113	162	130
Zambia	1,123	2,238	619	1,170	1,123	2,238	619	1,170	49	103
Total	2,553,704	2,064,158	1,211,286	976,312	2,651,921	2,065,893	1,261,490	977,163	77,047	55,813

[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] Probably from New Hebrides, but possibly some from Fiji.
[4] Less than ½ unit.
[5] Actual imports originating in Congo (Kinshasa) were approximately 111,000 tons (gross weight) in 1966 and approximately 73,000 tons (gross weight) in 1967. See note 6.
[6] In addition: Gabon imports reported as Congo (Kinshasa) were approximately 110,000 tons (gross weight) in 1966 and approximately 345,000 tons (gross weight) in 1967; those reported as Western Africa, n.e.c., were approximately 121,000 tons (gross weight) in 1966 and approximately 48,000 tons (gross weight) in 1967.
[7] 1967 data adjusted to include ore reported from country of transshipment (Trinidad and Tobago) and also 10,660 tons (gross weight) incorrectly reported as British West Africa.
[8] In addition: Ivory Coast imports reported as Western Africa, n.e.c., were approximately 17,000 tons (gross weight) in 1966.
[9] Actually from Gabon and Ivory Coast.

Table 8.—U.S. imports for consumption of ferromanganese, by countries

Country	1966			1967		
	Gross weight (short tons)	Mn content (short tons)	Value (thousands)	Gross weight (short tons)	Mn content (short tons)	Value (thousands)
Australia	13,103	10,260	$1,217	-------	---------	--------
Belgium-Luxembourg	21,753	16,653	2,348	45,410	34,655	$4,916
Canada	5,250	4,191	1,063	7,824	6,525	2,099
Chile	158	137	27	1,159	947	153
France	61,067	46,970	6,510	37,344	28,902	4,014
Germany, West	52,602	39,855	5,594	21,080	16,247	2,395
India	13,077	10,001	1,911	19,023	14,354	2,016
Italy	1,620	1,297	312	2,134	1,717	416
Japan	14,558	11,577	2,841	6,554	5,332	1,218
Mozambique	2,238	1,745	244	---------	---------	--------
Norway	14,991	11,538	1,640	6,983	5,501	907
South Africa, Republic of	26,384	20,608	2,863	41,213	32,053	4,294
Spain	1,653	1,283	170	3,197	2,402	324
Sweden	3,991	3,250	612	8,268	6,882	1,691
United Kingdom	19,527	15,198	2,103	15,590	12,031	1,665
Total	251,972	194,563	29,455	215,779	167,548	26,108

Both general imports and imports for consumption of manganiferous ores containing more than 10 percent manganese but less than 35 percent manganese totaled 5,500 short tons, compared with 43,000 tons in 1966. Ghana supplied 5,100 tons, and Mexico the remainder in 1967; in 1966, Ghana was the source of 34,000 tons.

Silicomanganese imports for consumption totaled 34,936 tons containing 23,416 tons of manganese, compared with 35,771 tons containing 24,046 tons of manganese in 1966. Sources by tons gross weight were as follows (1966 data in parentheses): Norway, 20,892 (17,720); Yugoslavia, 11,200 (7,584); Mexico, 1,322 (4,236); France, 781 (168); Canada, 676 (2,356); Japan, 66 (502); Brazil, (1,828); Chile, (1,237); and the Republic of South Africa (140). General imports were essentially the same for both years. Manganese metal imports for consumption were 2,237 tons in 1967 and 2,020 tons in 1966. The Republic of South Africa provided 2,037 and 1,446 tons, respectively; Japan, 200 and 574 tons, respectively. General imports were 2,426 and 2,030, respectively for the 2 years. There were no spiegeleisen imports in 1967, but 133 tons came from Canada in 1966.

Imports for consumption classified as "Manganese compounds, other" totaled 2,106 tons in 1967 and 1,403 tons in 1966. The respective sources (1966 quantity, and price per pound, in parentheses) were in gross weights: Japan, 2,344 (888) (16.4 cents); United Kingdom 391 (392) (6 to 7 cents); Belgium-Luxembourg 370 (121) (14.9 cents); and small quantities at high unit prices from the Netherlands. The imports from Japan, and possibly those from Belgium-Luxembourg as well, 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 by Public Law 90–49; that is, through June 30, 1970. 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.

Presidential Proclamation 3822, signed December 16, 1967, made effective beginning January 1, 1968, those reductions of Rate 1 duties, applicable to most countries, that were promised by the Kennedy Round of negotiations earlier in the year. Resulting duties for calendar year 1968 for the more important manganese alloys, and metal, imported from countries other than the U.S.S.R. and other specified Communist countries then became as follows:

TSUS Number	*Item*	*1967 rate*	*1968 rate*
607.35	Low-carbon ferromanganese.	0.6 cent per pound Mn content plus 4.5 percent ad valorem.	0.5 cent per pound Mn content plus 4 percent ad valorem.
607.36	Medium-carbon ferromanganese.	0.9375 cent per pound Mn content.	0.8 cent per pound Mn content.
607.37	High-carbon ferromanganese.	0.625 cent per pound Mn content.	0.55 cent per pound Mn content.
607.57	Silicomanganese____	0.9375 cent per pound Mn content plus 7.5 percent ad valorem.	0.84 cent per pound Mn content plus 6.5 percent ad valorem.
632.32	Manganese metal___	1.875 cent per pound plus 15 percent ad valorem.	1.8 cent per pound plus 14 percent ad valorem.

These will be stepped down annually until January 1, 1972, when the rates for these alloy items will be roughly half those in effect in 1967, and the duty for metal will be 1.5 cents per pound plus 10 percent ad valorem.

WORLD REVIEW

Australia.—The first shipment of manganese ore from the Groote Eylandt deposits, in the Northern Territory, was made in March 1966, its destination being the Bell Bay, Tasmania, ferromanganese plant of the affiliated Tasmanian Electro-Metallurgical Co. Pty., Ltd. By June, Groote Eylandt's annual ore productive capacity was 200,000 tons. Plans called for this to be doubled by mid-1968 to 400,000 tons. Besides Bell Bay, shipments were made in 1966 and 1967 to Australia's Newcastle Steelworks, Japan, Norway, and the United States. Completion of a second closed, rotating-hearth electric furnace in September 1966 at Bell Bay brought that plant's ferromanganese capacity to 75,000 tons per year of high-carbon alloy containing 78 percent manganese, 14 percent iron, 6.8 percent carbon, and 0.3 percent silicon. This permitted exports to begin in October and the first shipment was to the United States. Entirely apart from these developments, Bell Brothers Pty. Ltd. contracted for export in 1967 of Western Australia metallurgical ore to Japan: 50,000 tons of good grade from Pilbara and 100,000 tons of lower grade from the Peak Hill area. Australian production of manganese ore other than metallurgical for 1962–66 was as follows:

Type	1962	1963	1964	1965	1966
Battery:					
Short tons___	896	1,362	829	1,960	____
Percent MnO_2	72.0	73.2	69.7	66.6	____
Other:					
Short tons___	2,444	1,147	1,220	802	727
Percent MnO_2	42.9	33.0	47.5	67.9	62.6

Brazil.—Indústria e Comércio de Minério, S. A. (ICOMI), operating the Serra do Navio mine, Amapá; Cia. Meridional de Mineraçao, operating the Morro da Mina, Minas Gerais; and Sociedade Brasileira de Mineraçao, Ltda. (SOBRAMIL), mining the Urucum deposits in Mato Grosso, supplied 97 percent of the total manganese ore exported in 1966 and approximately 80 percent of the total shipping ore produced. Of total exports of 1,054,000 short tons, the United States took 681,500 tons; Japan, 89,800; Norway, 81,600 tons; Spain, 36,200 tons; West Germany, 35,500 tons; Canada, 29,-200 tons; and seven other countries, the remainder.

Canada.—Metallurgical grade manganese ore was consumed in 1966 for the production of manganese ferroalloys by Chromium Mining & Smelting Corp., Limited, Beauharnois, Quebec, and by Union Carbide Canada Limited, Welland, Ont. Battery grade ore was consumed by

Burgess Battery Co. Limited, Niagara Falls, Ontario; Mallory Battery Company of Canada Limited, Toronto, Ontario; National Carbon Limited, Toronto, Ontario; and Ray-O-Vac (Canada) Limited, Winnipeg, Manitoba. Imports of ferromanganese were 49,000 short tons in 1966, compared with 35,000 in 1965. Consumption in 1965 was 61,000 tons.[2]

[2] Wigle, G. P. Manganese—1966. Mineral Resources Division, Department of Energy, Mines and Resources, Ottawa, Canada June 1967, 8 pp.

Table 9.—World production of manganese ore, by countries [1] [2]
(Short tons)

Country	Percent Mn e	1963	1964	1965	1966	1967 p
North America:						
Cuba	35–50	r 41,341	r 77,544	e 80,000	e 80,000	NA
Mexico [3]	45+	r 190,543	r 210,549	r 204,721	r 126,457	122,000
United States (shipments)	35+	10,622	26,058	29,258	14,406	12,585
South America:						
Argentina	30–40	r 32,204	r 41,081	r 22,446	r 12,236	NA
Brazil	38–50	1,382,727	1,490,077	1,538,893	r 1,603,745	1,248,000
Chile	43–48	51,234	21,893	r 18,284	19,754	16,374
Guyana	36–42	157,331	130,907	186,137	201,600	196,820
Peru	42–45	571	410	1,091	937	NA
Europe:						
Bulgaria	30+	r 42,437	57,000	46,000	e 46,000	e 46,000
Greece	35+	21,278	r 20,371	r 11,909	NA	16,500
Hungary	30−	167,960	188,711	234,792	r 231,485	e 240,000
Italy	30−	49,887	52,694	52,701	r 48,484	51,917
Portugal	38+	9,434	7,711	8,559	9,488	10,981
Rumania	35	286,601	e 110,000	138,891	123,000	e 123,000
Spain	30+	16,858	17,762	r 19,247	20,948	9,243
U.S.S.R. [4]	NA	7,345,000	7,822,000	8,351,000	e r 7,720,000	e 7,940,000
Yugoslavia	30+	8,964	8,580	8,925	9,498	10,826
Africa:						
Angola	30–52	----------	----------	----------	20,448	e 47,000
Botswana	30+	11,877	30,639	9,717	e 7,700	e 7,700
Congo (Kinshasa)	48+	297,660	341,385	416,205	274,809	307,813
Gabon	48–53	701,716	1,057,750	1,411,393	1,403,814	1,264,350
Ghana [5]	48+	449,121	509,341	665,821	647,422	e 580,000
Ivory Coast	32–47	153,291	150,383	198,179	194,212	164,721
Morocco	35–53	369,217	375,974	414,337	399,499	315,413
Rhodesia, Southern	30+	----------	160	e 230	NA	NA
South Africa, Republic of	30+	1,441,503	1,455,271	1,727,822	1,866,166	e 1,930,000
South-West Africa, Territory of	45+	----------	----------	4,185	25,367	NA
Sudan	36–44	e 275	e 9,400	1,102	1,653	e 1,600
United Arab Republic [6]	35+	e 7,000	e 47,000	e 26,000	e 26,000	NA
Zambia	35+	38,486	40,091	33,965	29,434	27,522
Asia:						
Burma	42+	e 220	NA	r 661	NA	NA
China, mainland e	30+	1,102,000	1,102,000	1,102,000	1,102,000	770,000
India including Goa	32–53	1,428,354	1,548,955	1,779,913	r 1,849,550	1,762,594
Indonesia	35–49	3,136	e 550	r 457	NA	e 13,000
Iran	35+	16,500	35,300	r 35,000	42,000	e 45,000
Japan	30–43	305,028	313,825	333,950	r 353,733	374,963
Korea, South	35+	4,580	4,753	7,376	6,583	7,982
Malaysia	30+	7,696	----------	1,754	r 64,803	93,713
Pakistan	42+	1,553	1,098	r 560	r 139	NA
Philippines	30+	8,450	8,824	57,038	61,832	95,331
Thailand	40+	7,285	12,185	36,848	77,825	86,603
Turkey	30–50	6,949	22,366	15,675	r 24,546	e 25,000
Oceania:						
Australia	35–54	40,389	68,442	r 112,414	r 303,470	e 600,000
Fiji	40+	3,621	1,004	6,040	r 5,871	6,547
New Hebrides	49–55	28,016	r 66,740	73,535	84,040	78,705
Total [7]	-------	r 16,249,000	r 17,487,000	r 19,425,000	r 19,141,000	18,650,000

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

[1] Czechoslovakia and Sweden report production of manganese ore (approximately 13 to 17 percent manganese content), but since the manganese content averages substantially less than 30 percent, the output is not included in this table. Czechoslovakia averages annually around 90,000 short tons and Sweden approximately 13,000 tons for the last 5 years.

[2] Compiled mostly from data available May 1968.

[3] Estimated from reported content.

[4] Grade unstated. Source: The National Economy of the U.S.S.R., Central Statistical Administration (Moscow).

[5] Dry weight.

[6] In addition to high-grade ore shown in the table, Egypt produced the following tonnages of less than 30 percent manganese content: 1963, e 46,000; 1964, e 315,000; 1965, e 174,000; 1966, e 178,000; and 1967, not available.

[7] Total is of listed figures only (rounded); no undisclosed data included.

Chile.—Manganese ore produced in each of the years 1964–67 averaged between 46 and 47 percent manganese.

Congo (Kinshasa).—All operations at the Kisenge mine of Société Miniere de Kisenge (SMK) stopped after an invasion of the town in November 1967 resulted in considerable destruction and pillage and the evacuation of all European personnel. The new Afropile Battery Co. plant, in which SMK has a large interest, was also closed. Mining was not resumed before the end of the year, but some preparation of previously mined stocks for shipment began in mid-December.

Ecuador.—Government approval was received by Union Carbide Corp. to erect a dry-cell battery plant in Quito.

Gabon.—Manganese ore exports in 1967 totaled 1,352,000 short tons, distributed (in percent) as follows: United States, 63; France, 13; West Germany, 12; Japan, 9; Norway, 2; Belgium-Luxembourg and Italy, the remaining 1. All production continued to come from the Moanda deposits of Cie. Minière de l'Ogooué (COMILOG). Improvements planned for the aerial tram by 1968, including an increase in speed and replacement of existing steel buckets with alloy buckets of lighter weight, were expected to raise its annual capacity to approximately 1,500,000 tons. This was believed to be the limit for the tram line and hence the effective limit of production capacity for the entire COMILOG operation. The Moanda deposits lie on five high plateaus as a horizontal bed averaging 12 to 18 feet thick under a layer of loosely consolidated earth and clay of approximately the same thickness. The ore rests on Precambrian black schist with occasional thin layers of manganese carbonate in between, and consists for the most part of poorly crystallized manganese oxides interspaced with argillaceous siliceous layers. Portions provide battery-grade material, and a laboratory was built at the mine for regularly testing suitability for this purpose. After studying the feasibility of manufacturing dry cells in Gabon to supply the country's requirements and those of associated African States, the Government concluded that a $570,000 plant was indicated for annual production of 8 million round 1.5-volt batteries. Production of battery-grade concentrate of 82 to 84 percent manganese dioxide content was 29,000 tons in 1967 and 6,400 tons in 1966.

Ghana.—Operations at the Nsuta mine included continuing pilot plant investigations looking toward beneficiation of a large reserve of low-grade ore. Union Carbide Ghana Limited, jointly owned by Union Carbide Corp. and the National Investment Bank of Accra, was formed to manufacture flashlight and radio batteries in Ghana.

Greece.—A plant to manufacture dry cell batteries was being built near Thebes by Union Carbide Hellas S.A., a newly formed subsidiary of Union Carbide Corp.

Guatemala.—Cia. Minera de Guatemala, a small lead-zinc mining operation at Caquipec, Alta Verapaz, exported 272 short tons of manganese ore or concentrate to the United States in 1966. Manganese content exceeded 50 percent.

Guyana.—Manganese ore exported in 1967 totaled 215,000 short tons, averaging 36.1 percent manganese. The ore was from the Matthews Ridge mine of Manganese Mines Management Limited, a subsidiary of Union Carbide Corp.

India.—Delayed ore contract deliveries by the Government-owned Minerals and Metals Trading Corp. (MMTC) were the result of continuing difficulties with road and railroad transport, problems in obtaining high-grade ores, and loading difficulties at the ports.[3] Deliveries of Indian ferromanganese and ore to the United States on the 1963 government-to-government barter contract were completed by the end of November 1966, but some ferromanganese and electrolytic manganese metal to be made in the United States from this ore remained outstanding. Export duties on manganese ore containing 10 percent or more manganese, put into effect on August 2, 1966, were reduced late in May 1967 to 12.50 rupees ($1.65) per metric ton from 20 rupees ($2.65). These actions followed devaluation of the rupee June 8, 1966. Most of India's operating manganese mines in 1966 were open pit operations. Underground mines of importance were the

[3] Bureau of Mines. Mineral Trade Notes. V. 64, No. 4, April 1967, pp. 17–19.

Ukwa and the new Bharweli, Balaghat district, Madhya Pradesh; the Gowari Wadhona, Chhindwara district, Madhya Pradesh; the Mansar, Nagpur district, Maharashtra; and the Shivrajpur and the Bamankua mines, Gujarat. Cut and fill and/or square set mining methods were used with little mechanization. The total number of workers employed in all manganese ore mining in 1966 was estimated to be 42,500. Domestic consumption of manganese ore was estimated to be approximately 600,000 tons, of which 400,000 tons was used by the iron and steel industry, and the remainder largely by the producers of ferromanganese. Large annual losses to the Government (MMTC) in export of the ores resulted in formation of a "Consultative Committee for Manganese Ore" to study the industry's problems and suggest remedial measures. Mine operators maintained that direct negotiation of export contracts between themselves and foreign buyers, without going through MMTC, would be necessary to arrive at a real solution. Exports of standard peroxide ore of 86 percent manganese dioxide content were 110 short tons in 1966, none in 1965, and 50 tons in 1964; exports of peroxide ore of lower manganese dioxide content were 1,300, 2,300, and 2,000 tons, respectively. Exports of ferromanganese were 27,000 tons in 1967 and 17,000 tons in 1966. The United States took 98 percent of the 1966 exports of ferromanganese.

Italy.—Manganese ore produced in 1967 had an average manganese content of 30 percent compared with 28 percent in 1966 and 1965.

Ivory Coast.—A breakdown follows, by grades, of the manganese ore produced in 1967: 50 percent contained 45 to 47 percent manganese, 32 percent contained 40 to 42 percent manganese, 10 percent constituted fines containing 40 percent manganese, and 8 percent was fines of 32 percent manganese content. Total exports were 136,000 tons and consisted entirely of the two coarse grades. Total exports in 1966 were 172,000 tons and had 40-percent or better manganese content.

Japan.—The country's largest producer of synthetic manganese dioxide, Tekkosha Co., tripled productive capacity of its Hyuga plant to 18,000 tons per year. Together wtih 6,000 tons at its Yamagata plant, this brought the company's total capacity to 24,000 tons per year, and that of the country apparently to 39,000 tons. Japanese annual consumption was reported to run approximately 7,000 tons with the large difference exported.[4] As of April 1, 1967, after a survey of 75 metallurgical manganese ore mines, and 26 manganese dioxide mines, Japan's total reserves of metallurgical ore were stated to be 6,180,000 short tons averaging 24 percent manganese, while those of dioxide ore were 110,000 tons averaging 62 percent manganese dioxide. Production of dioxide ore was 16,000 tons in 1967, averaging 68.6 percent manganese dioxide, and 11,000 tons in 1966, averaging 68.1 percent manganese dioxide. Metallurgical ore produced in those 2 years averaged 30 and 31 percent manganese, respectively. Production of manganese metal was 7,000 tons in 1967, and 5,100 tons in 1966. A strike of 3 months duration in the middle of 1966 at Tekkosha's Yamagata plant affected that year's production and exports. Production of manganese dioxide (presumably synthetic dioxide) was 38,200 tons in 1967 and 25,600 tons in 1966.

Kenya.—Through Union Carbide Kenya Limited, Union Carbide Corp.'s first dry-cell battery plant in Africa started production in late 1967 at Nakuru.

Mexico.—A $5 million Alliance for Progress Loan was authorized by the Export-Import Bank of Washington for the purchase of equipment and engineering services by Cia. Minera Autlan for the development of its large deposit of carbonate manganese ore at Molango, Hidalgo. The loan was guaranteed by Bethlehem Steel Co. Plans called for development of an underground mine, small open pit, crushing and blending plant, large roasting and nodulizing kiln fired by natural gas, and construction of a gas pipeline from Pachuca, with production to begin in 1968. Mexico produced 39,000 tons of ferromanganese and 7,300 tons of silicomanganese in 1967.

Morocco.—Production of chemical-grade ore was 97,000 short tons in 1967 at an average grade of 84 percent manganese dioxide, and 86,000 tons of the same grade in 1966. Sinter produced in

[4] European Chemical News (London). V. 11, No. 262, Feb. 3, 1967, p. 24.

1967 totaled 83,000 tons and came from 105,000 tons of metallurgical ore that is included in the ore production figure of table 9. In 1966, there was 99,000 tons of sinter produced having a manganese content of 56 percent and coming from 125,000 tons of metallurgical ore that is also included in the reported ore production figure of table 9. The Bou Arfa mines, second largest manganese producer in Morocco and employing almost 1,000 workers, closed in spring 1967.

Philippines.—Ferromanganese production was 273 short tons in 1967 and 685 tons in 1966; silicomanganese production was 105 and 261 tons, respectively.

Red Sea.—Scientists of the Woods Hole Oceanographic Institution reported large, rich, underwater accumulations of iron, manganese, gold, silver, zinc, and copper at depths of 7,000 feet in the Red Sea between Port Sudan, Sudan, and Jidda, Saudi Arabia.

South Africa, Republic of.—In each of the fiscal years ending June 30, 1967, and June 30, 1966, South African Manganese Ltd. produced a total of more than 1 million tons of ore from its Mamatwan and Hotazel mines in the Kuruman area, and the Lohathla mine in the Postmasburg area. All are open pit operations. The ore at Hotazel lies in two continuous beds separated by 70 feet of iron formation. The top bed typically is 20 feet thick and is reported to analyze consistently 48 percent or more manganese, 14 percent iron, 5 percent silica, and 0.05 percent maximum phosphorus. The lower bed has a thickness of 40 feet, or more, and a similar analysis except that iron content is lower, roughly 9 percent. At Mamatwan the ore is also continuous and of consistent quality, analyzing 38 to 40 percent manganese, 4 to 6 percent iron, 4 to 6 percent silica, 12 to 14 percent calcium oxide (CaO), and 0.03 percent phosphorus. Diamond drilling at the Mamatwan mine has disclosed 200 million tons of ore. Large earth moving equipment is used at both mines and the ore is crushed and screened to minus 4-plus ½ inch, with no further beneficiation. At the Lohathla mine, where the ore occurrences are scattered and irregular, there is much hand mining and hand sorting. Lohathla ore is generally hard, high in iron, and low in silica.[5] Increases in rail freight rates averaging 18 percent became effective September 1, 1966, on manganese ores for export. The South African Railways continued with its electrification program of the line from Kimberley to north of Postmasburg. Expansion of the plant of Electrolytic Metal Corp. (Pty.) Ltd., South Africa's only producer of electrolytic manganese, was completed in 1966 to provide a designed capacity of 8,400 short tons of metal per year. After overcoming some technical difficulties, the desired level of operation was reached in August of that year. Output reached 8,700 tons in 1967 after having been 6,940 tons in 1966 and 5,550 tons in 1965.

Thailand.—Battery-grade manganese ore produced in Thailand totaled 10,000 short tons in 1967 and 8,200 tons in 1966, both averaging 75 percent manganese dioxide; tonnages for 1965 and 1964 were 4,500 and 3,400, respectively.

United Kingdom.—The duty on manganese metal containing from 96 to 99.5 percent manganese, not more than 1 percent carbon, and not more than 3 percent iron, was suspended late in 1966 and remained suspended through 1967.[6] This was reportedly for the purpose of facilitating entry from France of Gimel metal, an electrothermally produced alloy that competes in the United Kingdom with low-carbon ferromanganese rather than with electrolytic manganese metal. For steelmaking, United Kingdom practice has preferred low-carbon ferromanganese to electrolytic manganese metal. The latter, supplied by the Republic of South Africa, Japan, and the U.S.S.R., has been used for nonferrous alloys. Electrolytic manganese imports were duty free. Berk-Leiner Ltd., Treforest, South Wales, stopped producing electrolytic manganese dioxide in February 1966 in spite of the protection of a 10-percent import duty.

Upper Volta, Republic of.—Test drilling by the United Nations of the Tambao manganese deposit, near the Mali-Niger border and 10 miles north of the town of Markoye, proved reserves of 6.9 million tons of ore with good possibilities for an additional 2 or 3 million tons. Indications were that the ore would grade from 44 to more than 54 percent manganese. The

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[5] Metal Bulletin (London). Samangan of S. Africa. No. 5227, Sept. 1, 1967, pp. 21–23.

[6] Metal Bulletin (London). No. 5195, May, 5, 1967, pp. 15, 24; No. 5164, Jan 13, 1967, p. 15.

deposit is 220 miles from the terminus at Ougadougou of the railroad from Abidjan, Ivory Coast, and 600 miles inland from Cotonou on the Dahomey coast.

TECHNOLOGY

Numerous large rhodonite-quartz-carbonate veins containing zinc, lead, copper, and iron sulfides, with minor gold and silver values, fill fissures in Tertiary volcanic rocks of the San Juan Mountains near Silverton, Colo. The deposits constitute a sigificant potential source of manganese for an emergency or other period of high demand with favorable prices.[7] They outcrop at elevations of 11,000 to 13,000 feet with only surficial oxidation. The largest vein in the Eureka-Animas Forks district, the Sunnyside, carries manganese mineralization for a length of more than 8,000 feet with a maximum width of 200 feet. Samples over a 2,000-foot length had a weighted average manganese content of 8 percent. Where intersected by the recently completed American Tunnel at a depth of 2,400 feet below the outcrop, rhodochrosite and other manganese carbonate minerals were observed to be more abundant than rhodonite. An average manganese content of 10 percent or more was found in other veins of the district.

The potential of deep-sea manganese nodules as a resource received a thorough objective analysis.[8] Research has suggested that some of these nodules can be effectively used to alleviate air pollution by removing sulfur dioxide from power plant and other waste stack gases. The nodules were packed loosely as a column in a tower through which the gas was passed. Sulfur dioxide in the gas reacted with the manganese of the nodules to form manganese sulfate. Even when the gas contained only a few parts per million, removal of sulfur dioxide was 98 percent efficient. Approximately 40 percent of the manganese contained in the sulfated nodules was then recoverable by leaching with dilute sulfuric acid.[9]

In extensive use tests, the addition of methyl cyclopentadienyl manganese tricarbonyl to fuel oil, in the proper proportions, reduced the sulfur trioxide content of powerplant flue gas by 45 percent at a material cost approximating 0.45 cent per million Btu.[10] An added benefit was appreciable reduction of soot deposits.

By wet grinding a 4-to-1 mixture of manganese carbonate ore (18 to 27 percent manganous oxide, 10 to 12 percent iron) and ore slimes (22 percent manganous oxide, 24 percent ferric oxide) and subjecting the resulting slurry to powerplant flue gases, manganese sulfate was obtained. The sulfate solution was purified by the addition of "limestone meal," and manganese removed with "limewash", to give MnO·OH which was thickened, filtered, and dried, for a product analyzing 60 to 65 percent manganese with virtually no iron or phosphorus. Favorable costs were claimed, plus the added benefit of air pollution control, but scale of the work was not stated.[11]

In scaling up the cyclic sulfur dioxide and sulfuric acid leach processes that have been under development for recovering manganese from low-grade or offgrade ores, the decomposition of manganese sulfate has been a problem. Laboratory-scale investigations showed that satisfactory decomposition can be accomplished by partial reduction, using controlled quantities of solid reductants in the absence of air, at temperatures of 700° to 800° C instead of the higher temperatures required when heat alone is used.[12]

To obtain basic data for use in directing the nature of manganese research, solid state reactions of manganese with silica in various proportions were studied by the Bureau of Mines. The difficult separation of metallic and slag phases was accomplished by bromination with bromine vapor

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7 Young, William E. Manganese Occurrences in the Eureka-Animas Forks Area of the San Juan Mountains, San Juan County, Colo. BuMines Inf. Circ. 8303, 1966, 52 pp.

8 Brooks, David B. Low-Grade & Nonconventional Sources of Manganese. Resources for the Future, Inc., Washington, D.C., 1966, pp. 93–108.

9 Zimmerley, S. R. (assigned to Kennecott Copper Corp.) Use of Deep-Sea Nodules for Removing Sulfur Compounds From Gases. U.S. Pat. 3,330,096, July 11, 1967.

10 Belyea, A. R. Manganese Additive Reduces SO_3. Power, v. 110, No. 11, November 1966, pp. 80–81.

11 Steel. V. 160, No. 1, Jan. 2, 1967, p. 27; Hungarian Journal of Mining (Banyaszati Lapok), V. 99, January 1966, pp. 7–17.

12 Fuller, Harry C. (assigned to the United States of America as represented by the Secretary of the Interior). Process for Decomposing Manganese Sulfate To Form Manganous Oxide and Sulfur Dioxide. U.S. Pat. 3,301,634, Jan. 31, 1967.

Fuller, H. C., and V. E. Edlund. Decomposition of Manganese Sulfate by a Partial Reduction Process. BuMines Rept. of Inv. 6794, 1966, 18 pp.

under reduced pressure and carefully controlled rates of heating.[13]

A chlorination procedure was developed in the laboratory as the basis for a proposed process for recovery of manganese from virtually any manganiferous material. Recoveries of 90 to nearly 100 percent were obtained from the more important low-grade and offgrade domestic resources, including siliceous and carbonate resources.[14]

In laboratory experiments, molten manganiferous pig iron containing 4 to 5 percent maganese was injected with oxygen to reduce the metal to 1 percent or less manganese and make a slag containing approximately 40 percent manganese. After quenching with water, the slag was treated with concentrated sulfuric acid, roasted to inhibit gel formation, and the soluble manganese and iron sulfates leached out with water. These were precipitated as hydroxides, converted to oxide, and smelted to standard ferromanganese.[15] The work combined the Carosella melt-quench-leach process (see Manganese chapter, 1959 Minerals Yearbook) with the Wright process.[16]

With emphasis placed on iron rather than manganese recovery, four Cuyuna range (Minnesota) brown manganiferous iron ores, ranging in composition from 6.0 to 8.1 percent manganese, 36.3 to 46.5 percent iron, and 8.1 to 32.6 percent silica, were investigated in the laboratory by a procedure involving a metallizing high temperature reduction roast (1,040° or 1,120°C) and magnetic separation. Manganous oxide in the nonmagnetic fraction was leached with dilute sulfuric acid to recover as a byproduct more than 40 percent of the manganese contained in the ore. The magnetic fraction yielded an iron product analyzing 68 to 85 percent iron.[17]

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[13] Iverson, H. G., and E. L. Singleton. Reactions of Manganese With Silica. BuMines Rept. of Inv. 6905, 1967, 16 pp.

[14] Cochran, A. A., and W. L. Falke. A One-Step Operation for Recovery of Manganese as Chloride From Ores and Slags. BuMines Rept. of Inv. 6859, 1967, 22 pp.

[15] Davis, E. G., F. E. Brantley, and E. C. Wright. Recovery of Manganese From Slag Formed by Selective Oxidation of High-Manganese Pig Iron. BuMines Rept. of Inv. 6728, 1966, 16 pp.

[16] Wright, Edwin C. Method of Making Ferromanganese Having Over 60 Percent Manganese From Waste Steel Mill Slags and Low Grade Natural Ores. U.S. Pat. 2,764,857, May 22, 1956.

[17] Weston, P. L., and M. M. Fine. Reduction Roasting-Acid Solution Techniques in Laboratory Processing of Minnesota Manganiferous Ores. BuMines Rept. of Inv. 6775, 1966, 22 pp.

Mercury

By John G. Parker [1]

Decreased imports, especially from Italy and Mexico, and lower consumption characterized the U.S. mercury industry in 1967. Production from 122 mines was higher than the previous year, principally because of increased output from Nevada.

Secondary production, including Government releases of surplus mercury, provided 32 percent of the mercury for U.S. consumption compared with about 23 percent in 1966.

Foreign mercury production, mainly that of Spain, was considerably lower despite an increased price for the metal (average was $489.36 per flask at New York in 1967).[2]

Table 1.—Salient mercury statistics

	1963	1964	1965	1966	1967
United States:					
Producing mines	48	72	149	130	122
Production ... flasks	19,117	14,142	19,582	22,008	23,784
Value ... thousands	$3,623	$4,452	$11,176	$9,722	$11,639
Exports ... flasks	187	188	7,543	357	2,627
Reexports ... do	40	196	494	476	475
Imports:					
For consumption ... do	42,872	41,153	16,238	31,364	24,348
General ... do	43,126	41,107	17,838	34,757	23,899
Stocks Dec. 31 ... do	12,181	17,362	20,386	20,076	18,243
Consumption ... do	77,963	81,354	73,560	71,509	69,517
Price: New York, average per flask	$189.45	$314.79	$570.75	$441.72	$489.36
World:					
Production ... flasks	239,652	254,973	267,713	264,959	242,042
Price: London, average per flask	$171.42	$282.25	$607.85	$447.68	$499.36

Legislation and Government Programs.—Through the Office of Mineral Exploration (OME) of the Geological Survey, the Federal Government offered financial aid to qualified applicants searching for mercury. The offering of 50 percent of total allowable exploration costs at eligible domestic mercury deposits, in effect since 1957, was raised in September to 75 percent.

The stockpile objectives for mercury, which had been changed during 1966 to 200,000 flasks for conventional war and 8,600 flasks for nuclear war, remained the same in 1967. As of September 30, 1967, there were 200,365 flasks in the stockpile. Total releases of surplus mercury by General Services Administration (GSA) during 1967 were 11,454 flasks, leaving a surplus of 22,935 flasks for disposal at yearend. This material came from stocks previously transferred by the Atomic Energy Commission (AEC) to GSA. In 1965 AEC had offered 38,000 flasks to GSA but withdrew the offer in 1966 and instead offered 20,000 surplus flasks.

DOMESTIC PRODUCTION

In response to higher average prices for mercury in 1967, compared with those of 1966, primary mercury production in the United States increased 8 percent

[1] Commodity specialist, Division of Mineral Studies.

[2] Flasks as used in this chapter refers to a 76-pound flask.

above that of 1966. In 1967 the ore processed averaged 4.1 pounds of mercury per ton. Of 122 operations, the 78 in California, where output rose slightly, produced nearly 70 percent of the Nation's mercury. Output from 25 operations in Nevada increased 40 percent and output from Oregon was 35 percent greater than in 1966. A major producer, the Bretz mine in Oregon, closed in September 1966 because of ore depletion.

The quantity of secondary mercury, produced from battery scrap, reclaimed dental amalgams, sludges, and other sources, increased. The secondary figures as shown include GSA releases.

Properties producing 1,000 flasks or more:

State:	*County*	*Mine*
California	San Luis Obispo	Buena Vista.
Do	Sonoma	Mt. Jackson.
Do	San Benito	New Idria.
Nevada	Humboldt	Cordero.

Properties producing 500 to 1,000 flasks:

State:	*County*	*Mine*
California	Lake	Helen.
Do	Napa	Knoxville.
Do	Santa Clara	New Almaden.
Idaho	Washington	Idaho-Almaden.
Nevada	Esmeralda	B&B.
Do	Pershing	Red Bird.
Oregon	Lane	Black Butte.

Properties producing 100 to 500 flasks:

State:	*County*	*Mine*
Alaska	Aniak	White Mountain.
Arizona	Maricopa	Pine Mountain.
Arkansas	Pike	Great Southwestern Mining.
California	Trinity	Altoona.
Do	Napa	Corona.
Do	Sonoma	Crystal.
Do	Marin	Gambonini.
Do	Santa Barbara	Gibraltar.
Do	Santa Clara	Guadalupe.
Do	Lake	Konocti.
Do	San Luis Obispo	La Libertad.
Do	Kings	Little King.
Do	Fresno	Mercy.
Do	Sonoma	Socrates.
Oregon	Lake	Glass Butte.
Texas	Brewster	Study Butte.
Do	Presidio	Fresno.

Table 2.—Mercury produced in the United States, by States

Year and State	Producing mines	Flasks	Value [1] (thousands)
1966:			
Arizona	7	363	$160
California	71	16,070	7,100
Idaho	2	1,134	501
Nevada	29	3,355	1,482
Oregon	8	700	309
Alaska, Arkansas, Texas	13	386	170
Total	130	22,008	9,722
1967:			
California	78	16,385	8,018
Idaho	2	898	439
Nevada	25	4,703	2,301
Oregon	6	943	461
Alaska, Arizona, Arkansas, Texas	11	855	420
Total	122	23,784	11,639

[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	Pounds per ton of ore
1963	113,539	19,101	12.8
1964	r 149,907	14,115	7.2
1965	r 339,124	r 19,353	4.3
1966	r 321,080	r 21,993	5.2
1967	439,753	23,767	4.1

[1] Excludes mercury produced from placer operations and from cleanup at furnaces and other plants.

Table 4.—Production of secondary mercury in the United States

Year:	*Flasks* [1]
1963	10,520
1964	24,519
1965	46,670
1966	16,400
1967	22,150

[1] Includes GSA releases.

CONSUMPTION AND USES

Consumption of mercury by industry in 1967 was nearly 3 percent less than that in 1966. The increased use of mercury at existing chlorine plants, for agricultural purposes, and for catalysts in making plastics did not compensate for declines in mercury usage in pharmaceuticals, in paints, and that destined for new or expanded chlorine and caustic soda facilities. The three leading uses, consuming 59 percent, were in the electrolytic preparation of chlorine and caustic soda, in electrical apparatus, and in "other uses." Much of the "other uses" category includes mercury used for expansion and installation of chlorine and caustic soda plants.

In the manufacture of chlorine and caustic soda, an advantage of using mercury cells is that they yield a higher purity product. For each ton of chlorine, only 0.4 pound of mercury is consumed. Consequently up to a certain undetermined price for mercury, cells using the metal are more economical, thereby giving the producers a price advantage over those using diaphragm cells. About 7.6 million tons of chlorine was produced in 1967 compared with 6.9 million in 1966. In 1967 26 of 74 domestic chlorine plants used mercury cells and about 25 percent of chlorine production came from mercury-cell plants. Four plants, one each in Kentucky, Maine, Texas, and Wisconsin, were built during 1966 and 1967. At the new Texas plant facilities already were being expanded 60 to 70 percent by mid-1968, and three other companies, with plants in Louisiana, New Jersey, and Tennessee, were building or planning expansions. By 1970 it was estimated that the chlorine production capacity would be about 9.8 million tons per year with about 9.1 million tons produced.

Most of the mercury consumed in electrical apparatus applications was used in mercury battery cells which provide a relatively large quantity of power in small volume. They were said to deliver three to six times the energy of zinc-carbon batteries of comparable size but cost about four times as much.

Table 5.—Mercury consumed in the United States by uses

(Flasks)

Use	1963	1964	1965	1966	1967
Agriculture (includes fungicides and bactericides for industrial purposes)	2,538	3,144	3,116	2,374	3,732
Amalgamation	306	r 308	r 268	r 248	219
Catalysts	612	656	924	1,932	2,489
Dental preparations [1]	2,346	2,612	1,619	r 1,334	1,359
Electrical apparatus [1]	11,115	10,690	13,931	r 13,339	13,823
Electrolytic preparation of chlorine and caustic soda	7,999	9,572	8,753	11,541	14,306
General laboratory use:					
Commercial	1,241	r 1,583	r 1,119	r 1,563	1,133
Government	3,821	r 15,746	------	------	------
Industrial and control instruments [1]	4,943	4,972	4,628	r 4,097	3,865
Paint:					
Antifouling	252	547	255	140	152
Mildew proofing	6,403	4,898	7,534	7,762	6,151
Paper and pulp manufacture	2,831	2,148	619	612	446
Pharmaceuticals	4,081	5,047	3,261	3,668	1,945
Redistilled [1]	9,227	r 11,697	r 12,131	r 7,267	7,334
Other [2]	20,248	7,734	15,402	15,632	12,563
Total	77,963	r 81,354	73,560	r 71,509	69,517

r Revised.

[1] A breakdown of the "redistilled" classification showed averages of 43 percent for instruments, 14 percent for dental preparations, 23 percent for electrical apparatus, and 20 percent for all other uses in 1963–66, compared with 49 percent for instruments, 14 percent for dental preparations, 22 percent for electrical apparatus, 11 percent for general laboratory and 4 percent for all other uses.

[2] Includes mercury used for installation and expansion of chlorine caustic soda plants and vermilion.

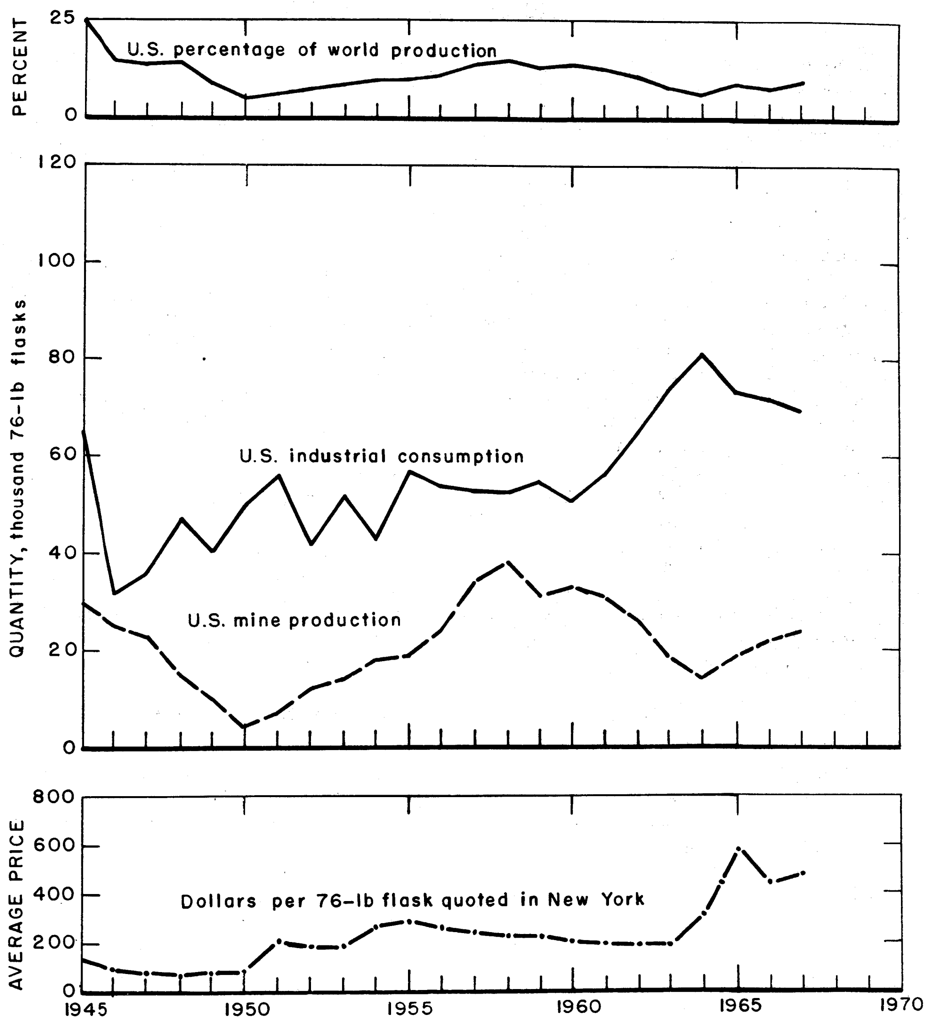

Figure 1.—Trends in production, consumption, and price of mercury.

Table 6.—Stocks of mercury, December 31

(Flasks)

Year	Producer	Consumer and dealer	Total
1963	1,581	10,600	12,181
1964	708	r 16,654	r 17,362
1965	1,432	18,954	r 20,386
1966	1,976	18,100	20,076
1967	723	17,520	18,243

r Revised.

Table 7.—Average monthly prices of mercury at New York and London

(Per flask)

Month	1966		1967	
	New York [1]	London [2]	New York [1]	London [2]
January	$509.29	$545.36	485.76	488.43
February	457.63	496.74	503.70	488.97
March	411.52	448.63	506.14	511.72
April	397.15	406.79	488.50	503.85
May	368.33	356.02	452.05	481.07
June	334.09	318.04	480.23	513.02
July	378.50	359.06	475.35	476.63
August	427.83	414.83	483.35	476.29
September	463.10	458.84	497.55	501.07
October	532.62	499.00	488.18	490.54
November	536.05	544.26	498.81	508.41
December	484.52	527.33	512.65	529.39
Average	441.72	447.68	489.36	499.36

[1] Engineering and Mining Journal, New York.
[2] Mining Journal (London) 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

Exports, considerably above those of 1966, were still only about one-third those of 1965. Although shipments were made to 41 countries, the principal recipients were India and Japan with 87 percent of the total. Sales to India were under an Agency for International Development program.

Imports of mercury metal into the United States decreased significantly from those of 1966 but were still about 50 percent greater than those of 1965. Compared with the previous year, mercury imports from Spain in 1967 showed the only considerable increase while those from Italy and Mexico dropped sharply. In 1967 U.S. imports for consumption from Spain were 27 percent of Spanish production compared with 9 percent in 1966 and 15 percent in 1965.

Table 8.—U.S. exports and reexports of mercury

Year	Exports		Reexports	
	Flasks	Value (thousands)	Flasks	Value (thousands)
1965	7,543	$5,031	494	$316
1966	357	197	476	280
1967	2,627	1,281	475	193

As a result of concessions granted by the United States at the sixth round of trade negotiations under the General Agreement on Tariffs and Trade (GATT) —the Kennedy negotiations completed at midyear—the rate on imported mercury was reduced to 22 cents per pound or $16.72 per 76-pound flask, effective January 1, 1968.

Table 9.—U.S. imports for consumption [1] of mercury, by countries

Country	1965		1966		1967	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
Bolivia	50	$18	------	------	40	$18
Canada	32	13	349	$74	391	97
France	------	------	------	------	250	80
Germany, West	150	80	------	------	------	------
Italy	1,203	334	13,942	5,554	4,091	1,831
Japan	------	------	50	26	------	------
Mexico	1,290	544	6,030	2,212	1,234	533
Netherlands	------	------	------	------	200	84
Peru	1,368	318	451	149	1,037	427
Philippines	------	------	1,150	519	550	238
Spain	10,995	5,811	6,115	2,524	13,470	5,837
Turkey	46	21	------	------	------	------
United Kingdom	3	1	(2)	(2)	------	------
Yugoslavia	1,101	474	3,277	1,264	3,085	1,590
Total	16,238	7,614	31,364	12,322	24,348	10,735

[1] Data include mercury imported for immediate consumption plus material withdrawn from bonded warehouses.
[2] Less than ½ unit.

Table 10.—U.S. imports [1] of mercury, by countries

(Flasks)

Country	1965	1966	1967
Bolivia	50	--------	40
Canada	32	r 349	391
France	--------	--------	250
Germany, West	150	--------	--------
Italy	1,297	14,485	5,117
Japan	--------	50	--------
Mexico	1,825	7,049	1,260
Netherlands	--------	--------	200
Peru	1,899	741	1,037
Philippines	--------	1,150	550
Spain	10,996	7,656	11,969
Turkey	135	--------	--------
United Kingdom	3	(2)	--------
Yugoslavia	1,451	3,277	3,085
Total	17,838	r 34,757	23,899

r Revised.
[1] Data are "general" imports; that is, they include mercury imported for immediate consumption plus material entering the country under bond.
[2] Less than ½ unit.

WORLD REVIEW

Canada.—Canada has had no significant mercury production in recent years, but Consolidated Mining & Smelting Co. of Canada Ltd. (COMINCO) expected to reactivate its Pinchi Lake, British Columbia, mercury property by January 1969. The mine, near Fort St. James, operated during the war years from June 1940 until July 1944 and produced almost 53,000 flasks of mercury. New installations will include an 800-ton-per-day concentrator and a mercury-recovery plant; capacity was expected to be over 20,000 flasks per year, or somewhat greater than current U.S. production.

Near Gold Bridge, British Columbia, in the Lillooet area, Silverquick Development Co. (B.C.) Ltd. drove a tunnel beneath a surface-exposed ore body, performed diamond drilling, and planned to construct a beneficiation plant and retort.

Two mercury-cell chlorine plants, one at Fort William, Ontario, and the other at Lebel-sur-Quevillon, Quebec, went on-

Table 11.—World production of mercury, by countries [1]

(Flasks)

Country	1963	1964	1965	1966	1967 p
Bolivia (exports)	105	[2] 32	52	4	100
Canada	-------	73	20	-------	-------
Chile	613	267	428	r 96	184
China, mainland e	26,000	26,000	26,000	26,000	20,000
Colombia	3	3	46	r 84	e 100
Czechoslovakia e	725	r 775	r 825	r 875	900
Italy	54,448	57,001	57,320	53,549	48,066
Japan	4,668	4,812	4,536	4,846	4,612
Mexico	r 17,202	r 12,561	r 19,203	r 22,074	23,874
Peru	3,092	3,275	3,117	r 3,166	2,980
Philippines	2,651	2,496	2,384	r 2,443	2,612
Rumania	194	194	191	r 190	190
Spain	56,954	78,322	r 74,661	r 70,054	e 50,000
Tunisia	-------	r 87	174	254	e 250
Turkey	3,042	2,615	2,755	r 3,420	e 3,500
United States	19,117	14,142	19,582	22,008	23,784
U.S.S.R. e	35,000	35,000	40,000	40,000	45,000
Yugoslavia	15,838	17,318	16,419	15,896	15,890
Total [3]	239,652	254,973	267,713	264,959	242,042

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Compiled mostly from data available April 1968.
[2] Purchases by Banco Minero.
[3] Total of listed figures only; no undisclosed data included.

stream. Another plant of this type was being constructed at Saskatoon, Saskatchewan.

Italy.—In the Monte Amiata area, which accounts for two-thirds of the Italian output of mercury, extensive exploration programs for new deposits of cinnabar (mercury sulfide) were underway. During 1966, additional reserves had been discovered in the Abbadia area and promising deposits in a mining area near Tolfa in Rome province. Societa Mercurifera Italiana of Grosseto, a subsidiary of Montecatini-Edison, planned to acquire Societa Mineraria Rimbotti S.p.A., a mercury mining and distilling company near Monte Amiata.

Table 12.—Italy: Exports of mercury by countries

(Flasks)

Destination	1966	1967
Australia	206	------
Bulgaria	249	------
Czechoslovakia	200	------
France	1,769	1,300
Germany:		
East	2,425	2,501
West	5,581	3,701
India	447	3,124
Israel	215	------
Japan	4,778	5,834
Netherlands	554	------
Poland	1,009	------
Rumania	499	------
Sweden	360	------
United Kingdom	9,886	8,789
United States	16,561	8,789
Other countries	r 688	2,889
Total	45,427	36,927

r Revised.

Mexico.—Mexican mercury production in 1967 was reported as 23,874 flasks, about 8 percent more than the revised figure of 22,074 flasks produced in 1966. Earlier discrepancies between excesses of exports over production, reported in 1963–65, were believed due to legitimate exporters shipping out mercury bought from *gambusinos* (prospectors) who did not report output from their small deposits, thereby avoiding high production taxes and Governmental regulations.

The Government planned to reduce production and export taxes, which totaled over $75 per flask in 1967, by 50 percent. This factor, instituted in the 1968 Federal budget, and an agreement between the Government of Mexico and the exporters to identify the individual sellers, were expected to lead to a cessation of smuggling and the reporting of more reliable production data.

Philippines.—Philippine mercury production was expected to be increased to 3,300 flasks annually with the installation of a fourth furnace at Palawan Quicksilver Mines, Inc. Reserves here were calculated at over 900,000 tons of ore averaging 2.61 pounds of mercury per ton or about 31,000 flasks, enough for over 9 years' production at current capacity. Beneficiation methods, for large additional resources of lower grade ore, were evaluated.

Spain. — Production dropped significantly at the Almaden mine, the largest mercury deposit and producer in the world. A comprehensive article described the geology, petrology, morphology of the mineralized body, the plant, types of extractive equipment, and number of personnel employed. Compared with other mercury ores which are generally about 1 percent, Almaden ore usually runs about 5 percent mercury. The mine was believed to have reserves for 100 years. Exploration was conducted on three mineralized veins to below 450 meters depth.[3] It was believed that cinnabar was emplaced before the quartz grains of the enclosing quartzite were silicified. This supposedly suggests a genetic relationship between mercury mineralization and the Gothlandic volcanism of upper Silurian time.[4]

Table 13.—Spain and Yugoslavia: Exports of mercury, by countries [1]

(Flasks)

Destination	Exporting countries			
	Spain		Yugoslavia	
	1965	1966	1965	1966
Australia	369	1,092	--------	--------
Austria	1,078	145	211	53
Belgium-Luxembourg	1,895	529	160	--------
Canada	3,208	1,551	145	--------
Czechoslovakia	300	2,927	290	--------
France	6,854	2,328	--------	--------
Germany:				
East	1,401	1,201	--------	--------
West	3,603	11,822	290	2,375
Hungary	200	1,339	--------	--------
India	3,046	233	--------	348
Italy	--------	--------	211	--------
Japan	12,295	5,153	--------	--------
Netherlands	4,766	2,527	71	72
Poland	280	1,426	1,160	--------
Portugal	239	737	--------	--------
South Africa, Republic of	50	2,806	--------	--------
Sweden	701	1,431	350	142
Switzerland	248	565	2,161	--------
United Kingdom	9,849	6,675	300	2,301
United States	14,372	7,856	5,251	6,115
U.S.S.R.	--------	--------	3,191	2,900
Other countries	r 27	286	12	10
Total	64,781	52,629	13,803	14,316

r Revised.
[1] This table incorporates some revisions.

Turkey.—In Sizma near Konya, a rotating kiln, of 175-ton-per-day ore capacity, was being installed to treat ores averaging 0.5 percent mercury (about 10 pounds per ton). When completed this will add 750 flasks to the annual production capacity.

Yugoslavia.—The Suplja Stena area, near Belgrade, was the site of a new mercury development. The ore is derived from the local Avala deposits. Over a period of 4 years, production was expected to average 150 tons (nearly 4,000 flasks) annually, before the ore grade dwindles below an economic level. After that time, other deposits in areas such as Ripanj, Topla, Cer, Cevljanovic, Mali Zvornik, and Bosanski Novi would be available for mining and processing.

[3] Zucchetti, Stefano. Osservazioni sul giacimento mercurifero di Almadén in Spagna (Observations on the Almaden Mercury Deposit, Spain). L'Industria Mineraria, Ser. II, v. 17, No. 12, December 1966, pp. 529–537 (in Italian).

[4] Saupe, Francis. Note préliminaire concernant la genése du gisement de mercure d'Almadén (Preliminary Note Concerning the Genesis of the Almaden Mercury Deposit). Mineralium Deposita (Berlin), v. 2, No. 1, June 1967, pp. 26–33.

TECHNOLOGY

Efforts to discover new mercury deposits in difficult terrain are being facilitated substantially by improved methods of geochemical prospecting. In one technique using a mercury vapor detector, a small sample of crushed rock is heated to about 500 ° C, thereby driving off mercury vapor and other volatile materials. Any contaminants pass through a thermoamalgamator but the mercury vapor amalgamates with silver. It is subsequently released from the amalgam into an absorption chamber where it is measured quantitatively. In a 1-minute analytical period, the device can detect as low as one part per billion mercury in a 1-gram sample.[5] In another instance, a mercury-vapor meter was used to investigate primary and secondary dispersion from cinnabar and stibnite deposits in Turkey.[6] Using geochemical methods, researchers stated that mercury mineralization could be expected in the vicinity of certain plants, the ashes of which contain more than 10 parts per million mercury.[7]

The mercury consumption pattern in the chlorine and caustic soda industry could be affected by technological innovations in equipment. Improvements in mercury-cell construction have led to high cell performance. In cases where rayon-grade NaOH is produced along with chlorine in electrolytic chlor-caustic plants, capital costs for mercury-cell plants were said not to differ much from plants using diaphragms. In the last 2 years mercury inventory for cells of specified capacity has dropped nearly 40 percent. Characteristics, including mercury inventory ratings and cell voltages, of 14 mercury cells used by the industry were described. Cells have been developed up to 330,000 amperes capacity. This was believed to be the maximum size of cell which would receive commercial acceptance in any new plants of present-day size.[8]

Two new cells were designed to ensure the more rapid flow of mercury in processing and the lowering of mercury requirements. One makes mercury flow evenly and thinly by centrifugal force from the center of a horizontal rotating cathode disk toward the circumference.[9] In the second cell, the design of the cell body is such that the mercury can electrolyze on both directions of flow. In addition, a steeply inclined bottom plate accelerates the mercury flow rate.[10]

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[5] Vaughn, W. W. A Simple Mercury Vapor Detector for Geochemical Prospecting. Geol. Survey Circ. 540, 1967, 8 pp.

[6] Koksoy, M., P. M. D. Bradshaw, and J. S. Tooms. Determination of Mercury in Geological Samples. Trans. Inst. Min. and Met. (London), v. 76, No. 726, sec. B, May 1967, pp B121–B124.

[7] Warren, Harry V., Robert E. Delavault, and John Barakso. Some Observations on the Geochemistry of Mercury as Applied to Prospecting. Econ. Geol., v. 61, No. 6, September–October 1966, pp. 1010–1028.

[8] Sommers, Howard A. The Design of Large Mercury Cells. Electrochem. Technol., v. 5, Nos. 3–4, March–April 1967, pp. 108–124.

[9] Murozumi, Masahiko. A New Type of Mercury Chlorine Cell (Asahi Horizontal Rotating Cathode Cell). Electrochem. Technol., v. 5, Nos. 5–6, May–June 1967, pp. 236–238.

[10] Shibata, Hiroshi, and Yasuo Yamazaki. The Flow of Mercury in the Kureha HD-Type Cell. Electrochem. Technol., v. 5, Nos. 5–6, May–June, 1967, pp. 239-241.

Mica

By Benjamin Petkof [1]

The sale or use of domestically produced sheet mica has remained greatly below the output recorded in the years prior to 1966. No great significance can be attached to the increased production recorded in 1967. Scrap and flake mica production increased almost 5 percent over that of the previous year. Almost all classes of mica imports showed significant decreases in quantity. Total exports of all classes of mica increased.

Table 1.—Salient mica statistics

	1963	1964	1965	1966	1967
United States:					
Sold or used by producers:					
Sheet mica________thousand pounds__	103	243	716	4	20
Value________________thousands__	$13	$58	$185	$1	W
Scrap and flake mica thousand short tons__	109	115	120	113	119
Value________________thousands__	$2,776	$3,353	$3,468	$3,732	$2,876
Ground mica___thousand short tons__	117	116	127	103	97
Value________________thousands__	$6,805	$6,902	$7,615	$6,247	$5,756
Consumption, block and film thousand pounds__	2,293	2,618	2,659	2,813	1,972
Value____________________thousands__	$2,782	$3,002	$3,188	$3,642	$2,757
Consumption, splittings thousand pounds__	6,687	7,608	8,260	7,100	6,188
Value____________________thousands__	$2,588	$3,149	$3,701	$3,221	$2,759
Exports____________thousand short tons__	4	5	4	6	7
Imports for consumption__________do_____	13	8	9	7	8
World: Production__________thousand pounds__	315,907	322,995	345,759	319,943	NA

NA Not Available. W Withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Sheet Mica.—Only a small quantity of uncut mica larger than punch and circle was produced during 1967. North Carolina and New Hampshire were the only producing States.

Scrap and Flake Mica.—The output of scrap and flake mica increased in quantity but declined 23 percent in value. North Carolina was the major producing State supplying 59 percent of domestic production. Nine States produced the remaining mica.

Ground Mica.—Sales of ground mica fell below 100,000 short tons for the first time since 1961. A decline of 6 percent in quantity and 8 percent in value was observed. Dry ground mica accounted for 85 percent of total production. Reports were received from 20 grinders operating 17 dry and three wet grinding plants in 11 States.

[1] Commodity specialist, Division of Mineral Studies.

Table 2.—Mica sold or used by producers in the United States

Year and State	Sheet mica: Uncut punch and circle mica: Pounds	Value	Uncut mica larger than punch and circle: Pounds	Value	Total sheet mica: Pounds	Value	Scrap and flake mica [1]: Short tons	Value
1963	97,828	$9,206	5,133	$3,698	102,961	$12,904	109,323	$2,776,381
1964	220,586	37,693	22,076	20,788	242,662	58,481	114,729	3,352,572
1965	670,506	139,844	45,580	45,142	716,086	184,986	120,255	3,467,701
1966	4,500	905	------	------	4,500	905	113,133	3,732,242
1967:								
Georgia	------	-------	------	------	-------	-------	17,158	290,738
New Hampshire	------	-------	16,000	W	16,000	W	-------	-------
North Carolina	------	-------	4,500	W	4,500	W	69,639	1,750,939
Other	------	-------	------	------	-------	-------	[2] 31,706	834,472
Total	------	-------	20,500	W	20,500	W	118,503	2,876,149

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, California, Colorado, Connecticut, New Mexico, Pennsylvania, South Carolina, and South Dakota.

Table 3.—Ground mica sold by producers in the United States by methods of grinding [1]

Year	Dry-ground: Short tons	Value (thousands)	Wet-ground: Short tons	Value (thousands)	Total: Short tons	Value (thousands)
1963	101,943	$4,596	15,308	$2,209	117,251	$6,805
1964	99,245	4,397	16,725	2,505	115,970	6,902
1965	110,600	5,316	15,997	2,299	126,597	7,615
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

[1] Domestic and some imported scrap.

CONSUMPTION AND USES

Sheet Mica.—The consumption of sheet mica consisting of block, film, and splittings, reached 8.2 million pounds, a decrease of 17 percent from 1966 consumption.

About 1.9 million pounds of muscovite block and film was consumed by industry for end uses. About 71 percent was consumed by electronic and electrical uses; the manufacture of vacuum tubes alone requiring 56 percent of the total consumption of mica block and film. Of the material consumed 3 percent was classified as Good Stained or better, 45 percent Stained, and 52 percent lower than Stained. Muscovite block and film was used during the year by 16 companies in nine States. New Jersey had 4 consuming plants during the year; North Carolina 3; New York 3; Massachusetts 1 and Pennsylvania 1. These States consumed 76 percent of the domestically fabricated block and film mica. The consumption of phlogopite block increased 48 percent.

Total consumption of mica splittings decreased 13 percent from that of 1966. India and the Malagasy Republic supplied the bulk of the splittings. Splittings were fabricated by 12 companies in nine States. Six plants, two in New York, two in Pennsylvania, and one each in New Hampshire and Massachusetts, consumed 4.7 million pounds of splittings, or about 80 percent of the total.

Built-Up Mica.—Fabricators prepared this variety of manufactured mica in various forms primarily for use as an electrical insulating material. Tape was the form in greatest demand (33 percent) followed closely by segment plate (27 percent) and molding plate (19 percent). Consumption of built-up mica decreased slightly from the quantity used in 1966.

Reconstituted Mica.—General Electric Co. at Schenectady, N.Y., and Samica Corp. (subsidiary of Minnesota Mining & Manufacturing Co.) at Rutland, Vt., continued to fabricate this material from specially delaminated mica scrap by papermaking techniques. This sheet material continued to displace built-up mica in various applications.

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 1967

(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	940	10,344	2,155	13,439	5,641	46	5,687	19,126
Stained	47,783	774,072	6,822	828,677	2,119	5,584	7,703	836,380
Lower than Stained [1]	154,236	264,328	31,266	449,830	19,874	509,156	529,030	978,860
Total	202,959	1,048,744	40,243	1,291,946	27,634	514,786	542,420	1,834,366
Film:								
First quality	6,788	--------	------	6,788	------	-------	-------	6,788
Second quality	37,453	--------	------	37,453	------	-------	-------	37,453
Other quality	3,050	--------	------	3,050	------	-------	-------	3,050
Total	47,291	--------	------	47,291	------	-------	-------	47,291
Block and film:								
Good Stained or better [2]	45,181	10,344	2,155	57,680	5,641	46	5,687	63,367
Stained [3]	50,833	774,072	6,822	831,727	2,119	5,584	7,703	839,430
Lower than Stained	154,236	264,328	31,266	449,830	19,874	509,156	529,030	978,860
Total	250,250	1,048,744	40,243	1,339,237	27,634	514,786	542,420	1,881,657
Phlogopite: Block (all qualities)	------	--------	4,400	4,400	------	85,759	85,759	90,159

[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 1967 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	3,773	1,491	575	3,463	-------	9,302
Stained	18,214	42,511	103,931	594,685	47,711	807,052
Lower than Stained	92,856	125,192	51,627	356,874	336,561	963,110
Total	114,843	169,194	156,133	955,022	384,272	1,779,464
Nonruby:						
Good Stained or better	2,563	180	4,181	2,900	-------	9,824
Stained	506	1,638	4,410	22,774	-------	29,328
Lower than Stained	8,600	650	900	4,000	1,600	15,750
Total	11,669	2,468	9,491	29,674	1,600	54,902
Film:						
Ruby:						
First quality	1,188	650	850	1,400	-------	4,088
Second quality	17,431	10,082	5,190	3,100	-------	35,803
Other quality	------	-------	-------	-------	3,050	3,050
Total	18,619	10,732	6,040	4,500	3,050	42,941
Nonruby:						
First quality	------	-------	1,500	1,200	-------	2,700
Second quality	-------	-------	1,650	-------	-------	1,650
Other quality	------	-------	-------	-------	-------	---------
Total	------	-------	3,150	1,200	-------	4,350

[1] Figures for block mica include all smaller than No. 6 grade and "punch" mica.

Table 6.—Consumption and stocks of mica splittings in the United States, by sources

(Thousand pounds and thousand dollars)

	Indian		Malagasy		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
Consumption:						
1963	6,406	$2,413	281	$175	6,687	$2,588
1964	7,261	2,949	347	200	7,608	3,149
1965	7,948	3,513	312	188	8,260	3,701
1966	6,749	3,005	351	216	7,100	3,221
1967	5,857	2,566	331	193	6,188	2,759
Stocks Dec. 31:						
1963	2,908	NA	172	NA	3,080	NA
1964	3,523	NA	245	NA	3,768	NA
1965	3,912	NA	210	NA	4,122	NA
1966	3,669	NA	206	NA	3,875	NA
1967	2,737	NA	159	NA	2,896	NA

NA Not available.

Table 7.—Built-up mica [1] sold or used in the United States, by products

(Thousand pounds and thousand dollars)

Product	1966 Quantity	1966 Value	1967 Quantity	1967 Value
Molding plate	1,144	$3,315	994	$2,940
Segment plate	1,607	3,518	1,442	3,039
Heater plate	444	1,273	332	1,002
Flexible (cold)	814	1,961	594	1,270
Tape	1,384	5,063	1,740	6,032
Other	187	601	234	716
Total	5,580	15,731	5,336	14,999

[1] Consists of alternate layers of binder and irregularly arranged and partly overlapped splittings.

Table 8.—Ground mica sold by producers in the United States, by uses

Use	1966 Short tons	1966 Value (thousands)	1967 Short tons	1967 Value (thousands)
Roofing	26,211	$887	27,161	$920
Wallpaper	W	W	W	W
Rubber	7,356	770	6,196	676
Paint	17,192	1,558	22,374	1,976
Plastics	927	128	903	126
Welding rods	799	39	525	25
Joint cement	24,860	1,604	17,063	945
Other uses [1]	26,105	1,261	22,831	1,089
Total [2]	103,450	6,247	97,053	5,756

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.

PRICES

Prices offered by mica fabricators for domestic clear sheet mica (roughly trimmed) as reported in Metals Week ranged from 7 to 12 cents per pound for the smallest size (punch) to $4 to $8 per pound for 6- by 8-inch sheets. Stained or electric mica was quoted 10 to 20 percent lower.

North Carolina scrap mica was quoted in Metal Week at $30 to $40 per short ton, depending on quality.

Prices listed for dry and wet ground mica changed in June 1966, the first change since June 1956.

Table 9.—Price of dry- or wet-ground mica in the United States in 1966 [1]

	Cents per pound
Dry-ground:	
Paint, 100 mesh	3¾
Plastic, 100 mesh	3¾
Roofing, 20 to 80 mesh	2–3
Wet-ground: [2]	
Biotite	7
Biotite, less than carlots [3]	8
Paint or lacquer, 325 mesh	8
Paint or lacquer, 325 mesh, less than carlots [3]	9
Rubber	8
Rubber, less than carlots [3]	9
Wallpaper	9

[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.

FOREIGN TRADE

Total exports of all classes of mica increased 31 percent in quantity over those of 1966, but decreased slightly in value. Exports consisted primarily of ground mica.

Almost all classes of mica imports for consumption showed a decline from the quantities imported in 1966. Total imports decreased 39 percent in quantity and 50 percent in value.

Table 10.—U.S. exports of mica and manufactures of mica, 1967 by countries

Destination	Mica, including sheet, waste and scrap and ground		Manufactured	
	Pounds	Value (thousands)	Pounds	Value (thousands)
Argentina	10,600	$1	11,319	$24
Australia	53,150	5	9,545	31
Belgium-Luxembourg	322,100	25	1,285	11
Brazil	----------	------	21,079	66
Canada	2,176,533	213	233,562	872
Chile	----------	------	6,217	11
Colombia	372,173	40	816	6
Ecuador	95,950	7	----------	------
Finland	----------	------	19,365	20
France	499,401	30	10,583	21
Germany, West	149,848	22	9,672	19
Iceland	8,800	1	----------	------
India	----------	------	2,416	25
Iran	291,400	24	----------	------
Israel	10,000	1	90	1
Italy	160,000	6	13,217	78
Jamaica	15,853	2	15,721	22
Japan	2,537,512	74	2,731	13
Libya	881,800	25	88	1
Mexico	381,342	26	32,368	130
Morocco	12,884	1	----------	------
Netherlands	208,750	10	1,406	13
New Zealand	8,000	(1)	1,216	15
Nigeria	122,000	8	----------	------
Panama	28,312	1	198	2
Peru	313,950	21	6,907	12
Philippines	84,956	9	468	6
South Africa, Republic of	59,861	3	22,321	66
Spain	44,000	1	11,223	31
Sweden	19,800	2	34,622	42
Switzerland	24,727	12	364	1
Taiwan	12,710	13	27,805	71
Trinidad and Tobago	104,539	10	12	(1)
Turkey	22,000	1	616	4
United Kingdom	3,757,402	102	5,259	37
Venezuela	1,346,047	68	9,043	42
Other countries	165,124	17	15,156	60
Total	14,301,524	781	526,690	1,753

[1] Less than ½ unit.

Table 11.—U.S. exports and imports of mica

(Thousand pounds and thousand dollars)

Year	Imports for consumption						Exports	
	Uncut sheet and punch		Scrap		Manufactured		All classes	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1965	2,116	$2,142	3,043	$71	9,942	r $6,371	8,326	$2,223
1966	3,247	3,993	2,642	71	7,535	6,670	11,348	2,541
1967	1,733	1,990	1,016	25	5,440	3,373	14,829	2,534

r Revised.

Table 12.—U.S. imports for consumption of mica by kinds and countries

Year and country	Unmanufactured[1]: Waste and scrap: Phlogopite: Pounds	Value (thousands)	Waste and scrap: Other: Pounds	Value (thousands)	Block mica: Pounds	Value (thousands)	Other: Muscovite: Pounds	Value (thousands)	Other: Other, n.e.c.: Pounds	Value (thousands)
1965	330,866	$11	2,712,489	$60	1,657,687	$1,527	405,075	$613	195,308	$234
1966	346,029	16	2,296,319	55	2,520,113	2,853	335,721	437	391,427	703
1967:										
Afghanistan							130	3		
Argentina					16,093	16	34,722	5	28,881	5
Brazil			665,355	16	791,000	930	173,992	177	80,395	60
Canada	63,920	1								
Germany, West							44,092	2		
India			216,051	6	312,469	350	29,983	67	10,863	141
Malagasy, Republic									58,722	75
Mexico			14,771	(2)						
Rhodesia							998	2		
South Africa, Republic of	56,000	1					4,782	2	101,100	20
Sweden					12,800	14				
Tanzania					8,674	7	22,881	106	140	3
United Kingdom					2	3	442	(2)	220	1
Total	119,920	2	896,177	22	1,141,038	1,320	312,022	364	280,321	305

Year and country	Manufactured: Splittings: Pounds	Value (thousands)	Not cut or stamped not over 0.006 inch in thickness: Pounds	Value (thousands)	Cut or stamped: Not over 0.006 inch in thickness: Pounds	Value (thousands)	Cut or stamped: Over 0.006 inch in thickness: Pounds	Value (thousands)
1965	9,460,061	3,493	209,058	666	89,209	1,788	77,924	214
1966	6,797,895	2,694	291,461	832	139,823	2,687	92,073	255
1967:								
Argentina			192	1				
Austria							113	3
Brazil	12,507	16	31,889	49	2,839	12	6,951	19
France					185	5	29	2
India	4,633,045	1,534	77,350	245	54,883	850	33,197	64
Italy					75	1		
Japan					709	23		

Table 12.—U.S. imports for consumption of mica by kinds and countries—Continued

Year and country	Manufactured—Continued							
	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)
Windward and Leeward Islands	-----	-----	57	(2)	1,165	3	-----	-----
Malagasy, Republic	233,665	148	-----	-----	-----	-----	-----	-----
Mexico	-----	-----	-----	-----	3,395	98	2,895	20
Mozambique	-----	-----	-----	-----	-----	-----	5,530	4
Netherlands	-----	-----	-----	-----	-----	-----	469	18
Rhodesia	-----	-----	-----	-----	-----	-----	43,034	28
South Africa, Republic of	4,299	2	-----	-----	-----	-----	-----	-----
Spain	-----	-----	-----	-----	-----	-----	165	1
Sweden	-----	-----	400	3	400	2	-----	-----
Tanzania	-----	-----	1,968	2	-----	-----	-----	-----
Trinidad and Tobago	-----	-----	-----	-----	96	(2)	-----	-----
United Kingdom	992	(2)	-----	-----	2,746	55	372	8
Total	4,884,508	1,700	111,856	300	66,493	1,049	92,755	167

Year and country	Mica plates and built-up mica		Ground or pulverized		Articles not specially provided for of mica	
	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
1965	10,502	13	86,566	8	7,835	189
1966	53,205	87	148,246	11	13,359	104
1967:						
Belgium-Luxembourg	23,958	21	-----	-----	-----	-----
Brazil	-----	-----	123	(2)	-----	-----
Canada	4,903	14	-----	-----	9,973	26
France	-----	-----	194,005	18	564	21
Germany, West	9,049	13	-----	-----	-----	-----
India	-----	-----	-----	-----	251	1
Japan	4,002	4	373	1	-----	-----
Netherlands	-----	-----	-----	-----	27	2
Rhodesia	-----	-----	-----	-----	1,870	1
South Africa, Republic of	-----	-----	32,000	2	-----	-----
Taiwan	-----	-----	-----	-----	82	3
United Kingdom	260	5	-----	-----	2,418	25
Total	42,172	57	226,501	21	15,185	79

[1] In addition to classes shown, 1,500 pounds ($348) of untrimmed phlogopite from which no piece over 2 by 1 inch may be cut was imported from Canada.
[2] Less than ½ unit.

WORLD REVIEW

India.—Total exports of all varieties of mica declined from 73 million pounds in 1966 to 46 million pounds in 1967. This may possibly reflect the world's increasing technological independence of this material.

During 1965–66 mica was produced in 700 mines in six Indian States. However, major production originated from Bihar, Rajasthan, and Andhra Pradesh. India also consumed mica domestically for the production of items such as micanite from waste mica, and sheet mica for electronic and electrical items.[2]

Table 14.—World production of mica by countries [1] [2]

(Thousand pounds)

Country	1963	1964	1965	1966	1967 [p]
North America:					
Canada (shipments):					
Block	16	89	13	[r] 4	NA
Ground	814	616	298	[r] 340	NA
Scrap	353	494	236	[r] 201	NA
Mexico	[r] 578	[r] 670	[r] 1,204	873	NA
United States (sold or used by producers):					
Sheet	103	243	716	[r] 4	20
Scrap	218,646	229,458	240,510	226,263	118,503
South America:					
Argentina:					
Sheet	196	315	231	[e] [r] 990	NA
Waste and splittings	--------	1,173	260	[e] 260	NA
Brazil	3,289	3,241	3,089	[r] 2,244	NA
Guatemala	--------	----------	22	37	--------
Europe:					
France	381	646	430	[e] 440	NA
Germany, West	11	18	26	[e] 25	NA
Norway, including scrap	[e] 6,610	8,818	6,614	[e] 6,610	NA
Sweden (ground)	44	46	----------	----------	NA
Yugoslavia	77	26	119	[e] [r] 120	[e] 120
Africa:					
Malagasy Republic (phlogopite):					
Block	214	205	201	141	119
Splittings	1,914	1,299	1,186	1,440	1,074
Mozambique, including scrap	--------	----------	22	NA	NA
Rhodesia, Southern:					
Block	60	75	64	NA	NA
Crude	225	157	181	NA	NA
South Africa, Republic of:					
Sheet	40	104	2	1	(3)
Scrap	4,680	6,764	5,000	[r] 4,927	10,181
South-West Africa, Territory of	1,197	831	260	55	NA
Tanzania (exports):					
Sheet	236	211	227	194	201
Scrap	--------	324	370	880	278
Zambia, sheet	--------	4	9	NA	--------
Asia:					
India (exports):					
Block	3,979	4,264	3,179	3,662	3,543
Splittings	15,595	19,378	20,781	14,138	12,185
Scrap [4]	55,547	42,256	58,781	54,901	30,951
Oceania: Australia: Damourite	1,102	1,270	[r] 1,728	[r] 1,193	NA
Total [5]	[r] 315,907	[r] 322,995	[r] 345,759	[r] 319,943	NA

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] Mica is also produced in China (mainland), Rumania, and U.S.S.R., but data on production are not available.
[2] Compiled mostly from data available May 1968.
[3] Less than ½ unit.
[4] Includes condenser film as follows: 1963, 234,000 pounds; 1964, 198,000 pounds; 1965, 176,000 pounds; 1966, 212,000 pounds; 1967, 203,000 pounds.
[5] Total is of listed figures only; no undisclosed data included.

Rhodesia, Southern.—Commercial mica deposits are almost completely confined to the Urungwe and Darwin districts in the northern part of the country. Mica is found on the margins of pegmatite dikes along with other associated minerals. Mica is mined in open pits and some deposits have been followed underground for a few hundred feet.[3]

[2] Bureau of Mines. Mineral Trade Notes. v. 65, No. 4, April 1968, pp. 25–29.
[3] U.S. Consul, Salisbury, Southern Rhodesia. State Department Airgram A-211, Apr. 26, 1968, p. 2.

Tanzania.—Production of sheet mica decreased 16 percent in 1966 compared with that of 1965. Waste mica, however, increased 137 percent in both production and exports.[4] Mica production decreased during 1967 because of a long rainy season and the need for farming to take precedence over mining in some localities.[5]

TECHNOLOGY

A short paper was published discussing the use and manufacture of wet-ground mica.[6]

The various micas found in the pegmatites of Gunnison County, Colo., were described. A chemical and paragenitic study of these micas was described and their origin discussed.[7]

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[4] Bureau of Mines. Mineral Trade Notes. v. 65, No. 1, January 1968, p. 22–23.

[5] Skillings' Mining Review. Tanzania's Mineral Industry. v. 56, No. 37, Sept. 16, 1967, p. 19.

[6] Clarkson, Elizabeth. The Wet Ground Mica Industry. Am. Paint J. v. 51, No. 38, Mar. 13, 1967, pp. 100, 102.

[7] Heinrich, William E. Micas of the Brown Derby Pegmatites, Gunnison County, Colorado. Am. Miner. v. 52, Nos. 7 & 8, July–August 1967, pp. 1110–1121.

Molybdenum

By John L. Morning [1]

The molybdenum short supply situation of the past few years reversed itself to one of over supply in 1967, despite reduced output of byproduct molybdenum from the copper industry, caused by labor problems. A high production level and reduced demand helped to increase the industrial inventory to 27 million pounds. Free world production capacity continued to increase with the startup of two new molybdenum mines and concentrators, the installation of molybdenum recovery systems by several copper producers, and expansion of facilities by other producers. Substantial increased production capacity in the next 3 to 5 years is expected from domestic, Chilean, and Canadian mines that will recover molybdenum as a byproduct from copper operations.

Table 1.—Salient molybdenum statistics

(Thousand pounds of contained molybdenum and thousand dollars)

	1963	1964	1965	1966	1967
United States:					
Concentrate:					
Production	65,011	65,605	77,372	90,532	88,930
Shipments	65,839	65,097	77,310	91,670	81,596
Value	$91,096	$97,121	$120,801	$144,327	$133,604
Consumption	49,241	56,409	68,112	75,476	58,967
Imports for consumption	-------	-------	142	5	1,179
Stocks, Dec. 31: Mine and plant	2,436	4,303	4,208	3,433	9,919
Primary products:					
Production	48,756	55,946	66,616	74,392	54,922
Shipments	49,599	60,403	71,718	78,811	57,231
Consumption	37,478	43,119	48,621	52,324	49,506
Stocks, Dec. 31: Producers	4,504	4,398	3,839	5,945	7,156
Free world: Production	75,055	77,829	98,460	124,967	125,363

Legislation and Government Programs.—Government stockpile disposal programs during the past few years helped to terminate the worldwide short supply situation in mid-1966. Over the past 5 years about 27 million pounds of molybdenum has been sold by the General Services Administration (GSA).

In March 1966, the Office of Emergency Planning (OEP) revised the national molybdenum stockpile objective to 55 million pounds of molybdenum in concentrate. This was followed by Congressional action and on May 6 the President signed a bill (Public Law 89–413) authorizing the disposal of 14 million pounds of molybdenum. In January 1967, OEP further reduced the objective to 40 million pounds of molybdenum and on November 24, 1967, the President signed Public Law 90–151 authorizing the disposal of an additional 15 million pounds of molybdenum.

At yearend under the Public Law 89–413 authorization, 2.9 million pounds of molybdenum was available to consumers and under the program of Public Law 90–151, 14.4 million pounds. During 1967, sales of molybdenum under both programs totaled about 2.8 million pounds. This compares with 8.9 million pounds sold during 1966. Most of the 1966 and 1967 stockpile sales were used to reinforce consumer stocks.

Early in 1967, OEP announced that

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there was no nuclear stockpile objective for molybdenum.

American Metal Climax, Inc., delivered about 1 million pounds of molybdenum contained in ferromolybdenum to the government stockpile under a contract to upgrade stockpile molybdenum concentrate to grade B ferromolybdenum. The original contract for 3,475,000 pounds of molybdenum was extended into the first quarter of 1968 for completion, owing to a work stoppage at Climax Molybdenum Co.'s Langeloth plant. An additional 512,138 pounds of molybdenum due under the contract will complete the ferromolybdenum subobjective of the molybdenum stockpile program.

Table 2.—Molybdenum material in government inventories on December 31, 1967

(Thousand pounds molybdenum)

Type	Stockpile objective	National (strategic) stockpile
Concentrate	21,250	[1] 37,415
Ferromolybdenum	7,500	6,988
Molybdic oxide	10,000	12,977
Total	[2] 38,750	57,380

[1] Includes 584,325 pounds reserved for upgrading.
[2] Equivalent to 40 million pounds of molybdenum in concentrate.

DOMESTIC PRODUCTION

The domestic molybdenum industry produced at near the record high level of 1966 despite labor problems in the copper industry during the second half of the year that limited recovery of molybdenum from copper ores. For the first 6 months of 1967, the industry operated at a 100-million-pound annual rate, thereby easing the supply situation for the balance of the year.

Molybdenum was recovered from ore mined mainly for its molybdenum content in Colorado and New Mexico; from molybdenum-bearing copper ores in Arizona, Nevada, New Mexico, and Utah; from a tungsten ore in California; and from uranium-bearing material in New Mexico, North Dakota, and South Dakota.

Domestic production capacity increased by about 14 million pounds in 1966 with the startup of two new plants and by expansions at several byproduct producers. Capacity was further augmented in 1967 with the startup of Climax Molybdenum Co.'s Urad mine and the installation of molybdenum recovery circuits by the following Arizona byproduct producers: Miami Copper Co. Division, Tennessee Corp. (a subsidiary of Cities Service Oil Co.), Pima Mining Co.; and Kennecott Copper Corp. (Ray mine). Domestic production capacity at yearend was about 110 million pounds per year.

According to the annual report of American Metal Climax, Inc., the Climax mine in Lake County, Colo. continued to operate at high levels. A record 15.4 million tons of ore was mined from which 58 million pounds of molybdenum was recovered. Production from the oxide plant, completed in 1966 (See Technology), contributed to the total. Work continued on development of the third mining level at the Climax mine from which production will be drawn in 1971 when the Phillipson level of the ore body is depleted.

Climax's Urad mine and concentrator, near Empire, Colo., was brought into production in September. A total of 325,000 tons of ore was mined producing 1.5 million pounds of molybdenum. Development work on the Henderson project was initiated with the first shaft 25 percent completed at yearend. After additional drilling and reevaluation of the deposit, proven and indicated ore reserves were estimated to total 303 million tons at a grade in place of 0.49 percent molybdenite.

During its second year of operation, the Questa mine of Molybdenum Corporation of America produced 9.4 million pounds of molybdenum. An extensive development drilling campaign significantly added to the firm's ore reserve.

Duval Corp. produced 4.3 million pounds of molybdenum, according to its annual report, with increased production occurring at its expanded Mineral Park facilities.

Duval's subsidiary, Duval Sierra Corp., entered into a copper production expansion contract with GSA which provides for the development of a large low-grade molybdenum-copper deposit adjacent to Duval's Esperanza mine. The concentrator was planned for a minimum of 60,000 tons daily with molybdenum production estimated at 12 million pounds annually.

Inspiration Consolidated Copper Co. made extensive changes to its molybdenum plant and processing procedures to improve recovery and product quality and to reduce operating costs. Labor problems shut down operations at the time changes were completed.

Pima Mining Co., Pima, Ariz. expanded its concentrating facilities to 30,000 tons daily. A molybdenum recovery plant was included in the expansion. The concern anticipates production of approximately 900,000 pounds of molybdenum annually.

American Smelting and Refining Company's Silver Bell mine in Arizona operated at full capacity throughout the year, whereas the Mission mine in Arizona was shut down in July for the balance of the year due to labor problems. Expansion of Mission's concentrator to 25,000 tons daily was completed during the first quarter.

The Anaconda Company's Twin Buttes mine and concentrating facilities near Tucson, Ariz. was scheduled for production by 1970. Although no announcement has been made by the company, byproduct molybdenum production can be expected as nearby mines of Duval Corp., American Smelting and Refining Company, and Pima Mining Co. recover molybdenum.

Molybdenum deposits under investigation during the year include the Sunrise mine near Everett, Wash., by Brenmac Mining Co. Ltd., Vancouver, Canada; Star Molybdenum mine near Tonasket, Wash., by Cambri Mining and Development Co., Vancouver, Canada; and a molybdenum-copper deposit near Lincoln, Mont., by The Anaconda Company.

Table 3.—Production, shipments and stocks of molybdenum products in the United States

(Thousand pounds of contained molybdenum)

	Product					
	Molybdic oxide [1]		Metal powder		Ammonium molybdate	
	1966	1967	1966	1967	1966	1967
Received from other producers	6,057	3,393	133	38	256	218
Gross production during year	68,490	50,391	4,652	2,326	2,660	1,291
Used to make other products listed here	16,730	12,422	1,710	1,136	2,073	739
Net production	51,760	37,969	2,942	1,190	587	552
Shipments:						
Domestic consumers	45,433	35,073	2,749	1,537	753	561
Exports	11,315	5,792	2	3	46	249
Total	56,748	40,865	2,751	1,540	799	810
Producer stocks, Dec. 31	2,949	3,211	659	347	229	190

	Product—Continued					
	Sodium molybdate		Other [2]		Total	
	1966	1967	1966	1967	1966	1967
Received from other producers	65	62	13	35	6,524	3,746
Gross production during year	901	832	18,226	14,401	94,929	69,241
Used to make other products listed here	3	17	21	5	20,537	14,319
Net production	898	815	18,205	14,396	74,392	54,922
Shipments:						
Domestic consumers	958	780	15,704	12,070	65,597	50,021
Exports	20	25	1,831	1,141	13,214	7,210
Total	978	805	17,535	13,211	78,811	57,231
Producer stocks, Dec. 31	38	110	2,070	3,298	5,945	7,156

[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.

CONSUMPTION

Consumption of molybdenum concentrate by conversion to technical oxide decreased significantly due to labor problems in the industry and to a shift in the product mix of exports. Since the startup of a roaster facility in the Netherlands in 1966, exports of molybdenum concentrate exceed those of roasted concentrate (molybdenum oxide).

The major end use category for molybdenum was in the iron and steel industry where advantage is taken of unique properties molybdenum imparts to various iron and steel products. The decline in steel production, especially in the output of alloy steels, resulted in reduced demand for molybdenum products.

Other important uses of molybdenum were as an additive to nonferrous alloys; as pure metal for a material of construction; as the purified molybdenum disulfide for lubrication applications; and in the form of chemical compounds for pigments and catalysts.

Table 4.—Consumption of molybdenum products by end uses, in 1967

(Thousand pounds, contained molybdenum)

End use	Molybdic oxides [1]	Ferromolybdenum [2]	Molybdenum metal powder	Ammonium molybdate	Sodium molybdate	Other [3]	Total
Steel:							
High speed	1,830	882	1	------	------	102	2,815
Hot work tool	188	120	------	------	------	4	312
Other tool	585	140	(4)	------	------	2	727
Stainless	4,164	1,882	3	------	------	56	6,105
Other alloy	18,124	1,763	2	------	------	53	19,942
Steel mill rolls	1,203	95	------	------	------	------	1,298
Gray and malleable castings	540	2,601	17	4	------	17	3,179
Welding rods	------	281	(4)	------	------	------	281
High-temperature alloys	1,654	765	42	------	------	1,580	4,041
Molybdenum powder: wire, rod, sheet, other	------	15	1,562	------	------	18	1,595
Chemicals: Inorganic pigments	402	------	(4)	6	75	7	490
Organic pigments	213	------	------	13	273	1	500
Catalysts	1,551	------	------	284	3	------	1,838
Miscellaneous [5]	3,334	1,793	95	29	45	1,087	6,383
Total	33,788	10,337	1,722	336	396	2,927	49,506
Stocks at consumers plants Dec. 31	6,730	2,288	209	356	38	653	10,274

[1] Includes technical and purified oxides.
[2] Includes molybdenum silicide, and calcium molybdate.
[3] Includes thermite molybdenum and molybdenum pellets, purified molybdenum disulfide, and molybdenite concentrate added direct to steel.
[4] Less than ½ unit.
[5] Includes cutting and wear resistance materials, alloy hard facing rods and materials, permanent-magnet alloys, soft magnetic alloys, copper, nickel and titanium-base alloys, metal to glass seal materials, electrical contact materials, electrical resistance alloys, friction material, diamond bit matrices, hard facing rods and materials, cast carbide dies or parts, ceramic pigments, lubricants, fertilizer, ground coat frit, and unspecified.

STOCKS

A high level of molybdenum production in 1967 and reduced steel industry demand allowed the molybdenum industrial inventory to increase 35 percent despite loss of byproduct molybdenum production due to the copper strike. A record molybdenum output in the first half of 1967 together with additional stockpile sales boosted consumer's stocks to an unprecedented high of 15.3 million pounds at midyear. During the second half of the year, inventories were drawn down, dropping to 10 million pounds at yearend. Due to this plentiful supply in the hands of consumers, a 5 months work stoppage at Climax Molybdenum Co.'s Langeloth plant was not felt by consumers. Producer stocks at mine and plant increased to the highest level since the late 1940's.

PRICES

Early in January 1967, the molybdenum industry announced price increases on molybdenum products that averaged 3.7 percent. The new prices remained in effect throughout the year and essentially represented the first price change since April 3,

1964. No objection was interposed by the Government for the January increase. This was in sharp contrast to the situation in 1966 when the Government made strong objections to a price increase for molybdenum products that averaged 5 percent. The industry was informed that this increase was totally unjustified and added unnecessarily to inflationary pressures on the economy. Although the industry felt the increase was justified and necessary to assure an adequate future supply of molybdenum, the price advance was rescinded.

On November 27, 1967, one producer announced selective price increases which were later rescinded when other molybdenum producers failed to support the increase. The old and new published prices are as follows.

	Per pound contained molybdenum	
	April 3, 1964	*January 11, 1967*
Molybdenite concentrate f.o.b. Climax, Colo	$1.55	$1.62
Bagged molybdic oxide [1]	1.74	1.82
Technical molybdic oxide in cans [1]	1.75	1.82
Molybdic oxide briquette [1]	1.77	1.85
Ferromolybdenum [1]	2.04	2.11

[1] Molybdenum products, f.o.b. Langeloth, Pa.

FOREIGN TRADE

Although total exports of molybdenum products in 1967 were about the same as those for 1966, value dropped sharply as an ample supply eliminated premium markets. Reduced exports of ferromolybdenum were offset by increased exports of concentrate, powder, and other semifabricated forms.

The shift in the traditional pattern of exports to European countries was due to the startup in 1966 of a new roaster facility in the Netherlands. (See World Review). Exports to most European countries decreased as the Netherlands became a focal point for supplying their molybdenum product requirements. The Netherlands received 16.3 million pounds of concentrate in 1967 compared with 11.6 million in 1966 and 1.5 million in 1965.

No molybdenum ore or concentrate was reexported in 1967. This compares with 164,482 pounds of molybdenum in concentrate reexported in 1966 and 128,281 pounds of molybdenum in 1965.

Table 5.—Molybdenum reported by producers as shipments for exports from the United States

(Thousand pounds of contained molybdenum)

Product	1966	1967
Molybdenite concentrate	15,140	22,240
Molybdic oxide	11,315	5,792
All other primary products	1,899	1,418

Table 6.—U.S. exports of molybdenum ore and concentrates (including roasted concentrates), by countries

(Thousand pounds and thousand dollars)

Destination	1966 Molybdenum (content)	1966 Value	1967 Molybdenum (content)	1967 Value
Australia	248	$478	73	$121
Austria	473	935	252	621
Belgium-Luxembourg	2,726	4,955	1,878	3,382
Brazil	14	20	17	39
Canada	1,014	1,469	3,415	5,312
Chile	16	28	(1)	1
France	1,978	4,008	1,526	2,651
Germany, West	4,779	10,160	1,971	3,502
Italy	1,084	1,875	455	787
Japan	3,405	6,782	2,690	4,916
Mauritius	10	14	------	------
Mexico	73	192	260	569
Netherlands	11,551	19,317	16,287	27,602
New Zealand	5	10	3	7
Philippines	10	19	21	48
South Africa, Republic of	45	73	20	50
Spain	2	5	1	(1)
Sweden	1,046	1,979	582	950
United Kingdom	1,145	2,145	488	775
Venezuela	131	272	55	94
Other	13	29	6	7
Total	29,768	54,765	30,000	51,434

1 Less than ½ unit.

Table 7.—U.S. exports of molybdenum products

(Thousand pounds, gross weight)

Product and country	1966	1967
Ferromolybdenum:[1]		
Australia	200	94
Brazil	268	81
Canada	523	317
Germany, West	101	------
India	44	292
Italy	62	------
Japan	------	72
Mexico	28	47
Netherlands	433	388
South Africa, Republic of	174	160
Spain	93	------
United Kingdom	107	20
Other countries	167	62
Total	2,200	1,533
Value (thousands)	$4,085	$2,436
Metal and alloys in crude form and scrap:		
Germany, West	16	15
Japan	20	9
Mexico	10	18
United Kingdom	5	(2)
Other countries	8	8
Total	59	50
Value (thousands)	$251	$131
Wire:		
Brazil	6	10
Canada	3	13
Chile	2	(2)
Germany, West	4	2
Mexico	2	2
Other countries	2	7
Total	19	34
Value (thousands)	$624	$661
Powder:		
Canada	3	213
France	1	(2)
Germany, West	76	1
Japan	4	(2)
Mexico	7	10
Sweden	19	15
United Kingdom	8	2
Other countries	2	(2)
Total	120	241
Value (thousands)	$502	$434
Semifabricated forms not elsewhere classified:		
Canada	24	4
France	2	4
Germany, West	1	1
Italy	(2)	2
Japan	8	227
Mexico	2	14
Netherlands	2	2
United Kingdom	13	9
Other countries	20	29
Total	72	292
Value (thousands)	$398	$702

1 Ferromolybdenum contains about 60 to 65 percent molybdenum.
2 Less than ½ unit.

There was no transaction for molybdenum ore or concentrate in 1967, however in 1966, 8,729 pounds of concentrate was imported which contained 5,000 pounds of molybdenum, valued at $13,750. In addition, during 1966, imports of molybdenum compounds (mainly technical oxide) totaled 430,195 pounds containing 266,673 pounds of molybdenum valued at $453,219. During 1967, 437,166 pounds of molybdenum compounds containing 30,601 pounds of molybdenum valued at $25,219 were received from the United Kingdom. The low molybdenum content of these imports indicates that no technical oxide was imported under this classification. Technical oxide was imported in 1967, under material in chief value molybdenum, and totaled 1,895,313 pounds containing 1,179,077 pounds of molybdenum valued at $1,967,643. During 1965 and 1966, technical oxide was imported as molybdenum compounds. Although the tariff rate is the same for both, the proper classification for technical oxide is 603.40, material in chief value molybdenum, whereas tariff classification 419.60, molybdenum compounds, is reserved for manufactured molybdenum chemical products.

In both years, wrought molybdenum was received chiefly from Austria, whereas unwrought molybdenum was received mainly from Canada in 1966 and West Germany in 1967. Over 60 percent of waste and scrap imports was received from West Germany in 1967 while the balance was imported from three countries. In contrast, the U.S.S.R. supplied about one-half of waste and scrap imports during 1966 with the balance supplied by seven countries.

Under the Kennedy Round of Tariff Negotiations which were completed during the year, the duties on molybdenum products were to be reduced by 50 percent over a 5-year period.

Table 8.—U.S. import duties

Item	Articles	Rate of duty, January 1, 1968 [1]
601.33	Molybdenum ore	21 cents per pound on molybdenum content.
603.40	Material in chief value molybdenum	18 cents per pound on molybdenum content plus 5 percent ad valorem.
607.40	Ferromolybdenum	Do.
	Molybdenum:	
628.72	Unwrought	Do.
628.74	Wrought	22 percent ad valorem.
	Molybdenum chemicals:	
417.28	Ammonium molybdate	18 cents per pound on molybdenum content plus 5 percent ad valorem.
419.60	Molybdenum compounds	Do.
420.22	Potassium molybdate	Do.
421.10	Sodium molybdate	Do.
473.18	Molybdenum orange	9 percent ad valorem.

[1] Not applicable to Communist countries.

WORLD REVIEW

Australia.—Most of Australia's small molybdenum production in recent years has been from the A. W. Molybdenite mine, operated by Canadian Key Molybdenum Pty. Ltd. in the Deepwater Mining Division. Considerable interest was shown by numerous mining concerns in exploration for molybdenum mineralization in Australia. A general exploration program on a number of concession areas totaling 2,000 to 3,000 square miles in the northern part of Western Australia was conducted by Westfield Minerals (W. A.) Ltd. Drilling was initiated on an interesting molybdenum showing.

Freeport of Australia, Inc., a subsidiary of Freeport Sulphur Co. of the United States, entered into a joint venture with Metals Exploration N. L. to explore an extensive molybdenite occurrence near Bathurst.

Kennecott Explorations Pty. Ltd., signed an option on a new copper prospect 200 miles north of Perth. Kennecott holds exploration rights for molybdenite, copper, lead, zinc, and tin on a 4,800-square-mile area.

Metals Exploration N. L. continued to investigate a complex molybdenum-tungsten-bismuth deposit at Wolfram Camp, North Queensland. At least nine pipe-type ore bodies have been located by underground exploration. The concern was expected to begin production of molybdenite and tungsten concentrate in the third quarter of 1967.

Canada.—Canada continued to improve its position as the free world's second largest producer of molybdenum. New mines brought into production in 1965 and 1966 operated at a high production level in 1967. Canada's production capacity was increased with the startup of the mine and concentrator of British Columbia Molybdenum Ltd., subsidiary of Kennecott Copper Corp. Initial operation of the 6,000-ton-per-day concentrating plant began in October and full capacity operation was expected by yearend. The ore reserve was estimated at 40 million tons grading 0.23 percent molybdenite.

Red Mountain Mines, Ltd. planned to expand its 400-ton concentrator to 800 to 1,000 tons per day. The ore reserve was reported at 1 million tons grading 0.45 percent molybdenum disulfide.

Endako Mines Ltd. (N.P.L.), British Columbia, Canada's largest molybdenum producer, continued its extraordinary production performance. Since the initial startup in May 1965, about 34 million pounds of molybdenum has been produced. In 1967, a total of 6.8 million tons of ore was treated in producing 14.3 million pounds of molybdenum. Average grade of ore treated was 0.212 percent molybdenite of which 83.3 percent was recovered. The concentrator was expanded during the year and at yearend was treating over 25,000 tons per day. The ore reserve at yearend was reported at 239 million tons grading 0.15 percent molybdenite with a cutoff grade of 0.08 percent molybdenite.

Table 9.—Free world production of molybdenum in ores and concentrates by countries [1]

(Thousand pounds molybdenum)

Country [1]	1963	1964	1965	1966	1967 [p]
Australia	[r] 13	---------	26	[r] 4	---------
Canada [2]	834	1,225	9,557	[r] 20,419	21,526
Chile	6,400	8,393	[r] 8,142	[r] 10,430	10,752
Japan	732	619	611	[r] 542	558
Korea, South	154	265	448	659	613
Mexico	90	117	108	[r] 289	[e] 300
Norway	[r] 463	[r] 503	[r] 527	[r] 500	570
Peru	[r] 1,122	871	[r] 1,499	[r] 1,484	2,037
Philippines	236	231	170	[r] 108	77
United States	65,011	[r] 65,605	[r] 77,372	90,532	88,930
Total	[r] 75,055	[r] 77,829	[r] 98,460	[r] 124,967	[e] 125,363

[p] Preliminary. [r] Revised. [e] Estimate.
[1] Molybdenum is also produced in Argentina, Bolivia, Nigeria, South-West Africa, and Spain, but production is negligible.
[2] Shipments.

Bethlehem Copper Corp. Ltd., British Columbia, a small byproduct molybdenum producer, removed its molybdenum circuit that had proved unsatisfactory. At yearend, consideration was being given to the reinstallation of a molybdenum circuit based on new laboratory test results. Currently about 1,000 pounds per day of molybdenum is lost in copper concentrate.

Canada's oldest molybdenum producer, Molybdenum Corporation of Canada Ltd., Lacorne, Quebec, suffered a disaster when its concentrator was destroyed by fire in October.

Possible future molybdenum producers are Brenda Mines Ltd., Highmont Mining Corp., and Lornex Mining Corp. Brenda completed financial arrangements required to further develop its low-grade molybdenum-copper deposit in the Peachland area of British Columbia. Ore reserves are said to be 167 million tons grading 0.19 percent copper and 0.087 percent molybdenite. A milling rate of 20,000 tons per day has been proposed. Highmont constructed a bulk sampling plant to treat ore from underground exploration. Ore reserves to a depth of 250 feet indicate 45 million tons grading 0.098 percent molybdenite and 0.30 percent copper. Twelve million tons of lesser grade material was also reported. Japanese capital is interested in the venture. Lornex carried out bulk sampling and milling tests during the year. An ore reserve of 330 million tons grading 0.031 percent molybdenum and 0.44 percent copper has been reported.

Other interesting potential molybdenum deposits under investigation are those of Bell Molybdenum Mines Ltd., Mayfair Molybdenum Mines Ltd., and Silurean Chieftain Mining Co. All three properties are in the Alice Arm area of British Columbia in the vicinity of the operating plant of British Columbia Molybdenum Ltd. Amax Exploration Co. continued underground exploration on its Smithers, British Columbia, prospect.

Chile.—In April, the Chilean Government purchased a 51-percent interest in a new corporation, Sociedad Minera El Teniente S. A. (El Teniente Mining Company, Inc.), that acquired the El Teniente property of Braden Copper Co., subsidiary of Kennecott Copper Corp. Kennecott retains the 49-percent interest and will operate the new concern. Financial arrangements were made to expand operations by 60 percent.

In 1966, Chile became a leading consumer of its own molybdenum concentrate output, utilizing about 25 percent of total deliveries with the balance being exported. Carburo y Metalurgia S. A., the molybdic oxide and ferromolybdenum producer, was considering expansion of conversion capacity at yearend.

Chilean molybdenum concentrate deliveries for 1967 were as follows: Chile, 25 percent; West Germany, 23 percent; United Kingdom, 17 percent; Sweden, 13 percent; Netherlands, 11 percent; Japan, 6 percent; France, 4 percent; and Belgium a small quantity.

Denmark.—Exploration of the Mestersvig molybdenum deposits in Greenland was delayed with the announcement of the new molybdenum occurrence in Colorado by American Metal Climax, Inc. (AMAX). AMAX is a partner in the Arctic Mining Co., Inc., the holder of a Danish concession for the exploration and exploitation of Greenland's large low-grade molybdenum deposit.

Germany, West.—American Metal Climax, Inc., formed a wholly owned subsidiary Climax Molybdenum, G.m.b.H. which was to market molybdenum products in West Germany, Switzerland, Austria, and the Netherlands. A subsidiary in Paris will continue to handle orders for France, Italy, and Spain, while another subsidiary will be responsible for the British and Scandinavian markets.

Japan.—During the year, the Japanese Ministry of International Trade and Industry studied the feasibility of stockpiling molybdenum, cobalt, tungsten, and vanadium. The stockpile aim would be to hedge against short supply situations with the venture financed 50–50 by the Government and the specialty steel industry.

Malaysia.—Geochemical anomalies found during a United Nations survey in 1965 resulted in the first discovery in Borneo of a porphyry copper desposit. Minor quantities of molybdenum, zinc, and mercury were also present. Diamond drilling by the Geological Survey, Borneo Region, Malaysia indicated that the size and grade of the deposit are sufficient to encourage further exploration.

Mexico.—A joint mineral exploration program of the Government agency Consejo de Recursos Naturales no Renovables and the United Nations resulted in the discovery of a potential copper molybdenum deposit in northern Sonora.

Netherlands.—In May 1966, a new roaster to convert molybdenum concentrate to technical molybdic oxide was placed in operation by Climax Molybdenum N. V., the Dutch subsidiary of Climax Molybdenum Co. The new plant was designed to produce 12 million pounds of molybdenum annually as technical oxide. The facility was constructed for a highly automated process from receipt of concentrate to final packaging.

Peru.—Southern Peru Copper Corp.'s open pit mine and concentrator at Toquepala produced 1,855 tons of molybdenum concentrate during the year, which compares with 1,634 tons produced in 1966 and 1,450 tons in 1965. Process changes to improve molybdenite recovery are continuously evaluated since overall recovery of molybdenum from the ore in 1966 was only 37.1 percent. (See Technology).

In 1966, a small operation began production of hand cobbed molybdenite in the Department of Piura for direct shipment.

An agreement was reached between the Peruvian Government and France's Bureau de Recherches Geologiques et Minieres for a joint mineral study for a variety of minerals including molybdenite. The agreement also provides for joint Franco-

Peruvian exploitation in event that commercial minerals are found.

Philippines.—The sole producer of molybdenum concentrate, Marinduque Mining and Industrial Corp. planned to increase its milling capacity to about 9,000 tons per day by mid-1968.

Sweden.—A potential resource of molybdenum was indicated when the Geological Survey revealed that the Billingden shale, mined for its uranium content, contained 320 grams of molybdenum per metric ton of shale.

Yugoslavia.—The Institute for Nuclear and Other Mineral Raw Materials, of Belgrade reported that significant amounts of rhenium occurs in the molybdenite ore at the abandoned Mackatica mine near Surdulica. It was estimated that 40 tons of rhenium was present in the known ore at the mine and much more in the as yet unexplored deposits of the surrounding area. Rhenium content of molybdenite ranges from 1 to 2,500 grams per ton. If this deposit is exploited for rhenium, a significant amount of molybdenum could be produced as a by-or coproduct.

TECHNOLOGY

Recovery of molybdenum, formerly lost in tailings was made possible with the startup of a new plant in mid-1966. Climax Molybdenum, a Division of American Metal Climax, Inc., developed a process for chemically recovering the molybdenum oxide content of ore from the upper zones of the Climax mine which was not recoverable by conventional flotation processes, thereby conserving a valuable molybdenum resource. A simplified flow pattern of the process was described by Climax as follows:

> Selected ore containing both sulfide and oxide molybdenum, and sufficiently enriched in the oxide molybdenum, is kept separate from the regular sulfide ore throughout the mining, crushing, grinding, and flotation operations. The tailing or residual pulp from the flotation units constitutes the feed to the oxide recovery plant.
>
> The feed to the new process facilities is received as a mixture of finely ground solids in water. Most of the oxide molybdenum values occur in the very fine slime particles: accordingly, it is possible to reduce the 5,700 tons per day of material for chemical processing to 1,650 tons per day by first making a concentrate based on particle-size separation.
>
> The oxide molybdenum is dissolved from this concentrate in large rubber-lined vessels with sulfuric acid and sulfur dioxide held at 140° F. The leach pulp is then agitated through granular activated charcoal in another series of tanks. The charcoal absorbs practically all of the molybdenum, but only a very small amount of other constituents, from the leach liquor. Waste slurry is separated from the loaded charcoal by screens and is discarded to the tailing pond.
>
> Molybdenum is dissolved from the charcoal in an ammonia solution, and the charcoal is returned to the adsorption circuit to be loaded with molybdenum again. To maintain its adsorbing power through many cycles, the charcoal must be regenerated periodically by a high temperature (1475° F.) heat-treating process.
>
> The molybdenum-bearing ammonia solution is evaporated to produce crystals of ammonium molybdate. These crystals are then heated to 1075° F. in a gas-fired rotary kiln and converted to molybdic oxide (MoO_3) which is the final product for shipment to the Climax conversion plant at Langeloth, Pa.

Additional information concerning the process, including a flow diagram, was published.[2]

Mineralization of the Urad (Climax Molybdenum Co.) ore body consists of molybdenite (MoS_2) associated with pyrite and trace amounts of lead and zinc sulfide. Milling technology follows that developed at the firm's Climax mine with the major exception of a leaching step to control the lead and zinc content of concentrate.[3] In order to meet a lead specification of less than 0.05 percent, flotation concentrate is leached with a solution of hot ferric chloride followed by hot pressure filtration and hot water washing. Ammonia is added to the final wash water to neutralize residual acid. More than 80 percent of the lead and about half of the zinc is removed from the concentrate. The development of this technology, along with large scale mining, made possible the economic development of this long-known resource.

The recovery of molybdenum as a byproduct from copper porphyry ore is generally poor, ranging from 40 to 70 percent depending on the refractoriness of the ore and individual company practices. Kennecott Copper Corp. was issued a patent[4] for a method of recovering small quantities of molybdenum usually lost in the waste slag in smelting copper con-

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[2] Engineering and Mining Journal. Carbon Adsorption Is Key to Recovery of Molybdenum Oxide at New Climax Plant. V. 168, No. 1, January 1967, pp. 106–109.

Guccione, Eugene. First Chemical Route for Molybdenum Processing. Chem. Eng., v. 74, No. 2., Jan. 16, 1967, pp. 140–142.

World Mining. Oxide Molybdenum Recovery at Climax. V. 3, No. 1, January 1967, pp. 22–25.

[3] Seeton, Frank A. Urad Mine. Deco Trefoil, v. 31, No. 4, August, September, October 1967, pp. 11–22.

[4] Kennecott Copper Corp. Process for the Recovery of Molybdenum Values from Ferruginous, Molybdenum-Bearing Slags. U.S. Pat. 3,314,783, April 18, 1967.

centrate. Although the method appears uneconomical under today's costs and economy, the technology developed may result in supplementing domestic supply in the future.

Large-scale mining operations require long-range planning for effective mine development to assure an adequate supply of ore to meet production schedules. Two publications describe[5] computer programing criteria at the Climax molybdenum mine. Although both reports are directed toward solving technical problems, the computer programs could be refined to include a financial analysis.

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[5] Mathias, Adrian J., A Mine Production-Scheduling Model and Critical Path Analysis of Mine Development Work for Long-Range Mine Planning. BuMines Rept. of Inv. 6937, 1967, 48 pp.

Sheinkin, Moshe, and Douglas E. Julin. Computer Simulation Aides in Mine Production at Climax. Min. Engr., v. 19, No. 4, April 1967 pp. 76–81.

Natural Gas

By William B. Harper[1] and Leonard L. Fanelli[2]

The marketed production of natural gas in 1967 totaled 18,171 billion cubic feet. Production for the year was up 965 billion cubic feet above 1966 levels, and Louisiana accounted for almost 66 percent of this increase. There were production declines reported for 19 of the 30 producing States. Primarily due to increased offshore production, Louisiana now accounts for 31.5 percent of total U.S. production compared with 26.9 percent in 1964, while Texas' share declined from 42.0 percent in 1964 to 39.6 percent in 1967. The wellhead price of gas increased 0.3 cent to an average of 16.0 cents per thousand cubic feet (Mcf), the highest level since 1963.

There were 718 fewer gas wells completed in 1967; the average depth per well declined from 5,928 feet in 1966 to 5,898 feet in 1967. Gas wells in operation were fewer in number at yearend, totaling 112,321 compared with 112,491 on December 31, 1966.

In 1967, a west Texas well was acclaimed the world's new record holder for a depth producing well. The well, (the Perry R. Bass, Inc. and Champlin Petroleum Co. No. 1 Roxie Neal, Section 2 Block 142, T & STL Survey)[3] was completed flowing gas from the Ellenburger Group at 21,812 to 22,447 feet. The new well located in the Gomez Field, Pecos County, flowed gas at the rate of 10.1 million cubic feet daily between these depths.

Industrial consumption continued to dominate gas demand. Much industrial use occurs in Texas and Louisiana where gas holds a strong competitive margin because of its proximity to large industrial complexes. Interstate shipments of domestically produced gas in the Southwest were beginning to decline because more of this gas is being consumed internally, particularly for petrochemicals. Total consumption for the year increased 5.7 percent, and industrial use, the largest segment, was up 6.2 percent. Intrastate gas usage has the added attraction of a shorter reserve life requirements (15 instead of 20 years) than interstate gas, and the time interval between contract negotiations and gas delivery is far shorter. These advantages tend to offset the narrowing price gap between the two gas supplies. The best prospects for interstate gas development appear to be in gas from the Outer Continental Shelf of the Gulf of Mexico.

There was 15.6 trillion cubic feet of gas processed at plants in 1967, and from this, 21.6 billion gallons of natural gas liquids and ethane was recovered. After some processing loss most of the remainder was directed to transmission companies and consumers.

According to the American Gas Association (AGA), there were 828,270 miles of gas pipelines at the end of 1967. This includes 225,360 miles of main transmission lines, 63,710 miles of gathering lines, and 539,200 miles of distribution lines. Compared with 1966 figures, main transmission lines increased 8,380 miles, gathering lines, 730 miles, and distribution lines, 19,590 miles.

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1 Mineral specialist, Division of Mineral Studies.
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3 Texas and St. Louis R.R., Survey.

Table 1.—Salient statistics of natural gas in the United States

	1963	1964	1965	1966	1967
Supply:					
Marketed production [1] million cubic feet	14,666,559	15,462,143	16,039,753	17,206,628	18,171,325
Withdrawn from storage do	911,741	880,498	959,865	1,141,614	1,132,534
Imports do	403,997	440,918	456,394	479,780	564,226
Total do	15,982,297	16,783,559	17,456,012	18,828,022	19,868,085
Disposition:					
Consumption do	14,560,953	15,451,979	16,033,189	17,191,711	18,172,894
Exports do	16,865	19,497	26,132	24,639	81,614
Stored do	1,041,802	1,009,302	1,077,980	1,210,469	1,317,363
Lost in transmission, etc. do	362,677	302,781	318,711	401,203	296,214
Total do	15,982,297	16,783,559	17,456,012	18,828,022	19,868,085
Value at wellhead:					
Total thousand dollars	2,328,030	2,387,689	2,494,542	2,702,759	2,898,741
Average cents per Mcf	15.9	15.4	15.6	15.7	16.0

[1] Comprises gas sold or consumed by producers, including gas loss due to natural gas liquids recovery, losses in transmission, quantities added to storage, and increases of gas in pipelines.

SCOPE OF REPORT

In this chapter, gas volumes are reported or converted to a pressure base of 14.73 pounds per square inch absolute (psia) at 60° F instead of base of 14.65 psia used previously. This change was adopted in response to the Bureau of the Budget's request to establish uniformity in reporting between Federal and industry gas statistics.

Data on natural gas production, consumption, and value are collected by annual surveys of oil and gas producers, natural gasoline plant 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 has made direct acquisition of total production impractical. Most of the output of 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 shipment from storage and receipts from other States.

LEGISLATION AND GOVERNMENT PROGRAMS

Permian Basin Decision.—The Federal Power Commission (FPC) decisions regarding Opinion No. 468 (and 468–A) fixing gas producer rates for interstate sales for resale in three of the FPC's 23 pricing areas, was handed down August 5, 1965. The three areas which supply 10 percent of the Nation's natural gas, include the southwest corner of New Mexico and southwestern Texas. The decision involved a dual price system based on national costs, including a 12-percent rate of return. The Commission set the following ceiling prices: 16.5 cents per thousand cubic feet for gas placed under contract since January 1, 1961 from new gas wells, nonassociated gas in the Texas portion of the Permian Basin; 14.5 cents per thousand cubic feet (Mcf) for pre–1961 gas including gas well gas, oil well gas, and residue gas in Texas (including production taxes); 15.5 cents per Mcf for new gas well gas in New Mexico plus production taxes, and for all pre-1961 gas in New Mexico, 13.5 cents per Mcf which includes gas well gas, oil well gas, and residue gas in New Mexico.

The Commission also set a minimum rate of 9 cents per Mcf for Permian gas of standard quality. The ceilings set by FPC applied only to the 336 producers who were parties to the Permian proceeding instituted in 1960. The new prices applied to all gas dedicated to the interstate market while applicable area prices are in effect.

Subsequently, on January 20, 1967, the U.S. Court of Appeals for the Tenth Circuit remanded Opinions 468 and 468–A in the Permian Basin Area Rate Proceeding (AR 61–1 et al) to the FPC for further hearings to equate group revenue requirements and to determine the effect of quality adjustments on revenues under area rates. The Court directed the Commission to make appropriate findings on these matters and also to devise a more adequate savings clause covering special exemption from area rates.

The Supreme Court on May 1, 1968, however, handed down a decision (7–1) upholding FPC Opinion 468 in the Permian Basin case in all respects. The Court overruled all of the grounds on which the Tenth Circuit had reversed Opinion 468. There were four aspects upon which the Court based its decision:

1. The statutory and constitutional authority of the Federal Power Commission to employ area regulations.
2. The validity of the rate structure adopted by the Commission.
3. Questions relating to the accuracy of the cost and other data on which the FPC derived maximum area prices.
4. Matters relating to the validity of refund obligations established by the Federal Power Commission.

At the same time, however, the Court observed that it had given consideration to "unusual difficulties of this first area case and the present experimental stage of area rate regulation." However, "this weight must significantly lessen as the Commission's experience with area regulation lengthens."

Pipeline Safety.—In November 1967 the U.S. Senate passed and sent to the House of Representatives a bill establishing safety regulations for pipelines. The bill was passed by the House on July 2, 1968, but with several amendments or modifications. These included an exemption of gathering lines in rural areas (but not in populated places); restrictions of the Secretary of Transportation's authority to require replacement of existing facilities found to be "potentially hazardous"; exemption of State or local facilities upon "annual certification" by the appropriate State agency that it had adopted the Federal safety standards; reduction of civil penalties; and reduction of authorized funds for the first 3 years from \$38 million to \$6.5 million.

The House and Senate adopted a conference report on the Natural Gas Pipeline Safety Act of 1968 (S 1166) and is awaiting action by the President.

CONSUMPTION

A total of nearly 18.2 trillion cubic feet of natural gas was consumed in the United States during 1967. This was an increase of 981.2 billion cubic feet, or 5.7 percent, above the volumes consumed in 1966. About 12.1 trillion cubic feet, or two-thirds of the gas consumed, is for industrial purposes; nearly one-half of the volume is consumed in the West and South Central States. Texas produces more gas than any other State but uses an amount equal to 54.5 percent of the volumes produced within its borders. Louisiana's consumption of about 1.5 trillion cubic feet was equal to 26.4 percent of the 5.7 trillion cubic feet produced in that State.

Reflecting a continued growth in the demand for natural gas, the United States gas industry spent \$2,252 million for new plant and equipment in 1967. Included were \$1,006 million for new transmission facilities, \$848 million for outlays related to distribution, \$186 million for production and storage, \$91 million for underground storage facilities, and other general expenditures totaling \$121 million.

Industrial Uses.—In the industrial use category, the electric power utilities in the West South Central region used 1.2 trillion cubic feet of natural gas for steam generation, and this accounted for 43.9 percent of the 2.7 trillion cubic feet used for this purpose in the entire United States. This is readily understandable, because no other fuel can compete in price with natural gas in the Southwest. Natural gas is also used extensively in California for steam generation. In this instance, however, air pollution controls and restrictions on fuel use in California precludes the likelihood of any noticeable competition from residual fuel oil in that State.

The industrial use of natural gas is extensive in the chemical and allied product industries; the metals group, including nonferrous metals; the building materials group; and also in foods, paper and allied products. Second in importance in terms of consumption of natural gas is the field use of gas for steam power generation for drilling and pumping; as fuel used in petroleum refineries and for use as pipeline fuel in pumping stations. The combined petroleum-related uses in 1967 added to 3.4 trillion cubic feet or 28.3 percent of the entire industrial use in the United States.

The uptrend in the price of natural gas for residential commercial and industrial applications has made gas unattractive as a raw material for carbon black manufacture.

Residential and Commercial Uses.—The number of gas consumers continues to increase. There were 39.5 million consumers of natural gas in the residential and commercial sectors at the end of 1967. Included in the residential accounts are consumers who use all or any part of applications such as cooking, water heating, air conditioning, and house heating. There was a net increase of 307,000 in the consumer total in 1967, with a gain of 350,000 in residential accounts offset in part by a loss of 43,000 commercial users.

This increase was smaller than the indicated gain in house-heating accounts reported by the American Gas Association for 1967, which suggests that for applications other than house-heating competitive fuels have made some inroads into the overall gas consumer demand.

Results of the AGA Heating Survey show a net increase of 978,000 customers who installed gas heating in 1967, bringing the total number of gas individual house-heating customers to over 28.8 million, a gain of 3.6 percent over the 1966 figure. New homes accounted for 579,000 or 59.2 percent of this increase; conversion from other fuels in existing dwellings represented 40.8 percent. In addition to these, 2,863,000 dwelling units in multifamily structures received gas heat from a central or master metered source, bringing the total number of families served by gas heating to 31,671,000, a gain of 3.8 percent over the 1966 figure.

The East North Central region leads the Nation in house-heating customers and the Pacific region ranks second. The AGA forecasts that in the 3 year period ending 1970, 3.0 million additional heating customers will be recorded.

In terms of over-all gas volumes used, residential and commercial uses absorbed 33 percent of gas consumption in 1967. Field use accounted for nearly 11 percent of the natural gas used. Electric utilities use of gas amounted to 15 percent, while petroleum refineries and other industrial plants made up the remaining 41 percent.

RESERVES

The AGA Committee on Natural Gas Reserves estimated that the total proved recoverable reserves of natural gas in the United States as of December 31, 1967, were 292.9 trillion cubic feet. This includes estimates of offshore reserves, but separate figures are shown only for the Gulf of Mexico (34.2 trillion cubic feet).

The change in reserves for the year was an increase of 3.6 trillion cubic feet. Most of the addition to the reserves in 1967 was the result of the extension of old fields and revisions of previous estimates. The number of gas well completions continued to decline, dropping from 4,377 in 1966 to 3,659 in 1967. The ratio of reserves to annual production declined from 16.5 years in 1966 to 15.9 in 1967.

PRODUCTIVE CAPACITY

The AGA Gas Reserves Subcommittee and the American Petroleum Institute (API) Reserves Subcommittee have prepared estimates of the productive capacity of the natural gas industry as of December 31, 1967. The capacity for nonassociated reservoirs is estimated at 84,732 million cubic feet per day, and from associated-dissolved, 23,344 million cubic feet per day. The productive capacity of natural gas from nonassociated reservoirs is defined as the maximum sustainable rate at which existing gas wells completed in such reservoirs can be produced under present conditions to an unlimited market without specific regard to the capacity of existing producing equipment and pipelines or established allowables. The productive capacity of associated-dissolved natural gas from both oil and gas wells is directly related to the productive capacity of crude oil. It represents the producing gas-oil ratio at the increased rate of crude oil production.

STORAGE

The development of underground gas storage facilities continued to expand, but at a more moderate rate than in the past several years. The additions for the year were less than 100 billion cubic feet and 76 percent was in States located in the heavy consuming Great Lakes region. The ability to store gas in these underground facilities close to major markets during off-season periods has been a dominant factor in the industry's growth. The gas transmission system would be hard pressed to meet peak demands without these supplemental stocks.

The industry added 1.3 trillion cubic feet to underground storage in 1967 and withdrew 1.1 trillion cubic feet.

In addition to underground storage, there is the growth in aboveground storage for liquefied natural gas (LNG). At present most of this type of storage is associated with peak shaving facilities of gas distributing utilities. 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. Storage of large volumes of natural gas can be accomplished in its liquefied state. By lowering the temperature to approximately −260° F, the gas will occupy 1/600-atmosphere pressure.

VALUE AND PRICE

The average value of natural gas at the wellhead increased 0.3 cent to 16 cents per thousand cubic feet (Mcf) while the cost at the point of consumption declined 0.4 cent to 51.9 cents per Mcf. The average cost of natural gas at the point of consumption varies greatly because of transportation costs (from a high of 170.7 cents per Mcf in Maine to a low of 24.1 cents Mcf in Texas). Costs to residential consumers remained the same in 1967, but commercial consumers price increased 1.6 cents per Mcf and industrial consumers benefited by a 0.4-cent reduction.

FOREIGN TRADE

Exports of natural gas to Canada were increasing rapidly, with shipments primarily from Michigan to the Windsor-Sarnia area of Ontario. This export market is expected to continue to expand as additional transmission facilities are installed. Exports to Mexico in 1967 were 11,159 million cubic feet.

Imports of natural gas from Canada also have been increasing steadily while the volumes imported from Mexico have remained at a rather constant level of about 50 billion cubic feet annually. Total imports in 1967 amounted to 564.2 billion cubic feet which was 84.4 billion, or 17.6 percent higher, than the 1966 level. Of the increase, 98.5 percent, or 83.1 billion cubic feet, represented additional imports from Canada. Between 1959 and 1967, the volume of gas imported annually from Canada increased from 81.9 billion to 513.3 billion cubic feet. Most of this imported gas is marketed in States within the Pacific Northwest area, including 394 billion cubic feet in 1967.

The first large-scale commercial export of liquefied natural gas (LNG) from the United States will be a joint venture of the Phillips Petroleum Company and the Marathon Oil Company. They are developing a liquefied natural gas project to market Alaskan gas reserves. A sale has been negotiated in Japan for about 139 million cubic feet per day (MMcfd) of liquefied natural gas to the Tokyo Electric Power Company, Inc., and the Tokyo Gas Company for an initial 15-year term. Shortly after the contract was signed, construction schedules for the producing facilities, liquefaction plant, ships and receiving facilities were prepared and coordinated. First deliveries are scheduled for the third quarter of 1969 so as to be ahead of the 1969–70 heating season.

WORLD REVIEW

The United States, U.S.S.R., Canada, Rumania, and Italy were the leading countries in marketed production of natural gas in 1967. Since 1964 the Netherlands has more than doubled production each year; for 1967 the gain was 115 percent. Marketed production in the United Kingdom increased from 123 million cubic feet in 1966 to 16,527 million cubic feet in 1967 when that country began producing from some North Sea wells.

Natural gas is rapidly becoming an important factor in the energy patterns of many nations in Europe. Natural gas is now, or soon will be transported by large-diameter pipelines from the Soviet Union to Italy, Austria, and possibly France. France also has agreements to purchase LNG from Algeria. The United Kingdom's needs are being supplied in part by liquefied natural gas shipped from Arzew, Algeria to Canvey Island in the Thames Estuary. Gas from the North Sea gasfields is now entering the British market. The Netherlands has become the focal point in gas as it has the world's largest gas reserve at Groningen. Some of the gas from the Netherlands is moving into markets in Germany, Belgium and France.

Nations in Eastern Europe, including Poland and Czechoslovakia, are entering into agreements to expand imports from the Soviet Union over the next decade.[4]

In addition to its arrangements with United Kingdom and France, the Algeria State Company has signed an agreement to supply Spain with Algerian natural gas (LNG) over a 15–year period beginning in 1970.[5]

Another important development in the transport of LNG is the Esso Libya venture which involves the sale of 345 million standard cubic feet daily of 1,350-Btu Libyan natural gas (the energy equivalent of 465 million standard cubic feet daily of 1,000-Btu natural gas) to Italy and to Spain, with deliveries to commence late in 1968. Most of the gas to be liquefied is produced in association with oil. The gas will be liquefied at Marsa el Brega, Libya, and then transported in LNG tankers to La Spezia, Italy, and to Barcelona, Spain. Nearly all of the gas to be liquefied is associated gas from the Zelton field and the Raguba field in the Libyan Desert.

[4] Oil and Gas Journal. V. 65, No. 25, 1967, p. 117.
[5] Page 111 of work cited in footnote 4.

Table 2.—Quantity and value of marketed production [1] of natural gas in the United States

State	1966 Quantity (million cubic feet)	1966 Value (thousands)	1966 Average wellhead value, cents per Mcf	1967 Quantity (million cubic feet)	1967 Value (thousands)	1967 Average wellhead value, cents per Mcf
Alabama	252	$32	12.8	248	$31	12.7
Alaska	11,267	2,794	24.8	14,438	3,610	25.0
Arizona	3,161	436	13.8	1,255	193	15.4
Arkansas	105,174	16,407	15.6	116,522	17,828	15.3
California	689,607	204,059	31.0	681,080	202,290	29.7
Colorado	136,667	17,767	13.0	116,857	15,542	13.3
Florida	212	30	14.2	123	18	14.8
Illinois	7,230	860	11.9	5,144	602	11.7
Indiana	215	51	23.7	198	46	23.4
Kansas	847,495	114,412	13.5	871,971	116,844	13.4
Kentucky	76,536	18,139	23.7	89,168	21,400	24.0
Louisiana	5,081,435	929,902	18.3	5,716,857	1,057,619	18.5
Maryland	696	181	26.0	621	159	25.6
Michigan	34,120	8,598	15.2	33,589	8,296	24.7
Mississippi	156,652	27,257	17.4	139,497	24,133	17.3
Missouri	----------	----------	------	121	30	24.5
Montana	30,685	2,547	8.3	25,866	2,173	8.4
Nebraska	10,196	1,621	15.9	8,453	1,454	17.2
New Mexico	998,076	124,760	12.5	1,067,510	138,776	13.0
New York	2,699	837	31.0	3,837	1,201	31.3
North Dakota	46,585	7,547	16.2	40,462	6,636	16.4
Ohio	43,133	10,223	23.7	41,315	9,957	24.1
Oklahoma	1,351,225	189,172	14.0	1,412,952	202,052	14.3
Pennsylvania	90,914	25,820	28.4	89,966	25,280	28.1
Tennessee	----------	----------	------	58	11	19.0
Texas	6,953,790	903,993	13.0	7,188,900	948,935	13.2
Utah	69,366	8,809	12.7	48,965	6,463	13.2
Virginia	4,249	1,275	30.0	3,818	1,149	30.1
West Virginia	211,610	49,940	23.6	211,460	50,962	24.1
Wyoming	243,381	35,290	14.5	240,074	35,051	14.6
Total	17,206,628	2,702,759	15.7	18,171,325	2,898,741	16.0

[1] Comprises gas either sold or consumed by producers, including gas loss due to natural gas liquids recovery, losses in transmission, quantities added to storage, and increases of gas in pipelines.

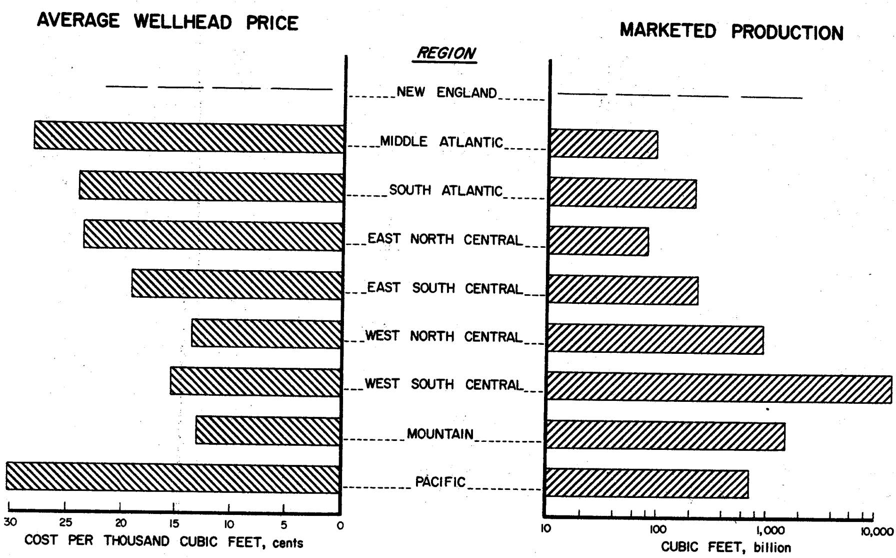

Figure 1.—Marketed production of natural gas by regions and average wellhead prices

Table 3.—Marketed production, interstate shipments, and total consumption of natural gas in the United States

(Million cubic feet)

State by region	Marketed production	Interstate movements: Receipts	Interstate movements: Deliveries	Interstate movements: Net receipts (+) or deliveries (−)	Transmission loss and unaccounted for	Change in underground storage	Consumption
New England:							
Connecticut	----------	135,569	83,826	+51,743	1,963	----------	49,780
Massachusetts	----------	143,318	12,682	+130,636	2,245	+174	128,217
Rhode Island	----------	88,523	69,418	+19,105	612	----------	18,493
Vermont, Maine, and New Hampshire	----------	7,004	----------	+7,004	426	----------	6,578
Total:							
1967	----------	374,414	165,926	+208,488	5,246	+174	203,068
1966	----------	341,029	149,842	+191,187	5,043	----------	186,144
Middle Atlantic:							
New Jersey	----------	673,228	420,719	+252,509	1,033	−6	251,482
New York	3,837	844,048	252,809	+591,239	3,228	+2,728	589,120
Pennsylvania	89,966	1,826,672	1,209,168	+617,504	11,305	+17,566	678,599
Total:							
1967	93,803	3,343,948	1,882,696	+1,461,252	15,566	+20,288	1,519,201
1966	93,613	3,152,931	1,667,256	+1,485,675	56,187	−13,089	1,536,190
East North Central:							
Illinois	5,144	2,163,355	1,152,186	+1,011,169	22,740	+31,495	962,078
Indiana	198	1,813,968	1,371,265	+442,703	3,478	+4,791	434,632
Michigan	33,589	698,475	40,418	+658,057	9,352	−7,152	689,446
Ohio	41,315	2,553,517	1,628,374	+925,143	2,338	+1,299	962,821
Wisconsin	----------	267,045	14,142	+252,903	4,870	----------	248,033
Total:							
1967	80,246	7,496,360	4,206,385	+3,289,975	42,778	+30,433	3,297,010
1966	84,698	6,943,234	3,885,251	+3,057,983	52,766	+46,556	3,043,359
West North Central:							
Iowa	----------	1,173,314	882,504	+290,810	4,838	+13,122	272,850
Kansas	871,971	1,693,221	2,083,980	−390,759	2,280	−2,511	481,443
Minnesota	----------	388,390	105,102	+283,288	202	----------	283,086
Missouri	121	1,661,867	1,291,995	+369,872	9,221	+69	360,703
Nebraska	8,453	1,156,110	973,066	+183,044	1,020	+646	189,831
North Dakota	40,462	6,374	9,512	−3,138	316	----------	37,008
South Dakota	----------	28,868	1,004	+27,864	129	----------	27,735
Total:							
1967	921,007	6,108,144	5,347,163	+760,981	18,006	+11,326	1,652,656
1966	904,276	5,803,100	5,040,007	+763,093	37,365	−1,118	1,631,122

See footnotes at end of table.

Table 3.—Marketed production, interstate shipments, and total consumption of natural gas in the United States—Continued

(Million cubic feet)

State by region	Marketed production	Interstate movements: Receipts	Interstate movements: Deliveries	Interstate movements: Net receipts (+) or deliveries (−)	Transmission loss and unaccounted for	Change in underground storage	Consumption
South Atlantic:							
Delaware	----------	23,389	1,518	+21,871	514	+294	21,063
Florida	123	227,439	----------	+227,439	2,031	----------	225,531
Georgia	----------	1,055,687	797,663	+258,024	3,690	----------	254,334
Maryland and District of Columbia	621	693,372	543,626	+149,746	1,726	+8,788	139,853
North Carolina	----------	673,861	574,676	+99,185	1,204	----------	97,981
South Carolina	----------	778,373	673,861	+104,512	3,973	----------	100,539
Virginia	3,818	795,107	680,254	+114,853	2,712	+72	115,887
West Virginia	211,460	1,090,403	1,124,633	−34,230	1,487	+10,515	165,228
Total:							
1967	216,022	5,337,631	4,396,231	+941,400	17,337	+19,669	1,120,416
1966	216,767	4,916,426	4,040,695	+875,731	25,069	−2,394	1,069,823
East South Central:							
Alabama	248	2,509,299	2,254,258	+255,041	1,113	----------	254,176
Kentucky	89,168	3,083,696	2,962,722	+120,974	3,942	+2,236	203,964
Mississippi	139,497	4,980,531	4,833,931	+146,600	3,286	−476	283,287
Tennessee	58	3,312,635	3,074,312	+238,323	6,169	----------	232,212
Total:							
1967	228,971	13,886,161	13,125,223	+760,938	14,510	+1,760	973,639
1966	233,440	13,014,234	12,330,958	+683,276	14,909	−4,098	905,905
West South Central:							
Arkansas	116,522	2,457,182	2,259,392	+197,790	14,927	+426	298,959
Louisiana	5,716,857	1,237,137	5,383,284	−4,146,147	16,428	+44,729	1,509,553
Oklahoma	1,412,952	1,054,717	1,936,297	−881,580	4,537	+26,505	500,330
Texas	7,188,900	323,801	3,528,253	−3,204,452	54,449	+11,069	3,918,930
Total:							
1967	14,435,231	5,072,837	13,107,226	−8,034,389	90,341	+82,729	6,227,772
1966	13,491,624	5,088,542	12,654,033	−7,565,491	123,323	+49,209	5,753,601
Mountain:							
Arizona	1,255	1,316,669	1,157,939	+158,730	1,219	----------	158,766
Colorado	116,857	218,751	93,325	+125,426	5,515	+1,134	235,634
Idaho	----------	323,124	288,469	+34,655	372	----------	34,283
Montana	25,866	66,519	11,495	+55,024	1,289	+13,819	65,782
Nevada	----------	35,627	----------	+35,627	592	----------	35,035
New Mexico	1,067,510	623,090	1,376,027	−752,937	12,616	+218	301,739
Utah	48,965	199,031	138,978	+60,053	1,113	+220	107,685
Wyoming	240,074	77,441	230,789	−153,348	2,658	−1,209	85,277

Total:							
1967	1,500,527	2,860,252	3,297,022	−436,770	25,374	+14,182	1,024,201
1966	1,481,336	2,693,162	3,112,955	−419,793	46,446	+27,164	987,933
Pacific:							
Alaska	14,438	----------	----------	----------	2,549	----------	11,889
California	681,080	1,329,287	----------	+1,329,287	61,228	+3,204	1,945,935
Oregon	----------	276,786	205,166	+71,620	1,743	----------	69,877
Washington	----------	394,651	264,821	+129,830	1,536	+1,064	127,230
Total:							
1967	695,518	2,000,724	469,987	+1,530,737	67,056	+4,268	2,154,931
1966	700,874	1,752,325	368,845	+1,383,480	40,095	−33,375	2,077,634
Total United States:							
1967	18,171,325	[1] 46,480,471	[2] 45,997,859	+482,612	296,214	+184,829	18,172,894
1966	17,206,628	43,704,983	43,249,842	+455,141	401,203	+68,855	17,191,711

[1] Includes receipts from Canada of 253,707 MMcf into Idaho; 83,718 MMcf into Minnesota; 30,769 MMcf into Montana; 613 MMcf into Vermont; 140,428 MMcf into Washington; 4,020 MMcf into New York and from Mexico 50,971 MMcf into Texas.

[2] Includes deliveries into Canada of 29,932 MMcf from New York; 40,418 MMcf from Michigan and 106 MMcf from Montana and into Mexico 3,716 MMcf from Arizona and 7,442 MMcf from Texas.

Table 4.—Net interstate pipeline movements

(Billion cubic feet

Region and State and State abbreviation	Net receipt (+) or delivery (−)	Receipts State, quantity							
New England:									
Connecticut (CT)	+51.7	MA	1.6	NY	133.9	----	-------	----	-------
Massachusetts (MA)	+130.6	NY	73.9	RI	64.7	----	-------	----	-------
Rhode Island (RI)	+19.1	CT	83.8	----	-------	----	-------	----	-------
Maine, Vermont, N. Hampshire (ME) (VT) (NH)	+7.0	CN	0.6	MA	6.4	----	-------	----	-------
Total	+208.4	NY	207.8	CN	0.6	----	-------	----	-------
Middle Atlantic:									
New Jersey (NJ)	+252.6	PA	672.9	----	-------	----	-------	----	-------
New York (NY)	+591.2	NJ	420.3	PA	404.6	CN	4.0	----	-------
Pennsylvania (PA)	+617.5	MD	531.8	OH	633.2	WV	553.4	----	-------
Total	+1,461.3	MD	531.8	OH	633.2	WV	553.4	CN	4.0
East North Central:									
Illinois (IL)	+1,011.2	IA	567.8	KY	372.9	MO	1,081.5	----	-------
Indiana (IN)	+442.7	IL	844.9	KY	827.9	----	-------	----	-------
Michigan (MI)	+658.1	IN	196.5	OH	487.9	WI	14.1	----	-------
Ohio (OH)	+925.1	IN	1,033.6	KY	1,110.5	----	-------	----	-------
Wisconsin (WI)	+252.9	IL	166.1	MN	100.9	----	-------	----	-------
Total	+3,290.0	IA	567.8	KY	2,311.3	MN	100.9	MO	1,081.5
West North Central:									
Iowa (IA)	+290.9	MO	209.9	NB	963.2	----	-------	----	-------
Kansas (KS)	−390.8	OK	1,662.7	----	-------	----	-------	----	-------
Minnesota (MN)	+283.3	IA	304.4	SD	.3	CN	83.7	----	-------
Missouri (MO)	+369.9	AR	791.4	KS	859.2	OK	10.7	----	-------
Nebraska (NB)	+183.0	CO	2.9	KS	1,135.6	WY	17.1	----	-------
North Dakota (ND)	−3.1	MN	4.2	----	-------	----	-------	----	-------
South Dakota (SD)	+27.9	IA	10.0	MT	9.1	NB	9.4	----	-------
Total	+761.1	OK	1,673.4	CN	83.7	AR	791.4	WY	16.8
South Atlantic:									
Delaware (DE)	+21.9	PA	23.4	----	-------	----	-------	----	-------
Florida (FL)	+227.4	AL	218.4	GA	9.0	----	-------	----	-------
Georgia (GA)	+258.0	AL	1,055.1	----	-------	----	-------	----	-------
Maryland and D.C. (MA)	+149.7	VA	675.2	WV	4.8	DE	1.5	----	-------
North Carolina (NC)	+99.2	SC	673.9	----	-------	----	-------	----	-------
South Carolina (SC)	+104.5	GA	778.4	----	-------	----	-------	----	-------
Virginia (VA)	+114.9	NC	574.7	TN	3.0	WV	213.0	----	-------
West Virginia (WV)	−34.2	KY	639.1	OH	97.9	----	-------	----	-------
Total	+941.4	AL	1,273.5	KY	638.5	OH	97.9	----	-------
East South Central:									
Alabama (AL)	+255.0	MS	2,506.3	----	-------	----	-------	----	-------
Kentucky (KY)	+121.0	TN	3,070.8	VA	.6	----	-------	----	-------
Mississippi (MS)	+146.6	AR	1,461.1	LA	3,516.3	----	-------	----	-------
Tennessee (TN)	+238.2	AL	977.8	GA	9.7	MS	2,324.5	----	-------
Total	+760.8	AR	1,461.1	LA	3,516.3	----	-------	----	-------
West South Central:									
Arkansas (AR)	+197.8	LA	1,740.1	OK	70.1	TX	640.1	----	-------
Louisiana (LA)	−4,146.1	TX	1,110.3	----	-------	----	-------	----	-------
Oklahoma (OK)	−881.6	TX	929.2	----	-------	----	-------	----	-------
Texas (TX)	−3,204.5	MX	51.0	----	-------	----	-------	----	-------
Total	−8,034.4	MX	51.0	----	-------	----	-------	----	-------
Mountain:									
Arizona (AZ)	+158.7	NM	1,298.2	UT	9.3	----	-------	----	-------
Colorado (CO)	+125.4	KS	58.7	NM	23.1	OK	67.3	WY	59.7
Idaho (ID)	+34.7	UT	61.9	CN	253.9	----	-------	----	-------
Montana (MT)	+55.0	ND	7.3	WY	26.1	CN	30.7	----	-------
Nevada (NV)	+35.6	AZ	19.8	ID	15.8	----	-------	----	-------
New Mexico (NM)	−752.8	TX	568.5	----	-------	----	-------	----	-------
Utah (UT)	+60.1	CO	80.5	WY	50.8	----	-------	----	-------
Wyoming (WY)	−153.4	SD	.3	----	-------	----	-------	----	-------
Total	−436.7	KS	58.7	OK	67.3	CN	284.6	ND	7.3

See footnotes at end of table.

of natural gas in the United States in 1967—Continued
at 14.73 p.s.i.)

Deliveries State, quantity													
----	-----	RI	83.8	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	CT	1.6	NH	6.4	----	-------	----	-------	----	-----	----	-----
----	-----	MA	64.7	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	----	-------	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	----	-------	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	NY	420.3	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	CT	133.9	MA	73.9	CN	29.9	----	-------	----	-----	----	-----
----	-----	DE	23.4	NJ	672.9	NY	404.6	----	-------	----	-----	----	-----
----	-----	CT	133.9	MA	73.9	DE	23.4	CN	29.9	----	-----	----	-----
----	-----	IN	844.9	WI	166.1	----	-------	----	-------	----	-----	----	-----
----	-----	MI	196.5	OH	1,033.6	----	-------	----	-------	----	-----	----	-----
----	-----	CN	40.4	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	MI	487.9	PA	633.2	WV	97.9	----	-------	----	-----	----	-----
----	-----	MI	14.1	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	PA	633.2	WV	97.9	CN	40.4	----	-------	----	-----	----	-----
----	-----	IL	567.8	MN	304.4	LA	10.0	----	-------	----	-----	----	-----
----	-----	CO	58.7	MO	859.2	NB	1,135.6	----	-------	----	-----	----	-----
----	-----	ND	4.2	WI	100.9	----	-------	----	-------	----	-----	----	-----
----	-----	IL	1,081.5	IA	209.9	----	-------	----	-------	----	-----	----	-----
----	-----	IA	963.2	SD	9.4	----	-------	----	-------	----	-----	----	-----
----	-----	MT	7.3	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	MN	.3	WY	.3	----	-------	----	-------	----	-----	----	-----
MT	1.8	CO	55.8	IL	1,649.3	WI	100.9	----	-------	----	-----	----	-----
----	-----	MD	1.5	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	----	-------	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	FL	9.0	SC	778.4	TN	9.7	----	-------	----	-----	----	-----
----	-----	PA	531.8	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	VA	574.7	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	NC	673.9	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	KY	.6	MD	675.2	----	-------	----	-------	----	-----	----	-----
----	-----	MD	4.8	PA	553.4	VA	213.0	----	-------	----	-----	----	-----
----	-----	PA	1,061.8	TN	6.7	----	-------	----	-------	----	-----	----	-----
----	-----	FL	218.4	GA	1,055.1	TN	977.8	----	-------	----	-----	----	-----
----	-----	IL	372.9	IN	827.9	OH	1,110.5	WV	639.1	----	-----	----	-----
----	-----	AL	2,506.3	TN	2,324.5	----	-------	----	-------	----	-----	----	-----
----	-----	KY	3,070.8	VA	3.0	----	-------	----	-------	----	-----	----	-----
----	-----	OH	1,110.5	VA	2.4	WV	639.1	GA	1,045.4	FL	218.4	IL	372.9
		IN	827.9										
----	-----	MS	1,461.1	MO	791.4	----	-------	----	-------	----	-----	----	-----
----	-----	AR	1,740.1	MS	3,516.3	----	-------	----	-------	----	-----	----	-----
----	-----	AR	70.1	CO	67.3	KS	1,662.7	MO	10.7	----	-----	----	-----
----	-----	AR	640.1	LA	1,110.3	NM	568.5	OK	929.2	MX	7.4	----	-----
----	-----	MO	802.1	MS	4,977.4	KS	1,662.7	NM	568.5	CO	67.3	MX	7.4
----	-----	CA	1,125.2	NV	19.8	MX	3.8	----	-------	----	-----	----	-----
----	-----	NB	2.9	UT	80.5	----	-------	----	-------	----	-----	----	-----
----	-----	NV	15.8	OR	19.5	WA	245.8	----	-------	----	-----	----	-----
----	-----	SD	9.1	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	----	-------	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	AZ	1,298.2	CO	23.1	----	-------	----	-------	----	-----	----	-----
----	-----	AZ	9.3	ID	61.9	----	-------	----	-------	----	-----	----	-----
----	-----	CO	59.7	MT	26.1	NB	17.1	UT	50.8	----	-----	----	-----
TX	568.5	CA	1,125.2	NB	20.0	SD	8.8	OR	19.5	WA	245.8	MX	3.8

Table 4.—Net interstate pipeline movements

(Billion cubic feet

Region and State and State abbreviation	Net receipt (+) or delivery (−)	Receipts State, quantity							
Pacific:									
Alaska (AK)	--------	----	-------	----	-------	----	-------	----	-------
California (CA)	+1,329.3	AZ	1,125.2	OR	204.1	----	-------	----	-------
Oregon (OR)	+71.6	ID	19.5	WA	256.2	----	-------	----	-------
Washington (WA)	+129.8	ID	245.8	CN	140.2	----	-------	----	-------
Total	+1,530.7	AZ	1,125.2	ID	265.3	CN	140.2	----	-------
Total United States	482.6	----	-------	----	-------	----	-------	----	-------
Foreign:									
Canada (CN)	--------	----	70.5	----	-------	----	-------	----	-------
Mexico (MX)	--------	----	11.2	----	-------	----	-------	----	-------

Note: Detail figures may not add to totals due to independent rounding.

of natural gas in the United States in 1967—Continued
at 14.73 p.s.i.)

					Deliveries State, quantity								
----	-----	----	-------	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	----	-------	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	CA	204.1	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	OR	256.2	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	----	-------	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	----	-------	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	----	513.3	----	-------	----	-------	----	-------	----	-----	----	-----
----	-----	----	51.0	----	-------	----	-------	----	-------	----	-----	----	-----

Table 5.—Number of consumers and volume of natural gas consumed by principal uses in the United States [1]

State by region	Number of consumers (thousands)		Volume of natural gas (million cubic feet)								
					Industrial						
	Residential	Commercial	Residential	Commercial	Field use (pumping, drilling, extraction loss and plant fuel)	Used as fuel at petroleum refineries	Used as pipeline fuel	All other industrial fuel including electric utilities	Total industrial	Total consumption	Consumed at electric utilities (included in other industrial use) [2]
New England:											
Connecticut	358	26	26,177	8,031	---------	-------	307	15,265	15,572	49,780	458
Massachusetts	965	61	73,471	21,602	---------	-------	1,981	31,163	33,144	128,217	8,582
Rhode Island	147	9	10,350	2,882	---------	-------	33	5,228	5,261	18,493	265
Vermont, Maine, and New Hampshire	59	4	3,967	1,593	---------	-------	19	999	1,018	6,578	---------
Total	1,529	100	113,965	34,108	---------	-------	2,340	52,655	54,995	203,068	9,305
Middle Atlantic:											
New Jersey	1,538	161	135,143	26,466	---------	6,534	712	82,627	89,873	251,482	23,800
New York	3,797	276	313,656	107,901	508	-------	6,728	160,327	167,563	589,120	84,286
Pennsylvania	2,202	137	279,817	76,988	2,391	25,383	23,612	270,408	321,794	678,599	2,362
Total	7,537	574	728,616	211,355	2,899	31,917	31,052	513,362	579,230	1,519,201	110,448
East North Central:											
Illinois	2,620	184	382,277	169,854	14,155	18,166	19,402	358,224	409,947	962,078	45,888
Indiana	932	90	139,519	57,181	5	5,120	11,165	221,642	237,932	434,632	14,934
Michigan	1,729	148	302,472	107,796	6,149	2,540	8,805	261,684	279,178	689,446	4,349
Ohio	2,348	179	442,360	141,374	2,656	13,807	13,344	349,280	379,087	962,821	6,359
Wisconsin	691	52	90,994	31,544	---------	(3)	2,780	[3] 122,715	125,495	248,033	20,170
Total	8,320	653	1,357,622	507,749	22,965	(3)	55,496	[3] 1,313,545	1,431,639	3,297,010	91,700
West North Central:											
Iowa	527	68	81,592	45,005	---------	-------	13,765	132,488	146,253	272,850	60,538
Kansas	544	56	84,912	31,218	38,322	30,335	57,222	239,434	365,313	481,443	135,749
Minnesota	554	46	89,020	38,911	---------	(3)	2,654	152,501	155,155	283,086	55,487
Missouri	895	92	133,355	68,736	---------	(3)	10,539	148,073	158,612	360,703	46,748
Nebraska	301	42	53,819	32,263	3,334	(3)	10,256	90,159	103,749	189,831	39,514
North Dakota	44	6	6,467	5,654	22,283	(3)	11	2,593	24,887	37,008	23
South Dakota	69	10	9,910	9,607	---------	-------	50	8,168	8,218	27,735	3,455
Total	2,934	320	459,075	231,394	63,939	(3)	94,497	773,416	962,187	1,652,656	341,514
South Atlantic:											
Delaware	73	5	6,844	1,968	---------	(3)	-------	[3] 12,251	12,251	21,063	3,913
Florida	343	25	9,430	19,084	210	-------	3,827	[3] 192,980	197,017	225,531	107,815
Georgia	681	53	80,322	28,590	---------	(3)	6,173	139,249	145,422	254,334	8,860

Maryland and District of Columbia	774	61	77,130	25,788	257	-------	1,825	34,853	36,935	139,853	372
North Carolina	219	34	21,416	11,047	---------	-------	4,353	61,165	65,518	97,981	2,063
South Carolina	197	22	13,774	7,495	---------	-------	2,419	76,851	79,270	100,539	15,149
Virginia	449	48	41,495	19,230	---------	-------	7,020	48,142	55,162	115,887	2,480
West Virginia	331	28	50,202	15,487	16,202	637	16,710	65,990	99,539	165,228	618
Total	3,067	276	300,613	128,689	16,669	(3)	42,327	[3] 631,481	691,114	1,120,416	141,270
East South Central:											
Alabama	501	36	45,543	30,004	162	(3)	15,221	[3] 163,246	178,629	254,176	7,863
Kentucky	484	47	69,542	25,698	13,328	(3)	28,980	[3] 66,416	108,724	203,964	380
Mississippi	297	34	26,145	13,082	9,709	(3)	48,738	[3] 185,613	244,060	283,287	74,035
Tennessee	376	47	41,659	31,261	355	(3)	22,268	[3] 136,669	159,292	232,212	24,991
Total	1,658	164	182,889	100,045	23,554	(3)	115,207	[3] 551,944	690,705	973,639	107,269
West South Central:											
Arkansas	348	47	52,777	33,122	13,766	10,561	12,057	176,676	213,060	298,959	54,486
Louisiana	792	79	74,386	35,348	311,167	109,432	56,936	922,284	1,399,819	1,509,553	223,282
Oklahoma	612	64	67,395	29,731	116,119	46,782	14,184	226,119	403,204	500,330	154,177
Texas	2,332	238	201,407	90,614	1,078,742	508,798	72,353	1,967,016	3,626,909	3,918,930	774,033
Total	4,084	428	395,965	188,815	1,519,794	675,573	155,530	3,292,095	5,642,992	6,227,772	1,205,978
Mountain:											
Arizona	366	35	25,376	15,095	33	-------	23,724	94,538	118,295	158,766	39,944
Colorado	474	57	75,351	38,855	6,794	2,034	1,615	110,985	121,428	235,634	36,443
Idaho	58	10	6,179	4,972	---------	-------	1,406	21,726	23,132	34,283	---------
Montana	129	16	19,756	13,090	6,648	3,533	776	21,979	32,936	65,782	502
Nevada	56	3	5,230	3,660	---------	-------	24	26,121	26,145	35,035	16,455
New Mexico	241	27	31,126	15,847	92,942	2,692	24,440	134,692	254,766	301,739	50,283
Utah	232	15	38,935	6,882	4,589	5,773	210	51,296	61,868	107,685	7,390
Wyoming	67	9	11,939	10,148	27,715	9,046	4,326	22,103	63,190	85,277	159
Total	1,623	172	213,892	108,549	138,721	23,078	56,521	483,440	701,760	1,024,201	151,176
Pacific:											
Alaska	9	2	1,958	2,722	1,659	-------	-------	5,550	7,209	11,889	4,318
California	5,303	337	522,122	181,392	135,300	108,885	18,414	979,822	1,242,421	1,945,935	579,952
Oregon	158	21	13,427	6,912	---------	-------	1,903	47,635	49,538	69,877	321
Washington	212	30	23,160	14,821	---------	-------	2,465	86,784	89,249	127,230	---------
Total	5,682	390	560,667	205,847	136,959	108,885	22,782	1,119,791	1,388,417	2,154,931	584,591
Total United States:											
1967	36,434	3,077	4,313,304	1,716,551	1,925,500	[4] 936,085	575,752	[4] 8,705,702	12,143,039	18,172,894	2,743,251
1966	36,084	3,120	4,138,259	1,622,740	1,772,708	903,398	535,353	8,219,253	11,430,712	17,191,711	2,608,768

[1] Includes natural gas which is distributed as component of mixed gas.
[2] Federal Power Commission, preliminary figures.
[3] Included in "All other industrial fuel" to avoid disclosure.
[4] Detail does not add to total. Total figures for "Used as fuel at petroleum refineries" included 70,605 MMcf which is excluded in total figure for "All other industrial fuel." Natural gas used to produce carbon black, amounting to 84,068 MMcf, is included in "All other industrial fuel."

Table 6.—Value of natural gas at the point of consumption in the United States

State by region	Value (thousand dollars)						Average value (cents per Mcf)					
	Residential	Commercial	Industrial: Field use (pumping, drilling, extraction loss, and plant fuel)	Industrial: All other including electric utilities	Industrial: Total	Total consumption	Residential	Commerical	Industrial: Field use (pumping, drilling, extraction loss, and plant fuel)	Industrial: All other including electric utilities	Industrial: Total	Total consumption
New England:												
Connecticut	47,825	12,279	---------	11,096	11,096	71,200	182.7	152.9	-----	71.3	71.3	143.0
Massachusetts	137,979	31,647	---------	19,561	19,561	189,187	187.8	146.5	-----	59.0	59.0	147.6
New Hampshire, Vermont, and Maine	7,763	2,364	---------	1,103	1,103	11,230	195.7	148.4	-----	108.3	108.3	170.7
Rhode Island	18,734	4,332	---------	4,242	4,242	27,308	181.0	150.3	-----	80.6	80.6	147.7
Total	212,301	50,622	---------	36,002	36,002	298,925	186.3	148.4	-----	65.5	65.5	147.2
Middle Atlantic:												
New Jersey	258,743	39,274	---------	43,925	43,925	341,942	191.5	148.4	-----	48.9	48.9	136.0
New York	446,646	135,632	143	109,261	109,404	691,682	142.3	125.7	28.1	65.4	65.3	117.4
Pennsylvania	320,881	69,638	932	168,007	168,939	559,458	114.7	90.5	39.0	52.6	52.5	82.4
Total	1,026,270	244,544	1,075	321,193	322,268	1,593,082	140.9	115.7	37.1	55.7	55.6	104.9
East North Central:												
Illinois	390,798	128,919	2,335	167,156	169,491	689,208	102.2	75.9	16.5	42.2	41.3	71.6
Indiana	137,008	48,947	1	105,505	105,506	291,461	98.2	85.6	20.0	44.3	44.3	67.1
Michigan	295,818	88,285	1,363	138,582	139,945	524,048	97.8	81.9	22.2	50.8	50.1	76.0
Ohio	379,103	105,589	875	197,443	198,318	683,010	85.7	74.7	32.9	52.5	52.3	70.9
Wisconsin	93,178	26,371	---------	55,113	55,113	174,662	102.4	83.6	-----	43.9	43.9	70.4
Total	1,295,905	398,111	4,574	663,799	668,373	2,362,389	95.5	78.4	19.9	47.1	46.7	71.7
West North Central:												
Iowa	75,685	29,529	---------	42,560	42,560	147,774	92.8	65.6	-----	29.1	29.1	54.1
Kansas	50,220	13,736	5,552	91,149	96,701	160,657	59.1	44.0	14.5	27.9	26.5	33.4
Minnesota	91,586	28,266	---------	53,283	53,283	173,135	102.9	72.6	-----	34.3	34.3	61.2
Missouri	111,885	42,204	---------	47,477	47,477	201,566	83.9	61.4	-----	29.9	29.9	55.9
Nebraska	42,732	17,168	603	26,810	27,413	87,313	79.4	53.2	18.1	26.7	26.4	46.0
North Dakota	6,085	3,579	3,047	975	4,022	13,686	94.1	63.3	13.7	37.4	16.2	37.0
South Dakota	9,840	5,995	---------	2,559	2,559	18,394	99.3	62.4	-----	31.1	31.1	66.3
Total	388,033	140,477	9,202	264,813	274,015	802,525	84.5	60.7	14.4	29.5	28.5	48.6

South Atlantic:												
Delaware	10,924	2,404	----------	4,064	4,064	17,392	159.6	122.2	-----	33.2	33.2	82.6
Florida	21,350	20,458	34	57,912	57,946	99,754	226.4	107.2	16.2	29.4	29.4	44.2
Georgia	82,491	19,823	----------	71,821	71,821	174,135	102.7	69.3	-----	49.4	49.4	68.5
Maryland	111,271	30,293	125	25,566	25,691	167,255	144.3	177.4	48.6	69.7	69.6	[1] 119.6
North Carolina	27,997	12,545	----------	30,549	30,549	71,091	130.7	113.6	-----	46.6	46.6	72.6
South Carolina	19,229	7,452	----------	31,059	31,059	57,740	139.6	99.4	-----	39.2	39.2	57.4
Virginia	60,630	18,761	----------	24,837	24,837	104,228	146.1	97.6	-----	45.0	45.0	89.7
West Virginia	42,273	10,750	3,926	36,736	40,662	93,685	84.2	69.4	24.2	44.1	40.9	56.7
Total	376,165	122,486	4,085	282,544	286,629	785,280	125.1	95.2	24.5	41.9	41.5	70.1
East South Central:												
Alabama	51,551	16,856	63	53,911	53,974	122,381	113.2	56.2	38.9	30.2	30.2	48.1
Kentucky	58,624	18,169	2,789	39,386	42,175	118,968	84.3	70.7	20.9	41.3	38.8	58.3
Mississippi	23,027	7,481	1,601	62,370	63,971	94,479	88.1	57.2	16.5	26.6	26.2	33.4
Tennessee	37,618	22,352	85	51,324	51,409	111,379	90.3	71.5	23.9	32.3	32.3	48.0
Total	170,820	64,858	4,538	206,991	211,529	447,207	93.4	64.8	19.3	31.0	30.6	45.9
West South Central:												
Arkansas	37,736	16,958	2,332	51,474	53,806	108,500	71.5	51.2	16.9	25.8	25.3	36.3
Louisiana	55,938	16,755	70,657	228,380	299,037	371,730	75.2	47.4	22.7	21.0	21.4	24.6
Oklahoma	52,311	15,436	17,998	59,030	77,028	144,775	77.6	51.9	15.5	20.6	19.1	28.9
Texas	175,425	50,291	187,185	530,703	717,888	943,604	87.1	55.5	17.4	20.8	19.8	24.1
Total	321,410	99,440	278,172	869,587	1,147,759	1,568,609	81.2	52.7	18.3	21.1	20.3	25.2
Mountain:												
Arizona	24,369	8,608	5	37,106	37,111	70,088	96.0	57.0	15.2	31.4	31.4	44.1
Colorado	50,033	21,841	929	26,740	27,669	99,543	66.4	56.2	13.7	23.3	22.8	42.2
Idaho	7,981	4,701	----------	9,484	9,484	22,166	129.2	94.5	-----	41.0	41.0	64.7
Montana	15,735	7,470	689	8,964	9,653	32,858	79.6	57.1	10.4	34.1	29.3	49.9
Nevada	7,406	3,339	----------	11,293	11,293	22,038	141.6	91.2	-----	43.2	43.2	62.9
New Mexico	28,325	9,683	10,464	39,526	49,990	87,998	91.0	61.1	11.3	24.4	19.6	29.2
Utah	26,575	3,852	728	16,556	17,284	47,711	68.3	56.0	15.9	28.9	27.9	44.3
Wyoming	7,880	4,465	3,967	8,051	12,018	24,363	66.0	44.0	14.3	22.7	19.0	28.6
Total	168,304	63,959	16,782	157,720	174,502	406,765	78.7	58.9	12.1	28.0	24.9	39.7
Pacific:												
Alaska	2,963	2,695	407	2,135	2,542	8,200	151.3	99.0	24.5	38.5	35.3	69.0
California	483,269	123,774	41,082	383,089	424,171	1,031,214	92.6	68.2	30.4	34.6	34.1	53.0
Oregon	21,132	9,622	----------	20,694	20,694	51,448	157.4	139.2	-----	41.8	41.8	73.6
Washington	34,277	17,237	----------	34,957	34,957	86,471	148.0	116.3	-----	39.2	39.2	68.0
Total	541,641	153,328	41,489	440,875	482,364	1,177,333	96.6	74.5	30.3	35.2	34.7	54.6
Total United States:												
1967	**4,500,849**	**1,337,825**	**359,917**	**3,243,524**	**[2] 3,603,441**	**9,442,115**	**104.3**	**77.9**	**18.7**	**31.7**	**29.7**	**51.9**
1966	**4,317,877**	**1,238,377**	**351,125**	**3,089,071**	**3,440,196**	**8,995,950**	**104.3**	**76.3**	**19.8**	**32.0**	**30.1**	**52.3**

[1] District of Columbia included with Maryland to avoid disclosure.
[2] Includes $114,116,000 "Used as pipeline fuel."

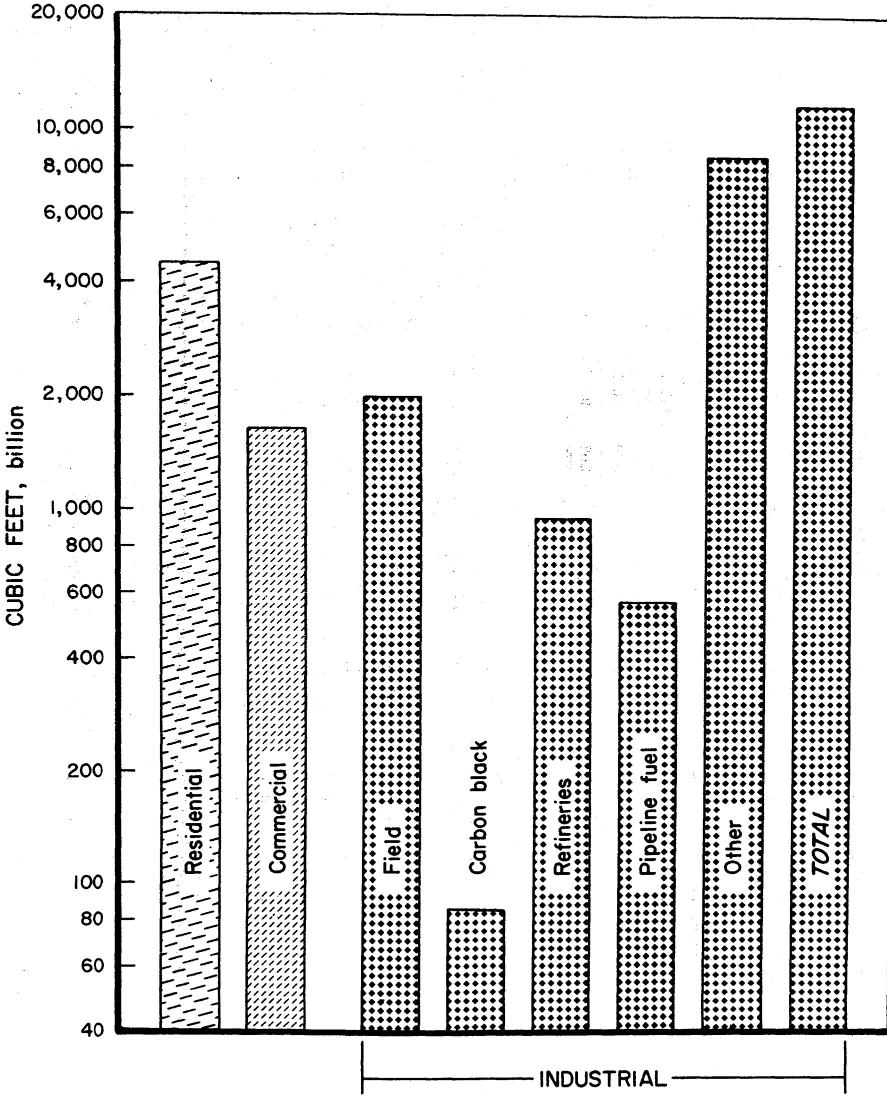

Figure 2.—Disposition of natural gas consumed in United States by principal use, billion cubic feet.

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 gallons)	Natural gas processed	Extraction loss (shrinkage)	Disposition of residue gas						Total residue gas
				Used at plants	Returned to formation	Vented or flared	Returned to transmission companies	Direct deliveries to consumers	Unaccounted for	
1966:										
Arkansas	96,714	112,996	4,963	4,935	15,196	27	87,875	------	------	108,033
California	987,802	517,798	37,912	29,920	129,877	188	319,901	------	------	479,886
Colorado	132,810	129,891	4,889	4,215	13,666	53	107,068	------	------	125,002
Kansas	839,217	1,193,190	27,607	7,045	------	108	1,158,430	------	------	1,165,583
Kentucky [1] [2]	591,533	481,833	35,143	2,438	------	------	444,252	------	------	446,690
Louisiana	3,031,791	r 2,971,155	87,294	53,562	144,515	953	r 2,684,831	------	------	r 2,883,861
Michigan	95,422	164,264	2,943	2,232	8,353	------	150,736	------	------	161,321
Mississippi	42,386	56,731	1,422	1,738	17,275	248	36,048	(4)	NA	55,309
Montana [3]	87,612	40,116	2,799	3,550	8,010	21	25,736	------	------	37,317
Nebraska	28,865	14,233	2,043	829	------	------	11,361	------	------	12,190
New Mexico	1,154,934	873,571	39,861	37,485	15,829	8,447	771,949	------	------	833,710
North Dakota	115,084	41,596	6,225	6,368	------	515	r 28,488	------	------	35,371
Oklahoma	1,562,378	1,020,633	48,655	46,349	49,511	1,089	875,029	------	------	971,978
Pennsylvania	5,074	3,138	172	13	50	------	2,903	------	------	2,966
Texas	10,250,137	r 6,760,088	r 411,256	347,809	r 891,626	26,529	r 5,082,868	------	------	r 6,348,832
West Virginia [5]	398,511	301,671	14,733	1,424	------	------	285,514	------	------	286,938
Wyoming	262,452	241,525	11,391	8,090	6,851	230	214,963	------	------	230,134
Total	19,682,722	r 14,924,429	r 739,308	558,002	r 1,300,759	38,408	r 12,287,952	------	------	r 14,185,121
1967:										
Arkansas	81,263	93,452	3,499	4,879	14,510	31	67,065	3,468	------	89,953
California	980,057	505,063	34,803	28,914	117,382	434	218,890	104,166	474	470,260
Colorado	123,389	112,440	4,126	4,148	9,817	187	93,293	640	229	108,314
Kansas	859,230	1,250,286	30,480	7,613	------	109	1,172,428	39,746	−90	1,219,806
Kentucky [1] [2]	604,877	483,902	25,226	3,502	------	------	448,127	6,559	488	458,676
Louisiana	3,599,292	3,383,334	115,177	52,804	138,564	1,478	2,383,548	616,280	75,483	3,268,157
Michigan	107,207	171,531	3,351	2,344	9,233	------	156,603	------	------	168,180
Mississippi	35,733	46,068	1,127	1,661	12,938	171	28,585	1,511	75	44,941
Montana [3]	103,756	60,500	3,377	4,963	14,787	378	36,586	------	409	57,123
Nebraska	28,543	13,130	1,170	730	107	77	11,122	------	−76	11,960
New Mexico	1,247,282	923,202	46,149	37,052	14,434	5,559	727,960	87,529	4,519	877,053
North Dakota	111,949	42,828	5,150	1,474	4,177	343	30,228	------	1,456	37,678
Oklahoma	1,574,538	1,038,103	50,952	48,164	56,531	1,326	775,311	105,041	778	987,151
Pennsylvania	2,924	2,247	121	14	49	------	2,063	------	------	2,126
Texas	11,481,028	7,018,237	433,684	312,011	929,381	25,394	4,973,776	329,361	14,630	6,584,553
West Virginia [5]	393,053	235,832	14,150	1,941	------	------	216,929	2,812	------	221,682
Wyoming	273,001	261,478	11,993	9,957	12,473	450	219,554	6,764	287	249,485
Total	21,607,122	15,641,633	784,535	522,171	1,334,383	35,937	11,562,068	1,303,877	98,662	14,857,098

r Revised.
[1] Includes gas from transmission lines previously processed in another state.
[2] Illinois included wih Kentucky.
[3] Utah included with Montana.
[4] Included in "Returned to transmission companies".
[5] Florida included with West Virginia.

Table 8.—Estimated proved recoverable reserves of natural gas in the United States as of December, 31, 1967

(Million cubic feet at 14.73 psia at 60° F)

State	Nonassociated	Associated-dissolved	Underground storage [1]	Total
Alaska	3,383,695	251,559	----------	3,635,254
Arkansas	2,528,883	261,405	20,963	2,811,251
California [2]	3,078,508	4,455,124	190,165	7,723,797
Colorado	1,503,440	246,754	19,069	1,769,263
Illinois	536	25,361	232,707	258,604
Indiana	1,830	8,394	64,557	74,781
Kansas	14,760,620	432,647	90,390	15,283,657
Kentucky	848,533	57,978	47,472	953,983
Louisiana [2]	70,899,751	15,310,629	79,629	86,290,009
Michigan	90,774	87,711	582,427	760,912
Mississippi	1,268,380	322,557	6,070	1,597,007
Montana	550,681	138,454	148,583	837,718
Nebraska	30,762	17,083	15,947	63,792
New Mexico	11,689,327	3,387,979	15,159	15,092,465
New York	24,809	213	96,064	121,086
North Dakota	6,219	875,913	----------	882,132
Ohio	239,989	100,006	422,736	762,731
Oklahoma	15,246,259	3,976,013	181,534	19,403,806
Pennsylvania	887,066	14,717	490,387	1,392,170
Texas [2]	88,507,297	36,822,517	85,250	125,415,064
Utah	762,697	462,750	1,070	1,226,517
Virginia	37,798	----------	----------	37,798
West Virginia	2,174,935	58,602	346,449	2,579,986
Wyoming	3,202,901	455,635	26,923	3,685,459
Other States [3]	25,585	10,255	212,621	248,461
Total	221,751,275	67,780,256	3,376,172	292,907,703

[1] Gas held in underground reservoirs (including native and net injected gas) for storage.
[2] Includes offshore reserves.
[3] Includes Alabama, Arizona, Florida, Iowa, Maryland, Missouri, Tennesse, and Washington.
Source: Committee on Natural Gas Reserves, American Gas Association.

Table 9.—Estimated productive capacity of natural gas in the United States [1], December 31, 1967

(Million cubic feet per day)

State	Productive capacity: Nonassociated	Productive capacity: Associated dissolved	Productive capacity: Total	State	Productive capacity: Nonassociated	Productive capacity: Associated dissolved	Productive capacity: Total
Alaska	255	100	355	New Mexico	3,552	1,668	5,220
Arkansas	1,484	101	1,585	New York	7	------	7
California [2]	1,591	1,112	2,703	North Dakota	2	156	158
Colorado	492	93	585	Ohio	88	32	120
Illinois	------	14	14	Oklahoma	9,214	2,877	12,091
Indiana	------	6	6	Pennsylvania	261	4	265
Kansas	9,161	525	9,686	Texas [2]	28,736	10,789	39,525
Kentucky	278	19	297	Utah	149	94	243
Louisiana [2]	26,785	5,314	32,099	Virginia	10	------	10
Michigan	121	58	179	West Virginia	620	17	637
Mississippi	592	95	687	Wyoming	1,144	200	1,344
Montana	160	52	212	Other States [3]	5	4	9
Nebraska	25	14	39				
				Total	84,732	23,344	108,076

[1] Productive capacity represents potential production rather than immediate or instantaneous production and is an estimate of the maximum rate of production which can be obtained at any time and from time to time during the heating season of the subject year, estimated to extend about ninety days from January 1, without regard to limitations of markets, transportation and processing facilities. Capacity estimates include natural gas from reservoirs now being cycled as well as gas from fields which are presently not producing, but do not include gas that may be available from underground storage reservoirs.
[2] Includes offshore.
[3] Includes Alabama, Arizona, Florida, Iowa, Maryland, Missouri, South Dakota, Tennessee, and Washington.
Source: Committee on Natural Gas Reserves, American Gas Association; Committee on Productive Capacity, American Petroleum Institute

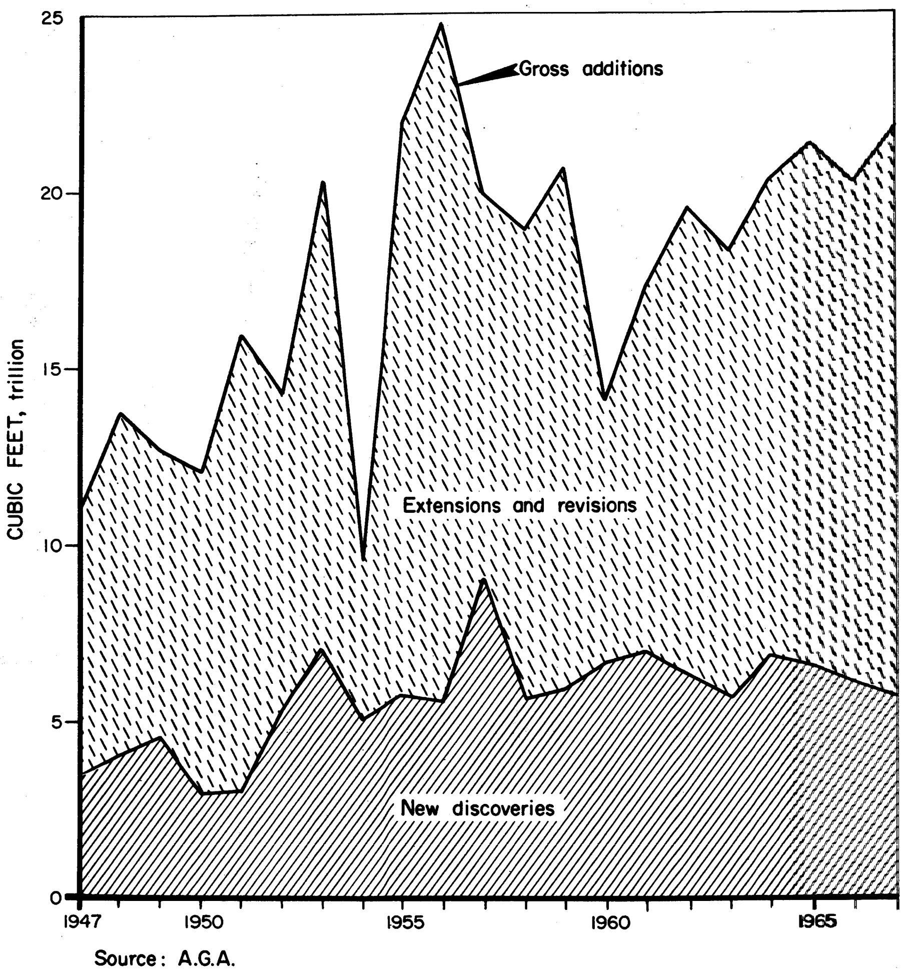

Figure 3.—Trends in annual gross additions to natural gas reserves, trilloin cubic feet.

Table 10.—Gas wells and condensate wells in the United States

State	Completed during 1966 [1]	Producing Dec. 31, 1966	Completed during 1967 [1]	Producing Dec. 31, 1967
Alabama	-----	----------	--------	----------
Alaska	5	19	4	21
Arizona	-----	9	2	7
Arkansas	56	818	70	909
California	63	1,068	72	1,059
Colorado	53	826	45	827
Illinois	3	3	1	3
Indiana	12	275	5	271
Kansas	130	8,608	147	8,603
Kentucky	168	6,020	200	6,215
Louisiana	500	8,977	465	9,036
Maryland	3	8	--------	13
Michigan	44	250	26	244
Mississippi	41	376	15	360
Missouri	-----	11	--------	11
Montana	11	784	22	648
Nebraska	1	37	1	37
New Mexico	342	8,017	257	8,274
New York	19	1,164	13	1,159
North Dakota	-----	31	--------	31
Ohio	236	r 3,790	214	3,865
Oklahoma	561	7,841	443	7,726
Pennsylvania	306	17,808	271	17,700
Tennessee	1	20	1	21
Texas	1,170	23,907	952	23,760
Utah	7	156	10	168
Virginia	-----	104	--------	104
West Virginia	594	20,830	384	20,500
Wyoming	51	741	39	749
Total	4,377	r 112,498	3,659	112,321

r Revised.
[1] From data compiled by the American Association of Petroleum Geologists and American Petroleum Institute.

Table 11.—Underground storage statistics, December 31, 1967

(Million cubic feet at 14.73 psia at 60° F)

State	Number of pools	Number of active wells	Total gas in storage reservoirs	Total reservoir capacity
Arkansas	7	28	16,949	23,182
California	6	155	114,749	287,852
Colorado	3	38	11,221	22,168
Illinois	21	891	222,209	413,584
Indiana	23	715	49,621	73,125
Iowa	5	204	128,558	167,571
Kansas	16	745	76,513	103,428
Kentucky	16	625	27,146	61,493
Louisiana	2	44	59,129	104,000
Maryland	1	53	20,262	64,770
Michigan	28	1,960	304,242	659,429
Mississippi	2	23	5,564	6,933
Missouri	1	66	26,380	45,000
Montana	6	168	108,578	163,831
Nebraska	1	15	4,888	39,270
New Mexico	3	34	2,405	58,650
New York	15	892	87,839	110,330
Ohio	21	2,658	329,923	502,513
Oklahoma	11	184	164,402	308,922
Pennsylvania	64	2,092	470,653	695,543
Texas	17	170	65,740	104,844
Utah	1	8	1,070	1,160
Washington	1	40	4,965	25,000
West Virginia	35	1,263	324,563	414,654
Wyoming	2	8	19,988	62,628
Total	308	13,079	2,647,557	4,519,880

Source: American Gas Association.

Table 12.—Natural gas stored underground in and withdrawn from storage fields

(Million cubic feet)

State	1966			1967		
	Total stored	Total withdrawn	Net stored	Total stored	Total withdrawn	Net stored
Alabama	394	---------	394	---------	---------	---------
Arkansas	1,259	852	407	1,317	891	426
California	45,634	79,417	−33,783	71,148	67,944	3,204
Colorado	11,284	2,718	8,566	6,391	5,257	1,134
Delaware	832	664	168	1,274	980	294
Illinois	104,189	84,789	19,400	119,125	87,630	31,495
Indiana	19,363	20,831	−1,468	25,027	20,236	4,791
Iowa	43,587	45,909	−2,322	49,603	36,481	13,122
Kansas	43,887	43,189	698	41,661	44,172	−2,511
Kentucky	22,718	27,332	−4,614	26,084	23,848	2,236
Louisiana	31,240	2,303	28,937	47,474	2,745	44,729
Maryland	---------	---------	---------	12,465	3,677	8,788
Massachusetts	---------	---------	---------	293	119	174
Michigan	244,103	214,456	29,647	222,800	229,952	−7,152
Mississippi	3,930	3,808	122	4,701	5,177	−476
Missouri	8,034	8,287	−253	10,206	10,137	69
Montana	19,812	6,610	13,202	19,919	6,100	13,819
Nebraska	4,246	3,487	759	5,012	4,366	646
New Jersey	767	---------	767	805	811	−6
New Mexico	586	738	−152	383	165	218
New York	36,553	41,504	−4,951	42,344	39,616	2,728
Ohio	132,647	133,822	−1,175	142,717	141,418	1,299
Oklahoma	33,836	23,527	10,309	47,438	20,933	26,505
Pennsylvania	201,827	210,732	−8,905	219,010	201,444	17,566
Texas	33,012	23,456	9,556	34,836	23,767	11,069
Utah	1,018	1,154	−136	609	389	220
Virginia	104	148	−44	158	86	72
Washington	408	---------	408	1,270	206	1,064
West Virginia	156,731	159,249	−2,518	159,545	149,030	10,515
Wisconsin	198	46	152	---------	---------	---------
Wyoming	8,270	2,586	5,684	3,748	4,957	−1,209
Total	1,210,469	1,141,614	68,855	1,317,363	1,132,534	184,829

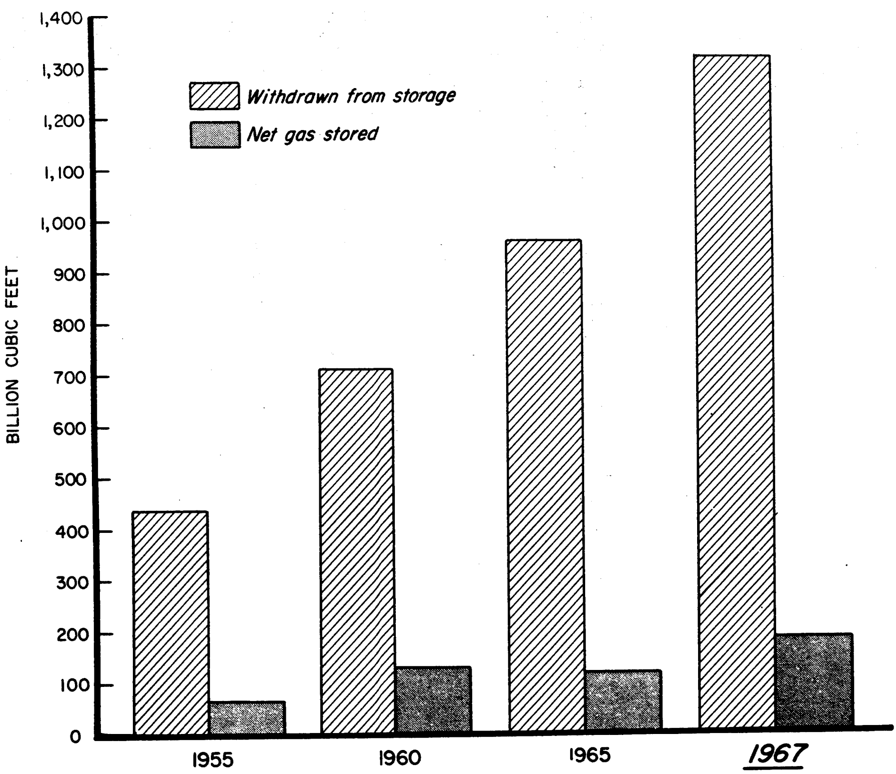

Figure 4.—Trends in net gas stored underground in U.S. storage fields.

Table 13.—Gross withdrawals and disposition of natural gas in the United States

(Million cubic feet at 14.73 psi)

State	Gross withdrawals			Disposition		
	From gas wells [1]	From oil wells [1]	Total [2]	Marketed production [3]	Repressuring	Vented and flared [4]
1966:						
Alaska	28,441	13,879	42,320	11,267	28,613	2,440
Arkansas	63,100	58,479	121,579	105,174	15,196	1,209
California	263,163	614,047	877,210	689,607	181,871	5,732
Colorado	134,065	20,748	154,813	136,667	14,073	4,073
Illinois	3,090	4,370	7,460	7,230	----------	230
Indiana	130	127	257	215	----------	42
Kansas	821,960	29,810	851,770	847,495	1,689	2,586
Kentucky	76,431	230	76,661	76,536	----------	125
Louisiana	4,168,820	1,196,457	5,365,277	5,081,435	182,734	101,108
Maryland	696	----------	696	696	----------	--------
Michigan	26,868	16,121	42,989	34,120	8,353	516
Mississippi	148,005	59,575	207,580	156,652	36,491	14,437
Montana	28,730	7,318	36,048	30,685	320	5,043
Nebraska	10,096	1,223	11,319	10,196	1,100	23
New Mexico	684,710	320,843	1,005,553	998,076	2,175	5,302
New York	2,659	40	2,699	2,699	----------	--------
North Dakota	430	73,876	74,306	46,585	----------	27,721
Ohio	36,156	7,197	43,353	43,133	----------	220
Oklahoma	1,051,593	449,970	1,501,563	1,351,225	61,132	89,206
Pennsylvania	90,725	640	91,365	90,914	353	98
Texas	5,784,515	2,150,348	7,934,863	6,953,790	871,427	109,646
Utah	27,323	69,454	96,777	69,366	25,486	1,925
Virginia	4,249	----------	4,249	4,249	----------	--------
West Virginia	210,060	2,340	212,400	211,610	724	66
Wyoming	225,238	41,758	266,996	243,381	19,751	3,864
Other States [5]	2,668	1,068	3,736	3,625	28	83
Total	13,893,921	5,139,918	19,033,839	17,206,628	1,451,516	375,695
1967:						
Alaska	42,688	23,129	65,817	14,438	39,989	11,390
Arkansas	81,491	46,038	127,529	116,522	10,010	997
California	287,681	573,639	861,320	681,080	176,675	3,565
Colorado	89,866	38,148	128,014	116,857	8,501	2,656
Illinois	1,630	3,640	5,270	5,144	----------	126
Indiana	106	92	198	198	----------	--------
Kansas	730,762	145,591	876,353	871,971	1,752	2,630
Kentucky	88,817	357	89,174	89,168	----------	6
Louisiana	5,070,825	1,016,600	6,087,425	5,716,857	208,719	161,849
Maryland	621	----------	621	621	----------	--------
Michigan	22,709	20,383	43,092	33,589	7,642	1,861
Mississippi	139,608	41,701	181,309	139,497	34,714	7,098
Montana	10,308	21,302	31,610	25,866	722	5,022
Nebraska	6,180	3,902	10,082	8,453	1,629	--------
New Mexico	774,007	301,003	1,075,010	1,067,510	1,508	5,992
New York	3,740	97	3,837	3,837	----------	--------
North Dakota	265	65,992	66,257	40,462	----------	25,795
Ohio	34,291	7,024	41,315	41,315	----------	--------
Oklahoma	1,133,163	488,173	1,621,336	1,412,952	81,755	126,629
Pennsylvania	89,751	590	90,341	89,966	375	--------
Texas	6,280,148	2,011,361	8,291,509	7,188,900	973,206	129,403
Utah	21,685	56,599	78,284	48,965	26,319	3,000
Virginia	3,818	----------	3,818	3,818	----------	--------
West Virginia	209,545	2,545	212,090	211,460	630	--------
Wyoming	221,850	36,115	257,965	240,074	16,393	1,498
Other States [5]	1,298	902	2,200	1,805	35	360
Total	15,346,853	4,904,923	20,251,776	18,171,325	1,590,574	489,877

[1] Estimated from the Bureau of Mines annual Supply and Distribution Natural Gas Survey.
[2] Marketed production plus quantities used in repressuring, vented and flared.
[3] Comprises gas sold or consumed by producers, including gas loss due to natural gas liquids recovery, losses in transmission, quantities added to storage, and increase of gas in pipelines.
[4] Partly estimated; included direct losses on producing properties and residue blown to the air.
[5] Alabama, Arizona, Florida, Missouri, South Dakota, and Tennessee.

Table 14.—Marketed production of natural gas by countries [1] at 60° F. (15.56° C.) and normal atmospheric pressure [2]

(Million cubic feet)

Country [1]	1963	1964	1965	1966	1967 p
North America:					
Barbados	128	94	102	NA	NA
Canada	1,111,478	1,327,664	1,442,448	1,341,833	1,465,372
Mexico	205,944	234,636	249,844	255,128	275,502
Trinidad	29,365	38,452	41,456	53,406	27,068
United States	14,666,559	15,462,143	16,039,753	17,206,628	18,171,325
South America:					
Argentina	125,254	136,795	149,111	e 160,000	e 172,000
Bolivia	3,853	4,145	3,453	3,795	3,503
Brazil	20,051	18,777	24,125	27,844	30,888
Chile	67,800	63,000	61,000	55,800	e 54,000
Colombia	17,243	26,919	31,738	35,922	NA
Peru	e 15,000	15,501	14,978	e 15,000	21,975
Venezuela	217,819	237,419	249,815	263,894	292,651
Europe:					
Austria	59,998	62,289	60,872	66,163	63,468
Czechoslovakia	35,243	32,842	30,017	50,000	e 50,000
France	171,664	179,751	178,268	182,258	196,455
Germany, West	45,732	69,322	98,104	119,646	153,194
Hungary [3]	21,590	27,702	39,128	54,843	72,183
Italy	256,666	271,357	275,524	310,626	330,791
Netherlands	18,964	27,015	57,244	117,878	253,731
Poland [3]	33,372	41,706	46,333	45,556	e 52,000
Rumania	356,711	403,186	454,391	497,196	559,525
U.S.S.R.	3,231,277	3,891,658	4,569,696	5,110,008	5,600,880
United Kingdom	200	200	449	123	16,527
Yugoslavia	6,745	9,676	11,653	14,196	16,313
Africa:					
Algeria	13,914	28,569	64,943	72,712	76,209
Gabon	318	318	388	388	600
Morocco	412	412	402	389	379
Nigeria	1,059	1,766	3,531	6,357	e 6,000
Tunisia	r 253	277	290	296	328
Asia:					
Afghanistan	----------	----------	----------	----------	76
Bahrain e	1,800	1,800	1,800	2,000	2,000
Brunei	7,390	6,460	7,870	10,000	e 14,000
Burma	597	NA	NA	NA	NA
India e	5,000	5,000	5,300	5,700	16,439
Indonesia	11,000	13,000	13,000	13,000	13,000
Iran	40,884	42,102	43,423	48,957	51,784
Iraq	e 11,500	13,500	12,900	21,419	e 23,000
Israel	347	1,069	2,559	3,371	3,859
Japan	59,845	65,640	62,861	64,509	66,734
Kuwait	53,532	57,761	63,356	66,200	e 70,000
Kuwait-Saudi Arabia Neutral Zone e	6,000	7,500	8,000	8,300	8,500
Pakistan	49,459	59,100	66,194	76,000	e 85,000
Qatar	3,092	2,789	2,850	e 2,900	e 3,000
Saudi Arabia	e 32,000	36,072	36,331	e 40,000	e 45,000
Taiwan	1,789	5,982	10,932	15,507	18,616
Oceania:					
Australia	96	106	144	143	152
New Zealand	5	5	5	4	4
Total [4]	21,018,948	22,931,477	24,536,581	26,445,895	28,384,031

e Estimate. p Preliminary. NA Not available.
[1] Natural gas is produced in mainland China and other countries, but data are not available.
[2] Compiled mostly from data available July 1968.
[3] Including gas for repressuring.
[4] Total is of listed figures only; no undisclosed data included.
NOTE: The data relate, as far as possible, to natural gas acually collected and utilized as fuel or raw material. They exclude gas used for repressuring (except where otherwise noted), as well as gas flared, vented, or otherwise wasted, whether or not it has first been processed for the extraction of natural gas liquids. Data for countries reporting in cubic meters have been converted using the standard factor of 35.3145 cubic feet per cubic meter. This is a change from the previous policy of using a factor reflecting differences in pressure and temperature conditions. This explains many of the revisions on this table.

Natural Gas Liquids

By William B. Harper [1] and Leonard L. Fanelli [2]

Reflecting the continued growth in the demand for natural gas, production of natural gas liquids in 1967 totaled 21,607 million gallons, exceeding the production of the preceding year by 9.8 percent and establishing a new peak. The total value was $1,179,936,000, an increase of 132.6 million or 12.7 percent, over 1966 values. The average value per gallon produced was 5.5 cents as compared with 5.3 cents in 1966.

Natural gas liquids are products obtained from natural gasoline plants, cycling plants, and fractionators after separating the natural gas. Included in these products are ethane, the liquefied petroleum (LP) gases (propane, butane, and propane-butane 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 napthas, jet fuel, kerosine, distillate fuel oil, and other finished products.

Shipments from plants and refineries of liquefied petroleum gases and ethane for fuel and chemical uses totaled 14,440.7 million gallons in 1967, an increases of 6.7 percent for the year. Natural gas liquids used as blending material in motor fuel (excluding finished gasoline and naphtha) totaled 10,302.7 million gallons in 1967 compared with 9,886.3 million in 1966, a gain of 4.2 percent.

These data presented in this chapter are 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. Field condensate, however, is reported with crude oil and is excluded from the total for natural gas liquids. Liquefied refinery (LR) gases and ethane produced at petroleum refineries are not natural gas liquids, but to obtain complete data on distribution of liquefied gases, tables are included in this chapter covering the production and stocks of liquefied refinery gases.

Annual reports were received from all producers and distributors and from most of the dealers that sell more than 100,000 gallons of LP gases annually. 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.

Data on shipments of liquefied petroleum gases, normally reported in this chapter, were not available at the time of publication and will be published in the Mineral Industry Survey "Liquefied Petroleum Gas Shipments, Annual," "Shipments of Liquefied Petroleum Gases and Ethane in 1967."

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 propane.

Butane–propane.—Includes all products covered by NGPA specifications for commerical butane propane mixtures.

Butane.—Includes all products covered by NGPA specifications for commercial butane, except those that contain 60 percent or more isobutane.

[1] Mineral specialist, Division of Mineral Studies.
[2] Survey statistician, Division of Statistics.

Isobutane.—Includes all products covered by NGPA specifications for commerical butane that contains 60 percent or more isobutane.

Other Mixtures of Liquefied Petroleum Gases.—Includes mixtures that cannot be classified within the five classifications mentioned, such as mixtures containing less than 50 percent ethane but more than 50 percent propane and butane.

Isopentane.—Includes segregated isopentane.

Natural Gasoline.—Breakdown by various Reid vapor pressure classifications indicated.

Plant Condensate.—Includes condensate, raw or deenthanized stream.

Gasoline.—Includes all products within the gasoline range for shipment as motor or aviation fuel.

Special Naphtha.—Includes all hexanes and heptanes.

Jet Fuel.—Includes all aviation turbine engine fuel for both military and commercial use.

Kerosine.—Includes all grades of kerosine or range oil.

Distillate Fuel Oil.—Includes all light oils for shipment as fuel.

Other Products.—All products not otherwise classified.

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 (counties), 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, Rush, 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 districts).

PAD district — *Refining district*

1.—*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 New York: Cayuga, Tompkins, Chemung, and all counties east and north thereof, and the following counties of Pennsylvania: Bradford, Sullivan, Columbia, Montour, Northumberland, Dauphin, York, and all counties east thereof.

1.—*Appalachian No. 1*—West Virginia and those parts of Pennsylvania and New York not included in the East Coast district.

2.—*Appalachian No. 2*—The following counties of Ohio: Erie, Huron, Crawford, Marion, Delaware, Franklin, Pickaway, Ross, Pike, Scioto, and all counties east thereof.

2.—*Indiana-Illinois-Kentucky*—Indiana, Illinois, Kentucky, Tennessee, Michigan, and that part of Ohio not included in the Appalachian district.

2.—*Oklahoma-Kansas-Missouri*—Oklahoma, Kansas, Missouri, Nebraska, and Iowa.

2.—*Minnesota-Wisconsin-North Dakota-South Dakota*—Minnesota, Wisconsin, North Dakota, and South Dakota.

3.—*Texas Inland*—Texas, except Texas Gulf Coast district.

3.—*Texas Gulf Coast*—The following counties of Texas: Newton, Orange, Jefferson, Jasper, Tyler, Hardin, Liberty, Chambers, Polk, San Jacinto, Montgomery, Galveston, Waller, Fort Bend, Brazoria, Wharton, Harris, Matagorda, Jackson, Victoria, Calhoun, Refugio, Aransas, San Patricio, Nueces, Kelberg, Kenedy, Willacy, and Cameron.

3.—*Louisiana Gulf Coast*—The following parishes of Louisiana: Vernon, Rapides, Avoyelles, Pointe Coupee, West Feliciana, East Feliciana, Tangipahoa, St. Helena, Washington, and all parishes south thereof; the following counties of Mississippi: Pearl River, Stone, George Hancock, Harrison, and Jackson; and Mobile and Baldwin Counties, Alabama.

3.—*North Louisiana-Arkansas*—Arkansas and those parts of Louisiana, Mississippi, and Alabama not included in the Louisiana Gulf Coast district.

3.—*New Mexico*—New Mexico.

4.—*Rocky Mountains*—Montana, Idaho, Wyoming, Utah, and Colorado.

5.—*West Coast*—Washington, Oregon, California, Nevada, Alaska, Arizona, and Hawaii.

Some data in the chapter are based on the Bureau of Mines refining districts, while 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.

Table 1.—Production, stock change, and shipments of natural gas liquids and liquefied refinery gases in the United States

(Thousand gallons)

Product	Production		Net change in stocks		Deliveries to refineries		Shipments for fuel and chemical use	
	1966	1967	1966	1967	1966	1967	1966	1967
Natural gas liquids:								
Ethane	1,250,068	1,542,712	52,714	27,072	----------	----------	1,197,354	1,515,640
Liquefied petroleum gases:								
Propane	6,275,665	7,130,239	205,017	650,749	111,636	85,680	5,959,012	6,393,810
Butane	2,942,344	3,170,563	−63,253	309,277	1,542,593	1,478,932	1,463,004	1,382,354
Butane-propane mixture	552,622	648,207	10,254	−5,255	128,352	121,548	414,016	531,914
Isobutane	1,113,595	1,226,140	23,250	29,294	1,090,345	1,196,846	----------	----------
Total	10,884,226	12,175,149	175,268	984,065	2,872,926	2,883,006	[1] 7,836,032	[1] 8,308,078
Isopentane	102,070	126,880	−90	680	102,160	126,200	----------	----------
Natural gasoline:								
12 pounds and less	2,278,676	2,444,366	−7,774	4,292	2,286,450	2,440,074	----------	----------
Over 12 pounds including 14 pounds	814,954	780,060	−7,058	−257	822,012	780,317	----------	----------
Over 14 pounds including 18 pounds	536,995	533,636	−792	39	537,787	533,597	----------	----------
Over 18 pounds including 22 pounds	101,500	127,468	−15	−90	101,515	127,558	----------	----------
Over 22 pounds including 26 pounds	388,389	387,460	2,953	−5,876	385,436	393,336	----------	----------
Over 26 pounds	1,341,555	1,450,401	−15,576	1,051	1,357,131	1,449,350	----------	----------
Total	5,462,069	5,723,391	−28,262	−841	5,490,331	5,724,232	----------	----------
Plant condensate	1,419,111	1,594,773	−1,740	25,509	1,420,851	1,569,264	----------	----------
Finished and other:								
Finished gasoline	375,335	305,022	52	−4,297	----------	----------	375,283	309,319
Special naphthas	4,800	2,241	−201	−31	----------	----------	5,001	2,272
Jet fuel	1,955	1,929	−252	258	----------	----------	2,207	1,671
Kerosine	53,886	54,375	2,343	6,259	----------	----------	51,543	48,116
Distillate fuel oil	47,957	14,959	407	−252	----------	----------	47,550	15,211
Other	81,245	65,691	−786	452	----------	----------	82,031	65,239
Total	565,178	444,217	1,563	2,389	----------	----------	563,615	441,828
Total natural gas liquids	19,682,722	21,607,122	199,453	1,038,874	9,886,268	10,302,702	9,597,001	10,265,546

Liquefied refinery gases:								
For fuel:								
Propane-propylene	2,115,078	2,254,938	19,656	46,326	----------	----------	2,095,422	2,208,612
Butane-butylene	292,992	426,132	−5,250	17,220	----------	----------	298,242	408,912
Butane-propane mixture	115,710	157,668	−1,218	4,116	----------	----------	116,928	153,552
Isobutane	----------	----------	----------	----------	----------	----------	----------	----------
Total	2,523,780	2,838,738	13,188	67,662	----------	----------	2,510,592	2,771,076
For petrochemical feedstocks:								
Ethane-ethylene	316,806	295,218	−15,246	−42	----------	----------	332,052	295,260
Liquefied gases:								
Propane-propylene	778,050	774,606	−1,554	−294	----------	----------	779,604	774,900
Butane-butylene	487,032	424,956	504	−504	----------	----------	486,528	425,460
Butane-propane mixture	329,364	293,706	−10,584	----------	----------	----------	339,948	293,706
Isobutane	26,124	56,490	−126	−84	----------	----------	26,250	56,574
Total	1,620,570	1,549,758	−11,760	−882	----------	----------	1,632,330	1,550,640
Total liquefied refinery gases	4,461,156	4,683,714	−13,818	66,738	----------	----------	4,474,974	4,616,976
Total ethane and liquefied petroleum gases	16,595,450	18,401,575	214,164	1,077,875	2,872,926	2,883,006	13,508,360	14,440,694
Total all products	24,143,878	26,290,836	185,635	1,105,612	9,886,268	10,302,702	14,071,975	14,882,522

[1] In addition 440,538 thousand gallons was imported in 1966 and 415,170 thousand gallons in 1967.

DOMESTIC PRODUCTION

The upward trend in production of natural gas liquids, which began in 1959, was even more pronounced in 1967. Production of natural gas liquids and ethane at natural gas processing plants in the United States totaled 21,607 million gallons, topping production of the preceding year by 1,924 million gallons, an increase of 9.8 percent. By way of comparison, the 1966 production was greater than that for 1965 by 1,137 million gallons, an increase of slightly over 6 percent. The production of the liquefield petroleum gases and ethane has been increasing at a faster rate than that of natural gasoline.

Strong demand and improved processing methods have encouraged efforts to maximize yields of the liquefied petroleum gases and the ethane as well as the finished products from the gas stream.

Propane, which represented 58.6 percent of the liquefied petroleum gases produced in 1967, amounted to 7,130 million gallons, an increase of 13.6 percent over the preceding year's total. Ethane production amounted to 1,543 million gallons in 1967—293 million gallons, or 23.4 percent more than in 1966.

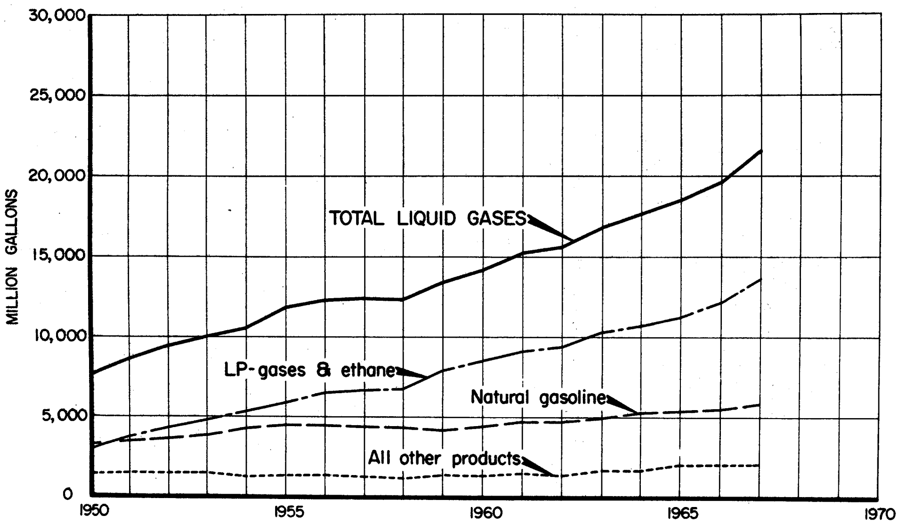

Figure 1.—Production of natural gas liquids in the United States.

RESERVES AND CAPACITY

Proved reserves of natural gas liquids in the United States totaled 8,614 million barrels as of December 31, 1967, according to estimates of the Committee on Natural Gas Reserves of the American Gas Association (AGA). Compared with 1966 levels, this was a net increase in reserves of 285 million barrels. Although there were net decreases in the reserves of 14 of the 21 States that are reported by the Committee, the sum of these decreases was much less than the extraordinary gain of 325 million barrels of natural gas liquids in Louisiana's proved reserves. In addition, Kansas had a substantial gain, and smaller gains occurred in a few other States. The principal declines were in California and Oklahoma.

The Committee also, estimated that the daily productive capacity of the natural gas liquids industry in the United States, as of December 31, 1967, was 132,552,000 gallons. Since natural gas liquids become available solely by separation from the produced natural gas, their rate of availability depends on the rate of production of gas from crude oil or natural gas reservoirs.

DEMAND AND USES

Demand for natural gas liquid at plants and terminals in 1967 was 20,568 million gallons, compared with 19,483 million gallons in 1966; one-half of the total was directed to refineries for use in gasoline blending. Shipments of natural gas liquids for blending totaled 10,303 million gallons in 1967 as compared with 9,886 million in 1966.

Shipments of ethane for use primarily in the manufacture of chemicals totaled 1,515.6 million gallons in 1967, which was 26.6 percent greater than in the preceding year. Shipments of the liquefied petroleum gases including propane, butane, and isobutane for fuel and chemical use were 8,308 million gallons. In addition, 442 million gallons of other finished products was shipped from natural gas processing plants during 1967. Finished gasoline represented 70 percent (or 309.3 million gallons) of those products. The other products (in million gallons) were special naphthas, 2.3; jet fuel, 1.7; kerosine, 48.1; distillate fuel oil, 15.2; and other miscellaneous products, 65.2.

PRICES AND VALUE

The total value at the plant for natural gas liquids and ethane in 1967 was $1,179.9 million, or an average of 5.5 cents per gallon. Table 11 shows the production value, and average value per gallon for the various natural gas liquids products in 1966 and 1967. The increasing demand of the petrochemical industry for natural gas liquids for use as feedstocks is reflected in the rise in market prices as shown in table 12.

STOCKS

The stocks of natural gas liquids and ethane at the end of 1967 totaled 2.76 billion gallons, which was 1.06 billion gallons, or 62.6 percent greater than the stocks on hand at yearend 1966. Most of this increase was in the inventories of butane and propane, both of which were at the highest levels on record.

Part of this rise reflected the expansion in natural gas processing capacity which has resulted in production of larger volumes of propane, *n*-butane, isobutane, and butane and propane mixtures. Another important factor was technological developments in refinery processes, which had a decided impact on supply and demand patterns for natural gas liquids.

The largest market for butane and isobutane is in gasoline blending, and the natural gas processing plants are the principal source of supply for refineries. But both the hydrocracking process and the catalytic reforming processes used at refineries yield propane, *n*-butane, and isobutane; hence, as capacity for hydrocracking grows so will the refinery production of some of the natural gas liquids used for upgrading gasoline. Hydrocracking on a modest scale began in 1960. By 1967 (March) there were 20 units operating in the United States with a total capacity of 270,000 barrels–per–stream day. It is estimated that hydrocracking capacity will reach 585,000 barrels–per–stream day by the end of 1968. "Barrels per stream day" refers to the throughput or output of a unit operating for a full day with no allowance for "downtime;" that is, when a unit is shut down for repairs and maintenance.

Underground storage of natural gas liquids continued to expand in 1967. At yearend, 1,465 million gallons of liquefied gases was in underground storage, an increase of 350 million gallons, or 31.4 percent, for the year. Over 59 percent of the stocks of LP gases and ethane were held in underground storage facilities as of December 1967.

Table 2.—Estimated proved recoverable reserves of natural gas liquids [1] in the United States

(Thousand barrels)

State	Reserves as of Dec. 31, 1966	Changes in reserves during 1967: Extensions and revisions [2]	Changes in reserves during 1967: Discoveries of new fields and new pools	Changes in reserves during 1967: Net production	Reserves as of December 31, 1967: Nonassociated with oil	Reserves as of December 31, 1967: Associated-dissolved	Reserves as of December 31, 1967: Total
Arkansas	16,174	(79)	-------	1,521	9,477	5,097	14,574
California [3]	242,163	(845)	350	23,066	9,081	209,521	218,602
Colorado	25,647	(418)	18	2,327	5,203	17,717	22,920
Illinois	2,870	(112)	3	463	3	2,295	2,298
Indiana	63	4	5	13	9	50	59
Kansas	256,848	32,615	695	18,206	262,779	9,173	271,952
Kentucky	52,294	2,032	1,016	3,704	[3] 51,638	---------	51,638
Louisiana [3]	2,282,394	482,676	27,335	185,217	2,195,735	411,453	2,607,188
Michigan	4,041	(76)	479	900	1,461	2,083	3,544
Mississippi	17,015	2,192	-------	1,895	12,186	5,126	17,312
Montana	10,638	66	-------	948	2,139	7,617	9,756
Nebraska	2,474	387	-------	595	1,211	1,055	2,266
New Mexico	559,783	40,411	1,844	46,336	391,308	164,394	555,702
North Dakota	66,974	(15)	-------	2,682	---------	64,277	64,277
Ohio	1,293	(600)	-------	111	---------	582	582
Oklahoma	475,605	14,726	6,765	41,343	296,653	159,100	455,753
Pennsylvania	1,235	-------	-------	73	1,162	---------	1,162
Texas [3]	4,101,622	242,242	57,878	298,747	2,205,917	1,897,078	4,102,995
Utah	42,708	1,964	-------	1,924	776	41,972	42,748
West Virginia	80,760	5,017	2,509	6,624	[4] 81,662	---------	81,662
Wyoming	86,365	8,650	24	7,798	47,556	39,685	87,241
Total	8,328,966	830,837	98,921	644,493	5,575,956	3,038,275	8,614,231

[1] Comprises natural gasoline, Lp gases, and condensate.
[2] Parenthesis denotes decrease.
[3] Includes offshore reserves.
[4] Not allocated by types but occurring principally in column shown.
Source: Committee on Natural Gas Reserves, American Gas Association.

Table 3.—Estimated productive capacity of natural gas liquids in the United States, December 31, 1967

(Thousand barrels per day)

State	Productive capacity: Nonassociated	Productive capacity: Associated or dissolved	Productive capacity: Total	State	Productive capacity: Nonassociated	Productive capacity: Associated or dissolved	Productive capacity: Total
Arkansas	4	2	6	Nebraska	1	1	2
California [2]	4	73	77	New Mexico	89	81	170
Colorado	2	6	8	North Dakota	-----	8	8
Illinois	-----	1	1	Oklahoma	106	68	174
Kansas	180	13	193	Texas [2]	853	596	1,449
Kentucky	13	-------	13	Utah	-----	7	7
Louisiana [2]	860	122	982	West Virginia	21	-------	21
Michigan	3	2	5	Wyoming	21	9	30
Mississippi	5	2	7				
Montana	1	2	3	Total	2,163	993	3,156

[1] The productive capacity of natural gas liquids is defined as the amount of hydrocarbon liquids that would be produced coincident with the estimated productive capacity of natural gas based on unit recoveries at normal producing rates. Such estimated capacities are not limited by lack of capacity of processing plants or other surface facilities and it is emphasized that adequate facilities would be required to effect the recovery of liquids from the natural gas produced at these rates. It should also be recognized that such facilities cannot be enlarged quickly. Therefore, the estimated natural gas liquid capacities, which relate to increased production of gas from oil and gas wells operating at their productive capacities, are theoretical. In the event of an emergency requiring capacity production of hydrocarbon liquids, both oil and natural gas liquids, the capacities of existing processing plants would limit the amount of natural gas liquid capacity realized.
[2] Includes offshore.

Source: Committee on National Gas Reserves, American Gas Association.

Table 4.—Natural gas liquids and ethane produced, value at plants in the United States in 1967, by States

(Thousand gallons and thousand dollars)

State	Number of operators [1]	LP gases and ethane			Natural gasoline and isopentane			Plant Condensate		
		Quantity	Value	Cents per gallon	Quantity	Value	Cents per gallon	Quantity	Value	Cents per gallon
Arkansas	5	53,730	$3,009	5.6	20,813	$1,353	6.5	4,268	$273	6.4
California	17	366,643	19,065	5.2	588,256	44,607	7.6	25,158	2,013	8.0
Colorado	6	71,544	3,649	5.1	50,908	3,156	6.2	937	59	6.3
Kansas	13	665,057	31,923	4.8	190,980	10,504	5.5	2,010	121	6.0
Kentucky [2]	4	572,739	33,791	5.9	31,928	2,363	7.4	210	16	7.4
Louisiana	43	1,844,689	92,234	5.0	940,976	64,927	6.9	500,391	37,529	7.5
Michigan	4	59,390	3,444	5.8	47,280	3,451	7.3	537	40	7.4
Mississippi	7	17,794	1,085	6.1	16,505	1,073	6.5	845	56	6.6
Montana [3]	6	73,014	3,218	4.4	30,742	1,875	6.1	----	----	----
Nebraska	3	20,738	1,223	5.9	7,805	578	7.4	----	----	----
New Mexico	15	909,168	40,003	4.4	320,004	19,520	6.1	15,625	1,031	6.6
North Dakota	3	88,665	3,901	4.4	22,867	1,418	6.2	417	25	6.0
Oklahoma	37	1,005,633	49,276	4.9	498,091	30,882	6.2	66,923	4,685	7.0
Pennsylvania	3	1,757	114	6.5	1,167	77	6.6	----	----	----
Texas	86	7,449,439	320,326	4.3	2,950,621	194,741	6.6	960,587	73,005	7.6
West Virginia [4]	6	344,040	19,085	5.5	47,662	3,193	6.7	1,351	66	4.9
Wyoming	15	173,821	7,648	4.4	83,666	5,438	6.5	15,514	1,024	6.6
Total	158	13,717,861	632,994	4.6	5,850,271	389,156	6.7	1,594,773	119,943	7.5

State	Number of operators [1]	Finished gasoline and naphtha			Other products [5]			Total		
		Quantity	Value	Cents per gallon	Quantity	Value	Cents per gallon	Quantity	Value	Cents per gallon
Arkansas	5	----	----	----	2,452	$154	6.3	81,263	$4,789	5.9
California	17	----	----	----	----	----	----	980,057	65,685	6.7
Colorado	6	----	----	----	----	----	----	123,389	6,864	5.6
Kansas	13	1,126	$74	6.6	57	4	7.0	859,230	42,626	5.0
Kentucky [2]	4	----	----	----	----	----	----	604,877	36,170	6.0
Louisiana	43	215,921	20,944	9.7	97,315	6,812	7.0	3,599,292	222,446	6.2
Michigan	4	----	----	----	----	----	----	107,207	6,935	6.5
Mississippi	7	----	----	----	589	38	6.4	35,733	2,252	6.3
Montana [3]	6	----	----	----	----	----	----	103,756	5,093	4.9
Nebraska	3	----	----	----	----	----	----	28,543	1,801	6.3
New Mexico	15	----	----	----	2,485	179	7.2	1,247,282	60,733	4.9
North Dakota	3	----	----	----	----	----	----	111,949	5,344	4.8
Oklahoma	37	1,130	77	6.8	2,761	202	7.3	1,574,538	85,122	5.4
Pennsylvania	3	----	----	----	----	----	----	2,924	191	6.5
Texas	86	89,086	6,949	7.8	31,295	2,410	7.7	11,481,028	597,431	5.2
West Virginia [4]	6	----	----	----	----	----	----	393,053	22,344	5.7
Wyoming	15	----	----	----	----	----	----	273,001	14,110	5.2
Total	158	307,263	28,044	9.1	136,954	9,799	7.2	21,607,122	1,179,936	5.5

[1] A producer operating in more than 1 State is counted but once in arriving at U.S. total.
[2] Illinois (1 operator) included with Kentucky.
[3] Utah (3 operators) included with Montana.
[4] Florida (1 operator) included with West Virginia.
[5] Includes kerosine, jet fuel, distillate fuel, etc.

Table 5.—Production of natural gas liquids and ethane at natural gas processing plants in the United States in 1967, by States and districts [1]

(Thousand gallons)

States by petroleum districts	January	February	March	April	May	June	July
District 1:							
Western Pennsylvania	286	265	292	288	255	187	176
West Virginia and Florida	37,052	35,331	37,482	37,080	32,876	34,393	31,704
Total	37,338	35,596	37,774	37,368	33,131	34,580	31,880
District 2:							
Illinois and Kentucky	54,438	50,530	53,380	49,938	53,035	48,956	46,868
Michigan	9,027	8,423	9,019	9,186	9,319	8,024	9,092
Kansas	78,625	74,292	79,592	75,725	69,998	60,820	65,143
Nebraska	2,499	2,360	2,662	2,565	2,380	2,380	2,461
North Dakota	9,953	9,077	9,666	9,267	7,193	8,383	9,669
Oklahoma	141,145	128,052	140,183	134,317	135,953	121,095	122,796
Total	295,687	272,734	294,502	280,998	277,878	249,658	256,029
District 3:							
Arkansas	7,745	6,968	7,241	7,385	7,434	6,890	6,765
Louisiana:							
Gulf	231,958	212,074	238,725	237,071	240,516	214,139	223,232
Inland	54,690	43,175	48,935	46,124	51,522	48,706	48,304
Total	286,648	255,249	287,660	283,195	292,038	262,845	271,536
Mississippi and Alabama	2,745	2,590	3,126	3,167	3,421	3,234	3,102
New Mexico	103,413	91,183	95,365	102,763	108,496	109,444	103,134
Texas:							
Gulf	213,857	188,316	188,959	187,673	195,216	201,827	208,836
West	298,570	276,383	333,094	327,343	342,258	327,097	351,402
East (field)	20,074	18,127	21,507	21,420	21,865	22,568	26,896
Panhandle	123,732	121,057	129,905	127,267	126,882	112,600	111,256
Rest of State (other)	306,806	265,878	286,294	286,050	285,407	292,428	300,741
Total	963,039	869,761	959,759	949,753	971,628	956,520	999,131
Total	1,363,590	1,225,751	1,353,151	1,346,263	1,383,017	1,338,933	1,383,668
District 4:							
Colorado	10,205	9,319	10,496	10,589	9,441	7,890	9,187
Montana and Utah	7,136	5,743	7,080	6,914	7,851	8,343	9,199
Wyoming	25,702	23,356	24,054	22,737	22,328	21,352	20,665
Total	43,043	38,418	41,630	40,240	39,620	37,585	39,051
District 5	85,542	78,487	85,105	81,964	83,236	80,342	80,894
Total United States	1,825,200	1,650,986	1,812,162	1,786,833	1,816,882	1,741,098	1,791,522

	August	September	October	November	December	Total
District 1:						
Western Pennsylvania	231	214	231	232	267	2,924
West Virginia and Florida	27,552	28,272	30,160	28,871	32,280	393,053
Total	27,783	28,486	30,391	29,103	32,547	395,977
District 2						
Illinois and Kentucky	48,320	48,313	47,194	49,607	54,298	604,877
Michigan	9,039	8,506	8,770	8,825	9,977	107,207
Kansas	65,325	64,910	71,899	73,450	79,451	859,230
Nebraska	2,321	2,096	2,204	2,437	2,178	28,543
North Dakota	9,749	9,744	10,171	9,634	9,443	111,949
Oklahoma	123,300	122,836	133,986	134,338	136,537	1,574,538
Total	258,054	256,405	274,224	278,291	291,884	3,286,344
District 3:						
Arkansas	6,883	6,513	6,041	6,213	5,185	81,263
Louisiana:						
Gulf	256,872	247,904	292,996	301,678	311,431	3,008,596
Inland	49,225	48,980	50,260	50,047	50,728	590,696
Total	306,097	296,884	343,256	351,725	362,159	3,599,292
Mississippi and Alabama	2,947	2,832	2,893	2,754	2,922	35,733
New Mexico	100,828	103,459	109,963	109,009	110,225	1,247,282
Texas:						
Gulf	192,955	188,631	197,310	191,227	201,787	2,356,594
West	356,210	336,831	339,252	321,217	313,320	3,922,977
East (field)	27,729	24,187	22,950	21,011	20,803	269,137
Panhandle	121,704	117,072	127,518	123,794	127,668	1,470,455
Rest of State (other)	295,375	264,039	294,136	287,800	296,911	3,461,865
Total	993,973	930,760	981,166	945,049	960,489	11,481,028
Total	1,410,728	1,340,448	1,443,319	1,414,750	1,440,980	16,444,598
District 4:						
Colorado	10,505	10,340	12,112	11,886	11,419	123,389
Montana and Utah	9,947	10,325	10,483	10,666	10,069	103,756
Wyoming	20,665	20,955	23,302	23,264	24,621	273,001
Total	41,117	41,620	45,897	45,816	46,109	500,146
District 5	78,779	78,389	82,424	80,681	84,214	980,057
Total United States	1,816,461	1,745,348	1,876,255	1,848,641	1,895,734	21,607,122

[1] Western Pennsylvania separated from eastern part of State to allow grouping in either Bureau of Mines refinery district or Petroleum Administration for Defense district. Districts shown for Texas and Louisiana are Bureau of Mines production districts. These districts are described under the heading "Districts."

Table 6.—Production, stock change, and shipments of natural gas liquids at plants and terminals in the United States in 1967, by months

(Thousand gallons)

	January	February	March	April	May	June	July
Production:							
Ethane	131,460	118,026	133,206	130,537	132,811	129,854	123,626
LP gases:							
Propane	589,998	540,978	620,769	608,029	603,697	555,664	575,741
Butane	268,537	242,660	265,166	260,485	268,378	252,074	260,328
Butane-propane mixture	47,027	42,467	43,926	42,512	49,977	58,333	60,592
Isobutane	116,190	102,174	103,000	100,927	97,324	94,771	96,757
Isopentane	10,094	9,160	10,133	10,954	11,110	10,701	10,657
Natural gasoline	453,936	432,119	474,056	470,099	486,813	476,352	495,089
Plant condensate	162,267	129,889	125,633	128,902	129,813	126,926	132,216
Finished gasoline and naphthas	32,414	23,126	25,305	23,450	25,738	25,732	25,779
Other finished products	13,277	10,387	10,968	10,938	11,221	10,691	10,737
Total	1,825,200	1,650,986	1,812,162	1,786,833	1,816,882	1,741,098	1,791,522
Stock change at plants and terminals	−201,284	−98,360	+100,716	+356,950	+336,354	+275,325	+281,557
Shipments:							
To refineries:							
LP gases:							
Propane	3,780	4,410	5,418	7,182	6,762	4,410	9,702
Butane	155,233	114,954	99,766	78,848	77,213	83,611	82,925
Butane-propane mixture	10,374	9,114	6,552	7,644	9,030	8,988	9,870
Isobutane	129,989	99,414	103,178	94,360	82,597	94,931	97,633
Isopentane	9,997	9,199	9,774	9,437	11,045	10,446	9,997
Natural gasoline	458,621	422,887	484,108	467,069	479,468	485,493	495,788
Plant condensate	146,286	131,805	121,345	104,097	137,544	130,261	128,993
Fuel and chemical use:							
Ethane	130,713	110,643	126,277	121,070	133,285	143,578	118,334
LP gases:							
Propane	745,347	653,348	583,363	386,044	386,561	346,265	398,051
Butane	148,598	123,857	97,635	88,941	77,666	69,580	73,202
Butane-propane mixture	40,576	34,561	35,571	29,836	41,545	50,786	50,137
Isobutane	----------	----------	----------	----------	----------	----------	----------
Finished gasoline and naphthas	34,314	22,905	25,583	23,830	23,763	28,134	27,663
Other finished products	12,656	12,249	12,876	11,525	14,049	9,290	7,670
Total demand for natural gas liquids at plants and terminals	2,026,484	1,749,346	1,711,446	1,429,883	1,480,528	1,465,773	1,509,965

	August	September	October	November	December	Total
Production:						
Ethane	128,106	120,892	132,273	129,894	132,027	1,542,712
LP gases:						
Propane	580,351	572,541	625,343	618,680	638,448	7,130,239
Butane	264,331	255,785	275,952	274,702	282,165	3,170,563
Butane-propane mixture	59,522	62,375	57,299	60,541	63,636	648,207
Isobutane	101,733	97,177	106,080	103,915	106,092	1,226,140
Isopentane	10,509	10,475	10,682	10,708	11,697	126,880
Natural gasoline	508,365	468,618	497,545	479,458	480,941	5,723,391
Plant condensate	126,199	121,692	133,198	134,981	143,057	1,594,773
Finished gasoline and naphthas	25,812	24,965	26,484	23,510	24,948	307,263
Other finished products	11,533	10,828	11,399	12,252	12,723	136,954
Total	1,816,461	1,745,348	1,876,255	1,848,641	1,895,734	21,607,122
Stock change at plants and terminals	+236,178	+176,557	+22,351	−234,610	−212,860	+1,038,874
Shipments:						
To refineries:						
LP gases:						
Propane	9,408	8,148	9,114	10,290	7,056	85,680
Butane	82,068	121,712	177,781	193,729	211,092	1,478,932
Butane-propane mixture	9,492	10,374	11,088	18,438	10,584	121,548
Isobutane	97,356	100,048	97,907	106,529	92,904	1,196,846
Isopentane	12,317	3,066	18,537	9,923	12,462	126,200
Natural gasoline	513,062	466,894	494,295	477,882	478,665	5,724,232
Plant condensate	126,360	121,690	133,521	136,965	150,397	1,569,264
Fuel and chemical use:						
Ethane	130,144	117,214	128,482	124,314	131,586	1,515,640
LP gases:						
Propane	407,087	434,231	540,066	749,599	763,848	6,393,810
Butane	107,125	101,030	158,949	176,169	159,602	1,382,354
Butane-propane mixture	51,317	52,816	49,040	42,041	53,688	531,914
Isobutane	---------	1	---------	---------	---------	---------
Finished gasoline and naphthas	25,559	23,524	25,606	24,356	26,354	311,591
Other finished products	8,988	8,044	9,518	13,016	10,356	130,237
Total demand for natural gas liquids at plants and terminals	1,580,283	1,568,791	1,853,904	2,083,251	2,108,594	20,568,248

Table 7.—Natural gas liquids utilized at refineries in the United States in 1967 by Bureau of Mines refinery districts and by months

(Thousand gallons)

District	January	February	March	April	May	June	July	August	September	October	November	December	Total
East Coast	13,020	17,640	14,238	11,550	6,468	12,810	16,170	16,506	26,628	23,730	25,872	19,110	203,742
Appalachian	1,260	798	714	546	546	378	882	672	1,050	1,134	1,218	1,344	10,542
Indiana, Illinois, Kentucky, etc.	86,814	74,130	58,464	53,802	53,088	56,868	57,456	69,006	76,566	99,666	106,890	111,678	904,428
Minnesota, Wisconsin, North Dakota, and South Dakota	10,584	8,778	8,316	5,964	4,494	7,686	8,484	8,988	9,366	10,374	11,886	13,398	108,318
Oklahoma, Kansas, Missouri	81,312	58,212	65,814	58,422	58,632	67,116	67,746	68,628	70,392	77,700	86,100	79,002	839,076
Texas:													
Inland	81,984	74,172	84,840	82,740	84,924	83,622	86,352	89,880	82,404	84,924	83,118	78,036	996,996
Gulf Coast	412,062	347,256	382,326	329,322	365,820	373,506	379,260	376,194	343,014	407,904	404,586	406,518	4,527,768
Total	494,046	421,428	467,166	412,062	450,744	457,128	465,612	466,074	425,418	492,828	487,704	484,554	5,524,764
Louisiana-Arkansas:													
Louisiana Gulf Coast	94,584	90,762	86,478	103,824	95,634	91,224	95,802	92,358	106,638	106,008	106,764	107,268	1,177,344
Arkansas and Louisiana Inland	21,714	18,312	20,958	17,388	18,858	19,866	19,698	20,454	19,740	20,160	19,320	17,934	234,402
Total	116,298	109,074	107,436	121,212	114,492	111,090	115,500	112,812	126,378	126,168	126,084	125,202	1,411,746
New Mexico	2,940	3,696	4,284	3,360	4,074	4,284	4,368	4,284	3,948	4,074	4,662	3,444	47,418
Other Rocky Mountain	18,606	14,490	16,926	15,540	14,994	14,910	15,078	14,448	15,372	20,538	19,068	21,294	201,264
West Coast	90,174	81,270	85,344	82,446	80,682	83,286	84,924	85,260	78,708	91,518	94,920	88,410	1,026,942
Total United States	915,054	789,516	828,702	764,904	788,214	815,556	836,220	846,678	833,826	947,730	964,404	947,436	10,278,240

Table 8.—Production of natural gas liquids and ethane at natural gas processing plants in the United States in 1967

(Thousand gallons)

States by petroleum districts	Liquefied petroleum gas and ethane: Propane (including ethane)	Liquefied petroleum gas and ethane: Butane	Liquefied petroleum gas and ethane: Butane-propane mixture	Liquefied petroleum gas and ethane: Isobutane	Liquefied petroleum gas and ethane: Total	Natural gasoline and isopentane	Plant condensate	Finished gasoline and naphtha	All other products [1]	Total
District 1:										
Western Pennsylvania	1,110	647	-------	4,892	6,649	1,167	---------	-------	-------	7,816
West Virginia [2]	280,191	58,957	-------	---------	339,148	47,662	1,351	-------	-------	388,161
Total	281,301	59,604	-------	4,892	345,797	48,829	1,351	-------	-------	395,977
District 2:										
Kentucky [3]	515,455	32,242	-------	25,042	572,739	31,928	210	-------	-------	604,877
Michigan	36,722	22,049	-------	619	59,390	47,280	537	-------	-------	107,207
Kansas	424,397	192,495	384	47,781	665,057	190,980	2,010	1,126	57	859,230
Nebraska	12,648	8,090	-------	---------	20,738	7,805	---------	-------	-------	28,543
North Dakota	55,189	33,476	-------	---------	88,665	22,867	417	-------	-------	111,949
Oklahoma	651,565	263,839	42,547	47,682	1,005,633	498,091	66,923	1,130	2,761	1,574,538
Total	1,695,976	552,191	42,931	121,124	2,412,222	798,951	70,097	2,256	2,818	3,286,344
District 3:										
Arkansas	35,019	11,334	106	7,271	53,730	20,813	4,268	-------	2,452	81,263
Louisiana:										
Gulf	1,002,483	353,603	9,562	245,907	1,611,555	859,075	382,214	95,590	60,162	3,008,596
Inland	127,178	57,923	23,725	24,308	233,134	81,901	118,177	120,331	37,153	590,696
Total	1,129,661	411.526	33,287	270,215	1,844,689	940,976	500,391	215,921	97,315	3,599,292
Mississippi [4]	9,385	7,694	715	---------	17,794	16,505	845	-------	589	35,733
New Mexico	510,886	309,620	18,579	70,083	909,168	320,004	15,625	-------	2,485	1,247,282
Texas:										
Gulf	840,540	211,474	361,801	152,591	1,566,406	633,864	136,190	14,504	5,630	2,356,594
West	1,927,930	703,758	62,976	115,679	2,810,343	938,115	173,705	-------	814	3,922,977
East (field)	117,718	63,113	4,519	---------	185,350	82,155	804	-------	828	269,137
Panhandle	532,208	231,183	4,916	284,933	1,053,240	415,431	1,513	-------	271	1,470,455
Other	1,104,047	451,275	104,659	174,119	1,834,100	881,056	648,375	74,582	23,752	3,461,865
Total	4,522,443	1,660,803	538,871	727,322	7,449,439	2,950,621	960,587	89,086	31,295	11,481,028
Total	6,207,394	2,400,977	591,558	1,074,891	10,274,820	4,248,919	1,481,716	305,007	134,136	16,444,598

Table 8.—Production of natural gas liquids and ethane at natural gas processing plants in the United States in 1967—Continued

(Thousand gallons)

States by petroleum districts	Liquefied petroleum gas and ethane					Natural gasoline and isopentane	Plant condensate	Finished gasoline and naphtha	All other products[1]	Total
	Propane (including ethane)	Butane	Butane-propane mixture	Isobutane	Total					
District 4:										
Colorado	48,848	19,017	-------	3,679	71,544	50,908	937	-------	-------	123,389
Montana[5]	42,954	26,101	3,959	-------	73,014	30,742	-------	-------	-------	103,756
Wyoming	104,809	67,542	-------	1,470	173,821	83,666	15,514	-------	-------	273,001
Total	196,611	112,660	3,959	5,149	318,379	165,316	16,451	-------	-------	500,146
District 5	291,669	45,131	9,759	20,084	366,643	588,256	25,158	-------	-------	980,057
Total United States	[6]8,672,951	3,170,563	648,207	1,226,140	13,717,861	5,850,271	1,594,773	307,263	136,954	21,607,122

[1] Includes jet fuel, kerosine, distillate, and other.
[2] Florida included with West Virginia.
[3] Illinois included with Kentucky.
[4] Alabama included with Mississippi.
[5] Utah included with Montana.
[6] Includes 1,542,712 thousand gallons of ethane, of which 340,183 thousand gallons was produced in Kentucky and Illinois, 147,366 thousand gallons in Louisiana Gulf and 872,603 thousand gallons in Texas.

Table 9.—Liquefied petroleum gas and ethane (LR gas) produced at refineries for fuel and chemical use in 1967

(Thousand gallons)

States by petroleum district	Propane	Butane	Butane-propane mixture	Total
District 1:				
East Coast [1]	552,006	67,620	546	620,172
West New York	21,462	420	---------	21,882
Pennsylvania	5,586	---------	---------	5,586
West Virginia	---------	---------	---------	---------
Total	579,054	68,040	546	647,640
District 2:				
Illinois	208,950	14,616	---------	223,566
Indiana	54,096	8,106	---------	62,202
Kansas	140,028	6,930	84	147,042
Kentucky	34,776	2,982	---------	37,758
Michigan	55,356	4,158	---------	59,514
Minnesota [2]	53,046	1,386	10,500	64,932
Ohio	186,606	1,302	---------	187,908
Oklahoma	124,866	44,856	64,260	233,982
Total	857,724	84,336	74,844	1,016,904
District 3:				
Arkansas	24,654	9,912	---------	34,566
Louisiana:				
Gulf	414,918	60,480	123,942	599,340
Inland	11,466	7,728	1,092	20,286
Total	426,384	68,208	125,034	619,626
Mississippi [3]	62,958	4,662	2,604	70,224
New Mexico	5,922	4,452	1,176	11,550
Texas:				
Gulf	911,778	436,128	130,704	1,478,610
Inland	106,302	55,104	210	161,616
Total	1,018,080	491,232	130,914	1,640,226
Total	1,537,998	578,466	259,728	2,376,192
District 4:				
Colorado	5,838	8,694	---------	14,532
Montana	11,256	3,990	---------	15,246
Utah	21,000	9,198	---------	30,198
Wyoming	7,140	27,342	---------	34,482
Total	45,234	49,224	---------	94,458
District 5	304,752	126,294	117,474	548,520
Total United States	[4] 3,324,762	[5] 906,360	452,592	4,683,714

[1] Excludes Pennsylvania.
[2] Missouri, Nebraska, North Dakota, Tennessee, and Wisconsin included with Minnesota.
[3] Alabama included with Mississippi.
[4] Includes 295,218 thousand gallons of ethane.
[5] Includes 56,490 thousand gallons of isobutane used for petrochemical feedstock.

Table 10.—Values and volumes of natural gas liquids and ethane produced in the United States

	Thousand gallons		Percent change	Thousand dollars		Percent change	Cents per gallon		Percent change
	1966	1967		1966	1967		1966	1967	
LP gases and ethane	12,134,294	13,717,861	+13.1	527,223	632,994	+20.1	4.3	4.6	+7.0
Natural gasoline and isopentane	5,564,139	5,850,271	+5.1	366,332	389,156	+6.2	6.6	6.7	+1.5
Plant condensate	1,419,111	1,594,773	+12.4	107,292	119,943	+11.8	7.6	7.5	−1.3
Finished gasoline and naphthas	380,135	307,263	−19.2	33,380	28,044	−16.0	8.8	9.1	+3.4
Other products	185,043	136,954	−26.0	13,134	9,799	−25.4	7.1	7.2	+1.4
Total	19,682,722	21,607,122	+9.8	1,047,361	1,179,936	+12.7	5.3	5.5	+3.8

Table 11.—Average monthly prices, liquefied petroleum gas (propane) in the United States [1]

(Cents per gallon)

	January	February	March	April	May	June	July
New York Harbor:							
1966	8.13	8.13	8.13	8.13	8.13	8.14	8.25
1967	9.21	9.25	9.25	9.25	9.25	9.10	8.75
Oklahoma:							
1966	5.00	5.00	5.00	5.00	5.00	5.00	5.00
1967	5.94	6.00	6.00	6.00	6.00	5.87	5.75
Baton Rouge:							
1966	5.25	5.25	5.25	5.46	5.50	5.50	5.50
1967	6.19	6.25	6.25	6.25	6.25	6.25	6.25

	August	September	October	November	December	Average for year
New York Harbor:						
1966	8.25	8.25	8.58	8.75	8.75	8.30
1967	8.75	8.75	8.75	8.75	8.75	8.98
Oklahoma:						
1966	5.00	5.08	5.48	5.50	5.52	5.13
1967	5.57	5.75	5.75	5.75	5.73	5.86
Baton Rouge:						
1966	5.50	5.57	5.75	5.75	5.77	5.50
1967	6.25	6.25	6.25	6.25	6.25	6.24

[1] Producers' net contract prices (after some discounts and summer-fill allowances) for propane, tank cars/transport trucks.

Source: Platt's Oil Price Handbook.

Table 12.—Stocks of natural gas liquids and ethane in the United States

(Thousand gallons)

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:									
1963	1,132,750	33,306	100,188	68,040	67,412	15,666	1,300,350	117,012	1,417,362
1964	1,205,745	37,968	99,191	83,832	56,889	14,868	1,361,825	136,668	1,498,493
1965	1,235,478	24,654	130,886	68,418	39,989	6,972	1,406,353	100,044	1,506,397
1966	1,453,625	24,654	112,265	54,600	39,916	12,726	1,605,806	91,980	1,697,786
1967:									
Jan. 31	1,242,227	22,176	107,677	62,202	54,618	6,846	1,404,522	91,224	1,495,746
Feb. 28	1,138,231	22,134	116,870	63,504	51,061	7,896	1,306,162	93,534	1,399,696
Mar. 31	1,246,538	22,386	107,117	65,604	53,163	6,930	1,406,818	94,920	1,501,738
Apr. 30	1,575,103	20,538	111,724	69,552	77,001	8,568	1,763,828	98,658	1,862,486
May 31	1,912,631	22,932	119,134	84,462	68,417	6,720	2,100,182	114,114	2,214,296
June 30	2,201,178	24,990	110,248	82,782	64,081	8,946	2,375,507	116,718	2,492,225
July 31	2,478,368	22,596	110,209	85,092	68,487	7,728	2,657,064	115,416	2,772,480
Aug. 31	2,718,414	23,520	103,704	88,998	71,124	6,300	2,893,242	118,818	3,012,060
Sept. 30	2,881,611	22,722	112,837	87,444	75,351	6,720	3,069,799	116,886	3,186,685
Oct. 31	2,906,131	24,360	108,232	81,438	77,787	5,544	3,092,150	111,342	3,203,492
Nov. 30	2,672,754	23,352	110,953	70,476	74,193	6,888	2,857,900	100,716	2,958,616
Dec. 31	[1] 2,464,762	23,310	112,104	87,234	67,814	5,922	2,644,680	116,466	2,761,146

[1] Includes 1,465 million gallons in underground storage.

FOREIGN TRADE

The United States imported 239,190,000 gallons of butane and 175,980,000 gallons of propane in 1967. Canada was the source of 99 percent of these imports. No breakdown between butane and propane is available for previous years, but the total imports of liquefied gases in 1966 were 440,538,000 gallons.

Exports of liquefied gas, principally butane-propane mixtures, increased from 343,171,000 gallons in 1966 to 389,372,000 gallons in 1967. Mexico is the principal market for liquefied gases exported from the United States and accounted for over 81 percent of the total volume shipped in 1967.

Table 13.—LP gases [1] exported from the United States, by countries

(Thousand gallons) [2]

	1965	1966	1967 [3]			
			Butane	Propane	Butane-propane mixtures	Total
Argentina	15,247	(4)	3	3,298	---------	3,301
Australia	11	65	9	---------	97	106
Bahamas	1,046	1,307	242	2,396	26	2,664
Belgium-Luxembourg	4	468	2	1	959	962
Brazil	2	15	2,803	481	---------	3,284
Canada	2,496	7,355	9,625	938	4,708	15,271
Dominican Republic	234	202	2	93	25	120
Guatemala	517	1,129	---------	7	1,147	1,154
India	1	2	1	---------	51	52
Japan	530	316	7	---------	247	254
Mexico	260,129	307,103	17,914	32,192	267,024	317,130
Netherlands	116	53	1	---------	1,225	1,226
New Zealand	39	77	25	10	39	74
South Africa, Republic of	53	126	9	---------	33	42
United Kingdom	33,682	24,357	7,447	35,565	34	43,046
Other	1,357	596	168	319	199	686
Total	315,464	343,171	38,258	75,300	275,814	389,372

[1] Data include LR gases.
[2] 4.5 pounds = 1 gallon.
[3] Eeffctive Jan. 1, 1967, LP gases shown separately, no longer one class.
[4] Less than ½ unit.

Nickel

By Horace T. Reno [1]

The nickel industry in 1967 had not fully recovered from the strikes of 1966 and experienced a shortage of skilled labor. Nevertheless, primary plant production was the third largest quantity on record. There was a worldwide shortage of nickel, and substantial quantities produced in Communist countries reached the free market. In the last half of the year nickel prices were raised 10 to 15 percent in the United States and the consumption rate decreased.

There was unusually high activity in nickel exploration in Canada and Australia. Australia joined the major nickel-producing countries of the world. Widespread exploitation of laterites as a major nickel source moved closer to fruition in Indonesia and the Philippines as these governments asked for and received bids from private concerns for concessions to mine laterites in their countries.

Laboratory research in nickel extractive metallurgy leveled off in 1967, but research in nickel processing methods and in physical metallurgy continued at the high level of the last decade.

Table 1.—Salient nickel statistics

(Short tons)

	1963	1964	1965	1966	1967
United States:					
Mine production	13,394	15,420	16,188	15,036	15,287
Plant production:					
Primary	11,432	12,185	13,510	13,237	14,615
Secondary	18,996	23,114	19,407	26,777	20,731
Exports	60,927	68,502	20,935	r 26,387	31,537
Imports for consumption	119,000	129,000	163,000	141,000	143,000
Consumption	124,478	146,920	172,084	187,833	173,798
Stocks Dec. 31: Consumer	17,191	17,185	14,047	r 31,288	30,907
Price cents per pound	79	79	79–77¾	77¾–85¼	85¼–94
World: Production	373,986	408,953	468,270	440,108	481,269

r Revised.

Legislation and Government Programs.—General Services Administration sold approximately 18.6 million pounds of nickel from government stockpiles, principally in the form of nickel cathodes during calendar year 1967. This disposed of all the surplus nickel available under current authorizations. Government stocks of nickel on December 31, 1967, were as follows:

Total inventory	*Net weight (short tons)*
National stockpile	69,536
Supplemental Stockpile	.....
Defense Production Administration Stocks	3,492

The nickel stockpile objective was reduced from 50,000 to 20,000 short tons on January 13, 1967; however, Congress had not authorized disposal of the stockpile nickel in excess of the objective by yearend.

The suspension of duty on ferronickel, unwrought nickel, and nickel powders was extended to September 30, 1967 by Public Law 90–48. After that date however, a duty of a 1.25¢ per pound applied to these items.

The Federal Government's Economic Development Administration granted the Knox Mining Corp. of Alexandria, Va., $85,555 for exploration of copper-nickel-cobalt deposits in the Crawford Pond area of Knox County, Maine.

[1] Mining engineer, Division of Mineral Studies.

DOMESTIC PRODUCTION

All primary nickel produced in the United States in 1967 was in the form of ferronickel. The Hanna Mining Co. mine and smelter at Riddle, Oreg., was the sole producer. Nickel salts were produced as a byproduct at copper and other metal refining plants. Part of the byproduct nickel orginated from scrap.

The outlook for expanding domestic primary nickel production was greatly enhanced in 1966 and 1967 by activity in the Duluth grabbro complex of northern Minnesota. This complex is a multiple intrusive of basic igneous rocks, extending northward from Duluth roughly paralleling the shoreline of Lake Superior to the Canadian border. The Bureau of Mines, the Geological Survey, and the Minnesota State Mines Experiment Station and University, studied and explored the area for many years attempting to interest private industry in exploiting its low grade copper and nickel ores. This work, the nickel scarcity, and the increasing price trend tipped the balance to favor possible exploitation. On June 14, 1966, International Nickel Co. (Inco) entered a mining lease agreement with the Department of the Interior's, Bureau of Land Management to explore 4,894 acres in the Superior National Forest, Lake and St. Louis Counties, Minn. On December 29, 1966, Minnesota awarded mineral exploration leases to 11 concerns which covered 88,000 acres of State-owned land in the same area.

In 1967 Inco started sinking a 1,100-foot preliminary development shaft and began engineering studies to assess the economic and technologic feasibility of mining these low-grade copper-nickel sulfide deposits. The other concerns holding leases in the area began exploratory sampling, mapping, and drilling. Reportedly, none was far enough advanced by the end of the year to indicate more than a possibility of profitable operations.

Table 2.—Primary nickel produced in the United States

(Short tons, nickel content)

	1963	1964	1965	1966	1967
Byproduct of copper refining	707	949	844	1,006	1,579
Domestic ore	10,725	11,236	12,666	12,231	13,036

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	1966	1967
New scrap:		
Nickel-base	3,126	1,457
Copper-base	6,476	6,334
Aluminum-base	595	540
Total	10,197	8,331
Old scrap:		
Nickel-base	15,297	11,260
Copper-base	893	840
Aluminum-base	390	300
Total	16,580	12,400
Grand total	26,777	20,731

Form of recovery	1966	1967
As metal	1,814	2,393
In nickel-base alloys	3,048	2,688
In copper-base alloys	8,020	7,810
In aluminum-base alloys	1,031	885
In ferrous and high-temperature alloys [1]	10,550	6,019
In chemical compounds	2,314	936
Total	26,777	20,731

[1] Includes only nonferrous nickel scrap added to ferrous and high-temperature alloys.

CONSUMPTION AND USES

A shortage in nickel supply resulted in decreasing use of metallic nickel, ferronickel, and nickel-bearing salts in the last half of 1967. Nevertheless, the year's total domestic consumption was the second highest on record.

Although Bureau of Mines' nickel consumption data in 1967 were expanded to include total shipments to the plating industry, nickel's use pattern in 1967 was not substantially different from that in 1966. The apparent wide variation shown in table 6, is due to changing reporting practice and the last half-year adjustment described above.

Table 4.—Stocks and consumption of new and old nickel scrap in the United States in 1967

(Gross weight, short tons)

Class of consumer and type of scrap	Stocks, beginning of year	Receipts	Consumption			Stocks, end of year
			New	Old	Total	
Smelters and refiners:						
Unalloyed nickel	127	997	645	370	1,015	109
Monel metal	523	1,894	260	1,728	1,988	429
Nickel silver [1]	893	5,576	615	4,888	5,503	966
Miscellaneous nickel alloys	7	5,314	59	5,256	5,315	6
Nickel residues	86	233	----	244	244	75
Total	743	8,438	964	7,598	8,562	619
Foundries and plants of other manufacturers:						
Unalloyed nickel	320	8,285	411	8,042	8,453	152
Monel metal	29	158	79	89	168	19
Nickel silver [1]	7,512	24,515	22,404	100	22,504	9,523
Miscellaneous nickel alloys	3	----	----	3	3	----
Nickel residues	605	399	310	349	659	345
Total	957	8,842	800	8,483	9,283	516
Grand total:						
Unalloyed nickel	447	9,282	1,056	8,412	9,468	261
Monel metal	552	2,052	339	1,817	2,156	448
Nickel silver [1]	8,405	30,091	23,019	4,988	28,007	10,489
Miscellaneous nickel alloys	10	5,314	59	5,259	5,318	6
Nickel residues	691	632	310	593	903	420
Total	1,700	17,280	1,764	16,081	17,845	1,135

[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 forms

(Short tons)

Form	1963	1964	1965	1966	1967 [1]
Metal	110,365	123,443	146,357	132,573	124,639
Ferronickel	-----	-----	-----	29,674	25,228
Oxide powder and oxide sinter	12,461	21,090	23,047	22,845	19,349
Matte	2	2	3	-----	-----
Salts [2]	1,650	2,385	2,677	2,741	4,582
Total	124,478	146,920	172,084	187,833	173,798

[1] Metallic nickel salts consumed by the plating industry are estimated.
[2] Figures do not cover all consumers for 1963 through 1966.

Table 6.—Nickel (exclusive of scrap) consumed in the United States, by uses

(Short tons)

Use	1963	1964	1965	1966	1967 [1]
Alloy steels:					
Wrought	19,727	24,679	27,009	27,807	18,780
Cast					4,881
Cast irons	5,901	6,605	6,937	7,286	6,596
Copper base alloys:					
Wrought (including coinage)	------	------	------	[2] 9,937	4,555
Cast	------	------	------		3,853
Electrical resistance alloys [3]	13,505	15,291	18,464	5,423	4,311
Electroplating:					
Anodes [4]	18,621	19,446	19,450	13,828	23,721
Solutions	1,050	1,645	2,037	1,925	4,041
Nickel alloys:					
Wrought	24,794	23,639	37,082	[2] 47,366	38,992
Cast					4,217
Permanent magnets	777	664	828	807	896
Stainless and heat resisting steels:					
Wrought	34,140	48,301	51,700	65,910	38,882
Cast					14,054
Other [5]	5,963	6,650	8,577	7,544	6,019

[1] Metallic nickel salts consumed by the plating industry are estimated.
[2] Copper base and nickel alloys formerly published together as nonferrous.
[3] Before 1966, included high-temperature alloy, now shown under nickel alloy.
[4] Includes metallic nickel used in baskets.
[5] Catalysts, ceramics, chemicals (other than electroplating), iron-nickel alloys.

Table 7.—Nickel (exclusive of scrap) in consumer stocks in the United States, by forms

(Short tons)

Form	1965	1966 [1]	1967
Metal	11,320	20,963	24,380
Ferronickel	821	5,819	2,455
Oxide powder and oxide sinter	1,622	4,118	3,679
Matte	1	------	------
Salts	283	388	393
Total	14,047	31,288	30,907

[1] Incorporates some revisions.

PRICES

Domestic nickel prices, which were last increased in the fall of 1966, were unchanged until September 15, 1967, when the Canadian Company, Sherritt Gordon Mines Ltd. raised its quoted U.S. price for nickel powder from 85.25 cents to .98 cents per pound. This instigated price increases in essentially all nickel-bearing raw materials. By October 1, 1967, prices asked for all the principal nickel material had been increased 10 to 15 percent.

	Cents per pound	
Type of nickel	*January-September*	*October-December*
Nickel powder.	85¼	98
Cathodes	85¼	94
Sinter-90	81¼	89

FOREIGN TRADE

U.S. consumers reacted to the worldwide shortage of nickel by establishing new points of supply in the Soviet Union, Republic of South Africa, and Finland. Trade with Canadian producers was modified by allocation to consumers. The Bureau of International Trade, U.S. Department of Commerce, withheld licenses for export of nickel alloys and nickel-bearing stainless steel scrap for about 4 weeks, mid-June to mid-July. After that, export rules were revised but trading continued as in the past, governed principally by prices charged for U.S. scrap.

Table 8.—U.S. exports of nickel and nickel alloy products, by classes

(Short tons and thousand dollars)

Class	1965		1966		1967	
	Quantity	Value	Quantity	Value	Quantity	Value
Unwrought	5,307	$8,155	r 11,456	r $17,592	7,453	$14,347
Bars, rods, angles, shapes, and sections	2,937	7,851	2,828	8,689	2,595	8,697
Plates, sheets, and strip	1,310	5,711	1,104	5,718	1,997	9,292
Anodes	276	552	194	403	232	558
Wire	380	1,914	475	2,203	565	2,530
Powders and flakes	253	1,356	334	1,376	533	2,144
Foil	4	15	13	71	6	26
Catalysts	2,547	6,064	3,135	6,589	3,441	9,387
Tubes, pipes, blanks, and fittings therefor, and hollow bars	1,198	4,748	972	3,214	823	3,417
Waste and scrap	6,723	4,168	5,876	6,229	13,892	20,331
Total	20,935	40,534	r 26,387	r 52,084	31,537	70,729

r Revised.

Table 9.—U.S. imports for consumption of nickel products, by classes

(Short tons)

Class	1965	1966	1967
Ore and matte	81	(1)	------
Unwrought (ingots, pigs, etc.)	132,559	r 112,886	113,860
Oxide and oxide sinter	13,600	7,711	6,208
Slurry [2]	24,057	20,400	23,006
Bars, plates, sheets	80	103	135
Rods and wire	267	340	428
Shapes, sections, and angles	4	1	1
Pipes, tubes, and fittings	35	14	107
Powder	2,640	4,123	3,716
Flakes	2	18	(1)
Waste and scrap	1,163	941	1,104
Ferronickel	32	11,898	9,020
Total: Gross weight	174,520	r 158,435	157,585
Nickel content (estimated)	163,000	141,000	143,000

r Revised.
1 Less than ½ unit.
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.

Tariff reductions negotiated during the Kennedy Round of the General Agreement on Tariffs and Trade (GATT) went into effect January 1, 1968, under authority of Presidential Proclamation 3822. The statutory rate of 3 cents per pound for the following was reduced as follows:

TSUS No.	*Item*	*New rate*
607.25	Ferronickel	Free
620.03	Unwrought nickel	Free
620.04	Nickel waste and scrap [1]	1 cent per pound
620.32	Nickel powder	Free

1 Duty suspended until June 30, 1969 as provided by Public Law 90-45.

The duty on nickel waste and scrap will be lowered progressively each year until free on January 1, 1972.

Table 10.—U.S. imports for consumption of new nickel products,[1] by countries

(Short tons)

Country	Metal		Oxide and oxide sinter		Slurry and other [2]			
	1966	1967	1966	1967	1966		1967	
	Gross weight	Gross weight	Gross weight	Gross weight	Gross weight	Nickel content	Gross weight	Nickel content
Australia	29	----	----	----	----	----	----	----
Canada	104,433	104,157	7,700	6,208	17,898	13,581	19,899	16,594
Finland	----	114	----	----	----	----	----	----
France	----	66	----	----	----	----	----	----
Germany, West	(3)	53	----	(3)	10	3	----	----
Netherlands	21	85	----	----	----	----	----	----
Norway	r 7,861	8,516	----	----	----	----	44	9
South Africa, Republic of	36	272	----	----	2,491	1,322	3,063	1,413
Sweden	----	11	10	----	----	----	----	----
U.S.S.R.	----	176	----	----	----	----	----	----
United Kingdom	r 506	398	1	(3)	1	(3)	----	----
Other countries	----	12	----	----	----	----	----	----
Total	r 112,886	113,860	7,711	6,208	20,400	14,906	23,006	18,016

r Revised.
[1] Ore and matte, 1966, Australia, less than ½ unit: 1967, no transactions.
[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

European industrial concerns experienced a shortage of nickel probably more serious than that in the United States. To meet this shortage, nickel was bought from Communist countries and the European Economic Community suspended the customs tariff on ferronickel, effective until June 30, 1968.

Australia.—Since Western Mining Company reported sulfide mineralization at Kambalda, 30 miles south of Kalgoorlie in 1966, Western Australia has been experiencing a nickel rush reminiscent of many of the gold rushes of the past. The interest in nickel spread to Queensland, and throughout the year most of the major international metal mining concerns had exploration crews in the field. Geologists who had worked in the iron ore deposits of Western Australia during the recent boom in that industry joined the search for nickel. Nickel finds were reported in several areas, but the reports were not adequate to evaluate the significance of the discoveries.

Western Mining Company progressively increased the rate of exploitation of its deposit at Kambalda, and by the end of the year was producing at the rate of 100,000 tons of ore annually. Its reserves in the area reportedly totaled more than 10 million tons of 3.8 percent nickel.

Botswana. — Bamangwato Concessions Ltd. a subsidiary of Roan Selection Trust Ltd. announced that it discovered copper-nickel ore in the Pikwe-Sedibe area 60 miles southeast of Francistown. The metals occur in sulfide minerals. The deposits and metallurgy problems attendant to exploiting it had not been fully delineated by the end of the year.

Canada.—Canadian nickel companies actively sought new properties in all the metal mineral provinces of the country. Most exploration was in the Sudbury district of Ontario and near existing nickel mines in Manitoba and British Columbia, but exploration crews worked the field season in Quebec, New Brunswick, northern British Columbia, and in the Yukon and Northwest Territories. Several discoveries were reported, but none was proved of immediate economic significance.

Canadian nickel mines were plagued by a shortage of skilled labor throughout the year. However, they managed to produce almost 250,000 tons of nickel, the second best year on record.

The nickel-bearing sulfide ores of Canada have been the mainstay of the free

Table 11.—World production of nickel, by countries [1]

(Short tons)

Country	1963	1964	1965	1966	1967 [p]
North America:					
Canada [2]	217,030	228,496	267,308	[r] 223,610	246,954
Cuba:					
Content of oxide [e]	16,100	16,200	20,200	[r] 17,500	[e] 26,000
Estimated content of sulfide	5,700	8,500	9,900	[r] 11,100	
United States:					
Byproduct of copper refining	707	949	844	1,006	1,579
Nickel recovered from domestic ore	10,725	11,236	12,666	12,231	13,036
South America: Brazil (content of ferronickel)	1,135	[e] 1,100	1,228	[e] [r] 1,525	1,180
Europe:					
Finland:					
Content of nickel sulfate	[r] 183	162	180	[r] 204	[e] 200
Content of concentrates	3,230	[r] 3,532	[r] 3,295	[r] 3,254	[e] 3,300
Poland (content of ore)	1,218	1,328	1,214	[e] 1,400	[e] 1,400
U.S.S.R. (content of ore) [e]	[r] 75,000	[r] 80,000	[r] 90,000	[r] 95,000	105,000
Africa:					
Morocco (content of cobalt ore) [e]	302	370	397	430	[e] 410
Rhodesia, Southern (content of ore)	131	173	[e] 770	[e] 770	[e] 440
South Africa, Republic of (content of matte and refined nickel) [e]	2,700	2,700	3,300	6,000	6,300
Asia:					
Burma (content of speiss)	112	78	[e] 55	[e] 75	NA
Indonesia (content of ore)	1,764	1,874	[r] 3,858	[r] 4,519	6,614
Korea, South (content of ore)	29	20	1	-----	NA
New Caledonia (recoverable) [3]	37,920	52,235	[r] 53,054	[r] 61,484	67,856
Oceania: Australia	-----	-----	-----	-----	[e] 1,000
Total [4]	[r] 373,986	[r] 408,953	[r] 468,270	[r] 440,108	481,269

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] Nickel is also produced in Albania and East Germany but production data are not available.
[2] Refined nickel and content of oxides and salts produced plus recoverable nickel in matte and concentrates exported.
[3] Nickel-cobalt content of metallurgical plant products plus recoverable nickel-cobalt in exported ores.
[4] Total is of listed figures only; no undisclosed data included.

world's nickel production in this modern industrial era. Laterite ores, which have been of interest since the price increases of 1966 and 1967, will supplement these deposits not displace them. Canadian firms mining sulfide ores and their 1967 nickel production or deliveries to customers as given in their annual reports to stockholders were as follows:

Company	*Type of operation*	*Pounds*
International Nickel Co. Ltd	Delivery	463,450,000
Falconbridge Nickel Mines Ltd	Delivery	74,754,000
Sherritt Gordon Mines Ltd	Production	22,224,172
Consolidated Canadian Faraday Ltd	Production	3,906,731
Marbridge Mines Ltd (Subsidiary of Falconbridge)	Production	2,211,000
Giant Mascot Mines Ltd	Recovery	4,752,936
Lorraine Mines (McIntyre-Porcupine Mines Ltd)	Production	1,477,548

International Nickel Company operated nine mines in Ontario and one in Manitoba in 1967 and was developing five new mines in Ontario and three in Manitoba. The company also was exploring the North Range property in the Sudbury district of Ontario and the Shebandown property in northwest Ontario.

Falconbridge Nickel Mines Ltd. operated six mines in the Sudbury district and was developing the Strathcona and Longvack mines in the same district.

International Nickel, Falconbridge, and Sherritt Gordon were engaged in large-scale plant expansion programs to increase Canadian nickel productive capacity 150 to 200 million pounds by 1970.

Dominican Republic.—Falconbridge Dominicana C. por A., subsidiary of Falconbridge Nickel Mines Ltd. of Canada, explored two adjoining lateritic deposits in its mineral concession and developed at least 62 million tons of ore containing 1.55 percent nickel. The ore begins at the surface and ranges to 180 feet thick, but averages about 30 feet. The company operated a 140-ton-per-day pilot plant on the property for 9 months. The product, ferronickel, proved satisfactory. Falconbridge proposed a plant to be operational in late 1971 capable of producing annually 50 million pounds of nickel in ferronickel and costing upwards of $150 million. The method of financing had not been decided by the end of the year.

France.—France imported more than 6,000 long tons of nickel-bearing materials from Cuba and exported substantial quantities of nickel products to mainland China.

Greece.—Société Minère et Metallurgique de Larymna Larco S.A. the joint venture of Hellenic, Chemical Products & Fertilizers Co. and Société Le Nickel which began operating in 1966 produced electrolytic nickel and ferronickel throughout the year. At yearend the new plant had not yet achieved smooth operation.

Guatemala.—The International Nickel Company subsidiary, Exploraciones y Explotaciones Mineras Izabal S.A., continued development of deposits near Lake Izabal. The company proposes to install mining and processing facilities capable of producing 50 million pounds of nickel annually, but the project was delayed pending resolution of financial matters with the Guatemalan Government. In the meantime, the company started exploration of lateritic ores in two other areas.

Indonesia.—Early in 1967 the Ministry for Mining of the Republic of Indonesia asked interested concerns around the world to submit proposals for developing nickel deposits in the ultrabasic rock formations on the Island of Sulawesi. Five bids were received. One each from Canadian, United States, Japanese, French, and United States-French concerns. International Nickel Co. of Canada and the combination of Kaiser Aluminum and Chemical Corp. of the United States/Société Le Nickel of France were chosen by Indonesia's Foreign Investment Committee for Mining to enter a final competition for a government-approved nickel concession. The concession will be awarded on the basis of the original proposal; the proposer's views on corporate taxes, land rent and royalties, and depreciation; the time required for exploration and construction; and the apparent benefits to the Indonesian economy.

Japan.—Tokyo Nickel Company, owned jointly by International Nickel Company of Canada, and Mitsui and Company and Shimura Kako Co. of Japan, inaugurated its nickel smelter at Matsuzaka early in the year. The smelter was operating at full capacity of 375 tons of nickel oxide sinter per month by the end of June. To control fumes sulfuric acid was produced as a byproduct. Tokyo Nickel Company was formed to ease Japan's dependence on foreign nickel, as the price of scrap and ores trended upward, and the grade of ore available to Japan trended downward.

In further reaction to high prices and low-grade ores, Nippon Yakin Kogyo Co., Nippon Mining Co. Ltd., and Taiheiya Nickel Co., Japanese smelting companies, with Société Le Nickel of France, formed Nippon Nickel Oxide Company Ltd. to produce nickel oxide. The firm planned to erect a 5,000-ton annual capacity smelting plant at Tsugaru on the Japanese coast.

New Caledonia.—The French Government announced early in the year that it would permit formation of a new company with limited foreign participation to exploit nickel deposits in New Caledonia. Such a company would end the nickel monopoly long held by Société Le Nickel. International Nickel Company of Canada announced that it would have a 40-percent equity interest in the new concern. A consortium of French Government and private companies and banks will own the other 60 percent. The composition of the French consortium was not decided in 1967. However, exploratory field work was started, and International Nickel Company described the new companies objective which is to add 50 to 100 million pounds of nickel annually to the world's supply.

Patino Mining Corporation of Canada explored nickel bearing mineral deposits on 74,000 acres of land in New Caledonia which it holds under option. The results of the work were encouraging and the company sought authorization from the Government of France to establish a mine and treatment plant to recover nickel and cobalt. Their petition was pending at the end of the year.

The French Ministry of Economy and Finance approved a proposal by Kaiser Aluminum and Chemical Corp. and Société Le Nickel to build a nickel processing plant in New Caledonia and to form a company there to market ferronickel products in North America.

Norway.—Expansion of the Falconbridge smelter at Kristiansand, started in 1966 was completed in 1967. A specially designed ocean-going ship will bring concentrates to the smelter from Canada. Terminal facilities were also improved to handle the special vessel.

Philippines.—Suragao Mineral Reservation Board publicly opened nine sealed bids to exploit the nickel laterite deposits of the Suragao Mineral Reservation. At yearend the proposals were still being evaluated. The rights to develop the deposits were to be awarded on the basis of technical feasibility and financial return to the Philippine economy.

Rhodesia, Southern. — Anglo-American Corporation of South Africa Ltd. and Trojan Nickel Mining Company Ltd. announced plans to exploit nickel deposits at Shamva and Bindura near Salisbury. Their plans include a smelter and refinery in conjunction with the mine. Apparently, Anglo-American was firmly committed to producing nickel in Southern Rhodesia. The corporation prospected for nickel in six other mineralized areas of the country during the year.

United Kingdom.—International Nickel Ltd. completed expansion of its Clydach refinery to an annual capacity of 40,000 tons of metal. The plant receives raw materials from Inco's Canadian operations and processes it to pure nickel and nickel compounds for sale to European industrial concerns.

Reportedly nickel cathodes produced in the Soviet Union were bought above market prices for processing in the United Kingdom and later sold at a loss. The purchases were made to stabilize the market as the shortage of nickel intensified.

Venezuela.—Société Le Nickel contacted with the Venezuelan Government to evaluate nickel deposits of Loma de Hierro in the State of Aragua. The Société is to determine the economic and technical feasibility of exploiting the deposits; arrangements to do so will be made on the basis of its report and agreements for Venezuelan participation in the project.

TECHNOLOGY

Judging by the number of reports and patents issued in 1967, researchers around the world had the same intense interest in nickel they have shown in the last decade. Apparently, the cycle of activity in nickel research and development has not yet reached its apex. There was a leveling or even slackening in the search for new methods of processing the laterite ores, but this was more than offset by research directed toward development of more economical procedures and greater efficiency in processes already developed through the laboratory stage. The proof of the researchers success is counted by the nickel developments cited in the world review section.

"Winning of Nickel", a comprehensive book on nickel technology ranging from geology through mining and extractive metallurgy sponsored by the International Nickel Company of Canada Ltd., was published.[2] This work undoubtedly was instigated by the growing obsolescence of nickel technology caused by research and development activities in the last two decades.

The plating industry seemed to be the subject of strong interest to researchers in nickel uses. A large number of patents was issued for methods of improving electroplating.

Most patents in which nickel was involved had to do with nickel's use in chemical compounds. Many new nickel bearing alloys were developed; several apparently having immediate application in aircraft turbine engines, and chemical industry facilities. The worth of the others will take 2 or 3 years to develop. Quenched and tempered 8 percent nickel-steels, exhibited properties promising for application at low temperatures.[3]

Bureau of Mines' researchers described the magnetic susceptibility of 19 nickel- and cobalt-bearing minerals.[4] This basic

[2] Boldt, J. R. Jr., "Winning of Nickel", D. Van Nostrand Inc. U.S.A. 1967, 487 pp.

[3] The American Society of Mechanical Engineers. A Quenched and Tempered 8-Percent Nickel Steel for Applications Down to —275F, 67-PET-37, 1967, 9 pp; Explosion-Bulge and Drop-Weight Tests of Quenched and Tempered 9-Percent Nickel Steel, 67-PET-38, 1967, 8 pp.

[4] Powell, H.E. Magnetic Susceptibility of 19 Nickel-and Cobalt-Bearing Minerals. BuMines Inf. Circ. 8351, 1967, 12 pp.

investigation was the only Bureau activity related to nickel resources in 1967. As private industrial concerns became interested in exploiting the laterite nickel-bearing ores, the Bureau of Mines' switched its attention to finding ways of recovering nickel from scrap. Bureau researchers completed a study of an electrolytic process for separating cobalt and nickel. They developed a method for recovering cobalt from the electrolyte and demonstrated the possibility of recovering high-purity nickel. The research was completed in 1967 and published early in 1968.[5]

[5] Sullivan, T. A., B. E. Barton, F. R. Cattoir. An Electrolytic Process for Separating Nickel and Cobalt. BuMines Rept. of Inv. 7082, 1968, 17 pp.

Nitrogen

By Richard W. Lewis [1]

Domestic production capacity of anhydrous ammonia continued to increase both in 1966 and in 1967. If all units had gone on stream as scheduled, domestic annual production capacity would have reached about 15 million short tons in 1966 and 18 million tons in 1967. However, a shortage of engineers and skilled craftsman developed, which delayed construction schedules, and capacity including byproduct ammonia at yearend 1966 was estimated at 13.5 million tons, and at yearend 1967, at about 16 million tons, with allowances being made for the closure of some obsolete plants.

World production of agricultural nitrogen in 1967 was estimated at 25.6 million tons and technical nitrogen (excluding gas and liquid elemental nitrogen) at 6.1 million.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient nitrogen statistics

(Thousand short tons of contained nitrogen)

	1963	1964	1965	1966	1967 p
United States:					
Production as ammonia	5,656	6,447	r 7,465	r 8,918	9,939
Production as high purity nitrogen gas	r 1,986	r 2,236	r 2,823	r 3,511	3,975
Exports of nitrogen compounds	219	337	459	707	828
Imports for consumption of nitrogen compounds	401	494	496	566	691
Consumption [1]	5,454	6,117	6,655	7,260	9,120
World: Production [1]	18,864	21,338	24,101	27,000	31,700

p Preliminary. r Revised.
[1] Estimated, excludes nitrogen gas.

Table 2.—Nitrogen production in the United States

(Short tons of contained nitrogen)

	1963	1964	1965	1966 r	1967 p
Anhydrous ammonia: Synthetic plants [1]	5,504,581	6,278,717	r 7,294,565	8,736,317	9,762,059
Ammonia compounds, coking plants:					
Ammonia liquor	12,059	13,325	13,131	11,121	11,913
Ammonium sulfate	131,385	144,362	146,992	161,939	157,287
Ammonium phosphates	8,234	10,638	9,823	8,928	7,929
Total	5,656,259	6,447,042	r 7,464,511	8,918,305	9,939,188
Nitrogen gas [1]	r 1,986,296	r 2,236,471	r 2,823,363	3,511,042	3,975,442

r Revised. p Preliminary.
[1] Bureau of the Census Current Industrial Reports.

Table 3.—Major nitrogen compounds produced in the United States

(Thousand short tons, gross weight)

Compounds	1966 [r]	1967 [p]
Ammonium nitrate	5,017	5,596
Ammonium sulfate	2,870	2,675
Ammonium phosphate	3,711	4,453
Nitric acid	5,514	6,122
Urea	1,716	2,173

[r] Revised. [p] Preliminary.

Sources: Bureau of the Census and Tariff Commission.

DOMESTIC PRODUCTION

Anhydrous ammonia again shattered all previous production records with an increase of 12 percent over 1966 production. The output of nitrogen (liquid and gas) also increased with a reported production of about 13 percent over that of 1966.

Construction schedules for new plants were delayed and several large capacity plants slated for operation in 1966 did not get into production until 1967. The following new ammonia plants and plant expansions were reported on stream, but not necessarily operating at full capacity in 1967.

Company	Plant location	New NH_3 capacity, 1,000 short tons per year
American Cyanamid Co.[1]	Avondale, La.[2]	350
Arkla Chemical Corp	Helena, Ark	210
Borden Chemical Co.[1]	Geismar, La	350
Chevron Chemical Corp	Pascagoula, Miss	525
E.I. duPont de Nemours & Co. Inc	Belle, W. Va.[2]	350
Do	Beaumont, Tex	350
Farmland Industries, Inc	Fort Dodge, Iowa	210
First Nitrogen Corp.[1]	Donaldsonville, La	350
Oklahoma Ordnance Works Authority	Pryor, Okla	30
Shamrock Oil & Gas Corp	Sunray, Tex	70
Tenneco Chemicals Inc	Houston, Tex.[3]	85
Terra Chemicals International, Inc	Sioux, Iowa	350
U.S. Steel Chemicals Co	Clairton, Pa	350
Wycon Chemical Co	Cheyenne, Wyo	105

[1] Reported as completed in 1966 Minerals Yearbook.
[2] Old plant to be abandoned.
[3] Expansion.

Additional new anhydrous ammonia plants and expansions, either planned or under construction in 1967 were announced as follows:

Company	Plant location	Capacity, 1,000 short tons per year	Completion date
Arkla Chemical Corp	Helena, Ark	210	1969
Central Farmer's Fertilizer Co	Donaldsonville, La	350	1969
Collier Carbon & Chemical Corp	Cook's Inlet, Alaska	525	1968
Farmer's Chemical Association, Inc	Tunis, N.C	210	1969
Farmland Industries, Inc	Dodge City, Kans	210	1969
Gulf Oil Corp., Chemicals Div	Donaldsonville, La	350	1968
Hill Chemicals Inc	Borger, Tex	350	1968
Nipak, Inc	Pryor, Okla	70	1968
Nitrogen, Inc (Subsidiary of First Mississippi Corp.)	Donaldsonville, La	350	1969
Sinclair Petrochemical, Inc	Fort Madison, Iowa	350	1968
Solar Nitrogen Corp	Lima, Ohio	525	1969
Southwest Chemical Corp	West Memphis, Ark	350	(Planned)
Tuloma Gas Products Co	Texas City, Tex	525	1968

Producers continued building urea plants during 1966 and 1967 in an effort to supply the increasing demands. In 1966, a 150,000-ton-per-year plant was put on stream by Olin Mathieson Chemical Corp. at Lake Charles, La. At Geismar, La., Borden Chemical Co. began production of what was stated to be the largest low biuret urea plant in the United States. This single reactor plant was engineered for a daily output of 500 tons.[2] In the spring of 1967, Wycon Chemical Co. placed a new 125-ton-per-day urea plant in full production at Cheyenne, Wyo.

Agway, Inc., started urea production at its new $8 million nitrogen fertilizer manufacturing complex at Olean, N. Y. The urea output capacity was reported at 175 tons per day. In addition, the complex included a 170-ton-per-day nitric acid plant, a 210-ton-per-day ammonium nitrate plant, and a nitrogen solutions plant of 600-tons-per-day output.

First Mississippi Corp. began construction on a new nitrogen fertilizer complex at Donaldsonville, La., which includes a 1,200-ton-per-day urea plant. Production was scheduled for early in 1969. Gulf Oil Corp. was constructing a complete urea plant (annual production capacity of 220,000 tons) at its Faustina plant also at Donaldsonville.

At Cook Inlet, Alaska, Collier Carbon & Chemical Corp., in a joint venture with Japan Gas Chemical Co., Ltd., was constructing a urea plant in conjunction with its large anhydrous ammonia plant. Both were due on stream in 1968. The prilled urea plant was engineered to have an annual production capacity of 350,000 tons, one of the world's largest.

Production capacities for nitric acid and ammonium nitrate also were increased chiefly due to increasing demands for ammonium nitrate, both for fertilizer and explosive use. In addition to the new Agway units, several other new nitric acid and ammonium nitrate plants started production in 1966 and 1967. A 320-ton-per-day nitric acid plant at Hannibal, Mo., of the American Cyanamid Co. and a 180-ton-per-day unit at Odessa, Tex., owned by El Paso Products Co., were completed. A 400-ton-per-day ammonium nitrate unit also was erected at Cyanamid's Hannibal, Mo., plant. Celanese Corporation of America was reported to have a new 135-ton-per-day nitric acid plant on stream at Bay City, Tex. The entire output was planned for nonagricultural use. Terra Chemicals International, Inc., had nitric acid and ammonium nitrate units under construction at its $27 million fertilizer complex at Port Neal, Iowa. Units were designed for a daily output of 350 tons of nitric acid and 415 tons of ammonium nitrate. Farmers Chemical Association, Inc., added a nitric acid unit to its fertilizer plant at Tyner, Tenn. The new unit with a daily capacity of 500 tons was to replace an old World War II 300-ton-per-day plant. Hercules, Inc., was completing an 800-ton-per-day nitric acid plant at Louisiana, Mo.,

[2] Reynolds, J. C. Sr., and C. J. Wetherell. Borden Chemical Builds Giant Low Biuret Urea Plant. Farm Chem., v. 129, No. 6, June 1966, pp. 73–78.

said to be the largest in the United States. Cominco American Inc. started production of ammonium nitrate at its 200,000-ton-per-year plant near Beatrice, Nebr. A 300-ton-per-day nitric acid plant was constructed for MisCoa Chemical Co. at Yazoo City, Miss., and United States Steel Corp. increased its nitric acid and ammonium nitrate output by nearly 50 percent at its Geneva works in Provo, Utah.

CONSUMPTION AND USES

Domestic consumption of nitrogen, as compounds, increased 25.6 percent over that for 1966. About 70 percent of all nitrogen consumed, excluding gaseous and liquid nitrogen, was used in fertilizer materials.

According to reports of the U.S. Department of Agriculture, 6,027,000 tons of nitrogen was consumed by agriculture as fertilizers during the fiscal year ending June 30, 1967. This was an increase of 13 percent over the previous 12-month period consumption.

During the calendar year 1967, of the 9,119,000 tons of nitrogen consumed, 2,745,000 tons are estimated to have been used for nonagricultural purposes.

PRICES

Prices on nitrogenous materials generally decreased during the year. Agricultural urea dropped to a low of $82 per ton while the industrial grade dropped to $94 per ton, bagged. The usual seasonal discounts were given on anhydrous ammonia for delivery in August and September, but the price did not recover throughout the remainder of the year. Prices were weakened due to an over-supply situation.

Table 4.—Price quotations for major nitrogen compounds in 1967

(Per short tons)

Compound	Jan. 2	Dec. 25	Effective date of change
Ammonium nitrate, fertilizer grade, 33.5 percent N (nitrogen):			
Bulk, carlots, f.o.b. works	$64.00	$61.00	(1)
Ammonium sulfate, standard granular, bulk, f.o.b. works	32.00	31.00	June 12
Anhydrous ammonia, fertilizer, tanks. works, freight equalized east of Rockies	92.00	84.00	Aug. 14
Sodium nitrate, domestic, commercial, bulk, carlots, works	44.00	44.00	
Sodium nitrate, imported, commercial, bulk, carlots, port warehouse	44.00	44.00	
Urea:			
Industrial, 46 percent N, bags, carlots, delivered freight equalized	100.00	94.00	
Agricultural, 45 percent N, bulk, 50-ton cars, works	85.00	82.00–86.00	Jan. 16

[1] Unsteady, quoted at $61.00 from Jan. 16 through Mar. 6, at $64.00 from Apr. 3 to Aug. 14, and varied between $61.00 and $64.00 until December. Bagged material was priced $5.00 higher than prices quoted.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE

Gross weight of nitrogenous fertilizer materials exported during the year continued to increase and was 4 percent above that of 1966. Ammonium sulfate and ammonium phosphate shipments accounted for nearly 80 percent of the total quantity exported but slightly less than 50 percent in terms of nitrogen content. Anhydrous ammonia shipments increased nearly 130 percent. This large increase was the result of greater emphasis being placed on foreign sales at discounted prices as an inducement. Large quantities of anhydrous ammonia were produced in excess of domestic demand.

The quantity of nitrogenous fertilizer materials imported during 1967 was 8 percent more than that of 1966. Urea imported for consumption, after declining for 2 years, was substantially increased. Anhydrous ammonia imports, chiefly from Trinidad, continued to increase and was 42 percent above those of 1966.

Table 5.—U.S. exports and imports for consumption of major nitrogen compounds

(Thousand short tons)

Compounds	1966 Gross weight	1966 Nitrogen content	1967 Gross weight	1967 Nitrogen content
Exports:				
Industrial chemicals: Anhydrous ammonia and chemical grade aqua (ammonium content)	54	44	39	32
Fertilizer mateiials:				
Ammonium nitrate	87	29	41	14
Ammonium phosphates and other nitrogenous phosphatic-type fertilizer materials	772	116	1,270	191
Ammonium sulfate	1,610	338	1,047	220
Anhydrous ammonia and aqua (ammonia content)	172	142	394	324
Nitrogenous chemical materials, n.e.c	25	5	27	5
Sodium nitrate	(1)	(1)	(1)	(1)
Urea	74	33	93	42
Total	2,794	707	2,911	828
Imports:				
Industrial chemicals: Ammonium nitrate	1	(1)	(1)	(1)
Fertilizer materials:				
Ammonium nitrate	154	51	177	58
Ammonium-nitrate-limestone mixtures	(1)	(1)	3	1
Ammonium phosphates	179	27	212	32
Ammonium sulfate	160	34	168	35
Calcium cyanamide or lime nitrogen	19	5	18	4
Calcium nitrate	38	6	32	5
Nitrogen solutions	82	29	73	25
Anhydrous ammonia	311	255	443	364
Potassium nitrate or saltpeter, crude	27	3	15	2
Potassium nitrate, sodium nitrate mixtures	40	6	45	7
Sodium nitrate	321	51	218	35
Urea	209	95	260	118
Other	20	4	24	5
Total	1.561	566	1,688	691

[1] Less than ½ unit.

WORLD REVIEW

Algeria.—A $50 million ammonia and nitrogen fertilizer project was under construction at Arzew, about 25 miles east of Oran. According to reports, the facility was to include a 350,000-ton-per-year ammonia plant, a 175,000-ton-per-year ammonium nitrate plant, and a urea plant with annual capacity of 140,000 tons. The project was scheduled for completion in 1969.

Argentina.—A $22 million facility to manufacture 135,000 tons of nitrogen fertilizers per year was scheduled for completion in 1968 at Campana, 50 miles northwest of Buenos Aires. Planned daily capacities for the plants included in the project were reported as follows: 220 tons of ammonia, 162 tons of urea, 147 tons of ammonium sulfate, and 117 tons of sulfuric acid.

Australia.—Ammonia Company of Queensland Pty. Ltd. completed its new 140-ton-per-day ammonia plant at Pinkenba, Queensland, in 1966.

Plans were developed by Kwinana Nitrogen Co., Pty. Ltd. for a 100,000-ton-per-year ammonia plant to be erected at Kwinana, West Australia, and construction was underway. Also included in the project were a 90,000-ton-per-year nitric acid unit and an ammonium nitrate plant with an annual capacity of 110,000 tons. Both projects were scheduled to be completed by late summer 1968.

Table 6.—World production and consumption of fertilizer nitrogen compounds, years ended June 30, by principal countries [r]

(Thousand short tons of contained nitrogen)

Country	Production [e]			Consumption [e]		
	1964–65	1965–66	1966–67	1964–65	1965–66	1966–67
Argentina	2	2	1	35	33	31
Australia	29	37	43	71	77	95
Austria	205	231	257	80	100	99
Belgium	354	376	351	134	168	174
Brazil	10	17	7	77	83	75
Bulgaria	240	278	327	204	255	298
Canada	377	413	483	192	204	231
Ceylon	------	------	------	44	41	53
Chile	214	202	165	66	41	40
China	551	750	860	1,032	1,465	1,930
Colombia	46	43	39	35	44	45
Cuba	------	------	28	84	99	116
Czechoslovakia	174	243	277	223	278	289
Denmark	23	28	28	194	211	246
Finland	84	76	88	103	106	111
France	1,146	1,146	1,308	968	970	1,079
Germany:						
East	368	384	379	373	452	477
West	1,421	1,564	1,655	865	963	980
Greece	39	84	129	146	150	163
Hungary	99	163	184	225	248	234
India	273	283	340	571	625	891
Indonesia	52	52	46	91	109	121
Ireland	------	37	39	30	41	54
Israel	24	25	25	26	24	28
Italy	929	985	1,036	448	504	535
Japan	1,536	1,800	1,972	843	849	919
Korea:						
North	99	116	123	102	116	123
South	66	83	109	249	281	295
Malawi, Southern Rhodesia, Zambia	------	------	------	51	52	51
Mexico	155	171	176	292	305	353
Netherlands	581	619	754	324	343	371
Norway	364	365	359	66	69	68
Pakistan	88	93	103	88	179	283
Peru	19	21	19	52	51	41
Philippines	10	11	23	39	43	57
Poland	396	435	509	402	488	518
Portugal	120	123	127	99	101	85
Rumania	119	183	291	120	174	228
South Africa, Republic of	68	76	85	122	109	108
Spain	280	304	366	451	452	466
Sweden	77	101	112	164	177	181
Switzerland	31	34	31	22	28	34
Taiwan	166	177	192	203	209	204
Turkey	35	36	36	66	94	108
U.S.S.R.	2,071	2,725	3,131	2,008	2,630	2,928
United Arab Republic	166	169	179	280	311	298
United Kingdom	657	724	787	644	694	753
United States	5,133	5,689	6,237	5,098	5,313	6,048
Viet-Nam, South	------	------	------	22	41	46
Yugoslavia	97	103	116	224	183	218
Other:						
North America [1]	91	104	110	147	123	132
South America	17	19	15	35	45	47
Europe	8	10	8	25	25	26
Asia	15	18	67	174	190	231
Africa	------	------	4	139	141	155
Oceania	------	------	------	22	12	14
World total	19,125	21,728	24,136	18,890	21,119	23,784
Estimated losses (in transit, bagging, etc.)	------	------	------	287	325	362

[r] Revised. [e] Estimated.
[1] Includes Central America.

Source: Nitrogen (London), No. 51, January/February 1968, pp. 14, 15.

A nitrogen fertilizer complex was being constructed at Walsh Island, Newcastle, New South Wales, for Eastern Nitrogen Ltd. (ENL). The complex includes a 210,000-ton-per-year ammonia plant, a granular ammonium nitrate unit with an annual output capacity of 175,000 tons and a 145,000-ton-per-year nitric acid unit.

ENL is a consortium of companies with Imperial Chemical Industries of Australia and New Zealand Ltd. the majority shareholder, together with Conzinc-Rio Tinto of Australia Ltd., King Ranch (Australia) Ltd., and Mitsui Chemical Industries Co. (Japan). The complex was scheduled for completion in 1968 at a total cost of about $21 million.[3]

Brazil.—Conjunto Petroquimica da Bahia, as subsidiary of the Brazilian petroleum corporation, Petroleo Brasileiros, was to have started construction on an ammonia and a urea plant at Camacari in the State of Bahia. Daily production capacities of 200- and 250-tons-per-day, respectively, were expected. Construction was started on a $70 million fertilizer complex for Ultrafertil, S.A., at Santos, to be completed by late 1969. The project included units with daily capacities of 500 tons of ammonia, 625 tons of nitric acid, 760 tons of ammonium nitrate solution, 690 tons of ammonium nitrate prills, 710 tons of sulfuric acid, 250 tons of phosphoric acid, and 525 tons of diammonium phosphate.

Burma.—Japan was reported to have granted credit with deferred payments to the Burmese Government for the construction of a 120-ton-per-day ammonia plant and a 205-ton-per-day urea plant near Chauk.

Canada.—Canadian Industries Ltd. completed a new 340,000-ton-per-year ammonia plant at Sarnia, Ontario. After some startup technical problems were solved, the plant appeared to be in successful operation in May. The firm's old plant (annual capacity of 66,000 tons) located at Millhaven was to be closed down.

The New Brunswick Development Corp. began operating its new fertilizer complex at Dorchester Cape, New Brunswick, in April 1966. The facility included a 150-ton-per-day nitric acid plant, a 190-ton-per-day ammonium nitrate plant, and a nitrogen solution plant with an expected output of 12,000 tons annually. Both fertilizer and explosive-grade ammonium nitrate prills were to be manufactured. Upon completion, Fundy Chemical Corp. Ltd., reportedly would take over its operation.

The construction work on the J. R. Simplot Chemical Fertilizer Co. fertilizer complex at Brandon, Manitoba, was completed and on stream. The facility was designed for an annual production of 100,000 tons of anhydrous ammonia, 35,000 tons of urea, about 100,000 tons of ammonium nitrate, 300,000 tons of ammonium phosphate, and 70,000 tons of nitric acid.

Brockville Chemical Industries Ltd. completed an expansion program at its Maitland, Ontario, plant with a new 150-ton-per-day urea unit and a 250-ton-per-day nitric acid plant. Both plants were successfully producing early in 1967 as scheduled.

Table 7.—Chile: Exports of nitrate in 1967, by countries

(Short tons)

Country of destination	Quantity
Argentina	9,744
Australia	12,179
Belgium	17,024
Brazil	41,419
China	26,741
Colombia	303
Denmark	5,512
Ecuador	551
France	27,540
Greece	5,448
India	4,205
Italy	13,228
Japan	38,691
Mexico	21,717
Netherlands	52,051
Peru	2,823
Portugal	3,858
Spain	76,970
Sweden	4,685
United Kingdom	11,104
United States	293,737
Other countries	29,077
Total	698,607

Colombia.—A British engineering group was contracted by Petroquimica del Atlantico, S.A., to furnish a 900-ton-per-day ammonia plant and a urea plant with a daily capacity of 400 tons. The plants were being erected at Barranquilla and were expected to be in operation early in 1969.

Czechoslovakia.—It was reported that a Netherlands-West German consortium was awarded a contract for the construction of a petrochemical complex, including an ammonia plant having an annual capacity of 350,000 tons. The complex, being erected at Zaluzi, was scheduled for completion in 1970. According to a published report on the Czechoslovakia nitrogen industry, production of fertilizer grew by 39 percent from 1964 to 1965 and 15 percent from 1965 to 1966. A target of 400,000 tons of fertilizer nitrogen was established for 1970, a growth rate of about 11 percent.[4]

3 Nitrogen (London). No. 46, March/April 1967, p. 12.

4 Nitrogen (London). Czechoslovakia. No. 50, November-December, 1967, pp. 17–20.

France.—Four new 1,000-ton-per-day anhydrous ammonia plants were scheduled to be operational by early 1969. Construction was progressing on a plant at Carling for Soc. Ammoniac Sarro-Lorraine, a French-German company, owned by Saarbergwerke A.G. (40 percent), Houilleres du Bassin de Lorraine (48 percent), and Charbonnages de France (12 percent). A 170,000-ton-per-year urea plant was being erected in the Saar district near Perl, West Germany, jointly by the same French and West German firms. The ammonia plant was expected on stream by 1968 and the urea plant a few months later. Sté. Normande de l'Azote (SNA), jointly owned by Office National de l'Azote (ONIA), Sté. Pierrefitte, and Cie. Francaise de Raffinage (CFR), was building its plant at Gonfreville near Le Havre. At the same site, SNA began erecting an 800-ton-per-day urea plant. The ammonia plant should be operational in 1968. The third giant plant, also to be in production in 1968, was under construction at Grand Quevilly for Sté. Ammoniac de Grand Quevilly (AGQ), owned by ONIA, Péchiney-Saint Gobain, and Sté. Pierrefitte. Also, an 800-ton-per-day urea plant was planned for erection next to this ammonia plant. The fourth 1,000-ton-per-day plant under construction was located at Nangis, southwest of Paris and was reported that it would be operated by a newly formed company called Société des Engrais de l'Ile de France (SEIF). Production from this plant was not expected before late 1968 or early 1969.[5]

Germany, East.—The 170,000-ton-per-year ammonia plant, under construction in 1966 at Schwedt-am-Oder was on stream. A fertilizer plant erected along with the ammonia unit was expected to have an annual output of 500,000 tons of calcium nitrate.

Germany, West.—Salzgitter Chemie GmbH., started up the first unit of a 100,000-ton-per-year urea plant at Langelsheim. The annual capacity of the first unit was given as 60,000 tons. The second unit was expected on stream in 1968.

Greece.—Government approval was given to Northern Greece Ammonia Co. to expand its 100,000-ton-per-year ammonia plant near Thessaloniki. The plant was part of a large complex started in May 1964 and on stream in 1966. Financial and technical assistance for the project was supplied by Standard Oil Co. of New Jersey and Thomas A. Pappas, of Boston, Mass. A doubling of the ammonia output is expected by the expansion. An expansion program also was announced for the fertilizer plant owned by Chemical Industries of Northern Greece, also at Thessaloniki, adding a 60,000-ton-per-year nitric acid plant and an 80,000-ton-per-year ammonium nitrate plant.

India.—The total installed capacity for nitrogen fertilizer production totaled about 496,000 tons nitrogen content at the beginning of the year. About 92 percent of this was in the public sector. Projects under construction or approved by the Government amounted to about 0.87 million ton of nitrogen for the private sector and 0.53 million ton for the public sector.

India's largest private fertilizer complex plant, built for Coromandel Fertilizers, Ltd., at Vishakhapatnam, was dedicated in December. Coromandel is a consortium made up of International Minerals & Chemical Corp. and Chevron Chemical Co., both U.S. firms, and the Indian firm EID-Parry Ltd. The Coromandel complex included units for producing ammonia, urea, sulfuric acid, and phosphoric acid, as well as complex fertilizers. The annual production capacity was stated to be 260,000 tons of complex fertilizers and 16,500 tons of urea.[6]

The Government approved a proposal by Dharamsi Morarji Chemical Co. Ltd. (Bombay) to erect a diammonium phosphate plant in Maharashtra in collaboration with the Kuwait Chemicals and Fertilizer Co. (Kuwait). The agreement provided for the Kuwait firm to supply, from Kuwait sources, liquid ammonia (estimated 120,000 tons annually) and sulfur (estimated 200,000 tons annually) at competitive prices.

Madras Fertilizers Ltd., jointly held by the Government of India and Amoco India, Inc., a subsidiary of American International Oil Co., awarded contracts for the engineering and construction of a large fertilizer complex to be erected near Madras. The complex was to include a single-train ammonia plant with a daily output of about 850 tons, a 950-ton-per-day urea plant, and a 1,250-ton-per-day compound fertilizer plant. About 30,000 tons of the total ammonia output of more

[5] European Chemical News (London). France Orders Fourth Big Ammonia Plant. V. 11, No. 260, Jan. 20, 1967.

[6] Bureau of Mines. Mineral Trade Notes. V. 65, No. 3, March 1968, pp. 18, 19.

than 200,000 tons was scheduled for use in the manufacture of industrial chemicals. The facility was to be completed and on stream early in 1970.[7]

Fertilizer Corporation of India Ltd., (F.C.I.) started construction on a fertilizer plant at Namrup which was scheduled for completion in 1968. An annual production of about 150,000 tons of ammonium sulfate was expected. Also, Fertilizer Corp. proposed an expansion of its Trombay fertilizer facility, increasing ammonia production from 385 to 660 tons, urea output from 330 to 1,034 tons and nitrophosphate from 1,200 to 5,000 tons per day.[8] Construction of the Namrup plant appeared to be on schedule in 1967, and testing was to start in December. F.C.I. also had ammonia plants under construction at Durapur and at Cochin with initial production scheduled for October 1969, and at Barauni with production expected late in 1970.

Japan.—As a result of being forced to accept a drastic cut in price for nitrogenous fertilizers in order to secure contracts with mainland China for 1967 delivery, the nitrogen industry arrived at a decision to replace existing small capacity plants with large modern units.

Sumitomo Chemico Co. having completed a new 750-ton-per-day ammonia plant in Nuhama, Shikoku, was planning to erect a 900- to 1,000-ton-per-day ammonia plant and closing down its 350-ton-per-day plants at Himeji and Befu. Showa Denko K.K. and Nissan Chemical Co. Ltd., both with new plants on stream, jointly proposed a 1,000-ton-per-day ammonia plant at Chiba, closing their old 270-ton-per-day plants. Toyo Koatsu Industries Inc. was considering a new ammonia 1,000-ton-per-day plant for Sakai, the site of a new 500-ton-per-day plant that started production in 1966. Mitsubishi Chemical Industries Ltd. was contemplating a 1,000-ton-per-day ammonia plant to replace its existing 450-ton unit at the Kurosaki Works and its subsidiary's (Mitsubishi Petrochemical Co.) 200-ton-per-day plant at Yokkaichi. Mitsubishi also planned to erect an ammonium phosphate plant with a 200-ton-per-day capacity.[9] Tohoku Hiryo K.K. and Nippon Suiso Kogyo were reported to have decided on a joint venture to erect a 1,000-ton-per-day ammonia plant and phase out their existing plants of 275 tons combined output. Still another major nitrogen producer, Ube Chemical Industries Ltd., planned to build a 1,000-ton-per-day ammonia plant.

Korea, South.—Korea Fertilizer Co. Ltd. began producing urea at its newly erected facility in Ulsan. Daily capacities of 600 tons of ammonia and 1,000 tons of urea were announced. Two other fertilizer plants were placed on stream in 1967, bringing the total to five and making South Korea self-sufficient in nitrogenous fertilizers. The five plants were reported to have a combined output of about 815,000 tons, slightly more than the Republic's annual demand.

Kuwait.—The Kuwait Petrochemical Industries Co. (KPIC) and the Turkish Nitrate Co. concluded an agreement on the construction of a chemical fertilizer plant near a refinery complex at Mersin, Turkey. Under the agreement, KPIC was to provide 50 percent of the capital required for the Mersin plant and the ammonia was to be supplied from a new two-unit 1,600-ton-per-day plant being constructed in the Shuaiba industrial area of Kuwait. The Mersin plant was expected to use about one-half of the output of the new ammonia plant. The remainder was planned for use in expanding the urea production of the Kuwait Chemical Fertilizer plant. When the new ammonia plant is put on stream, expected sometime in 1969, Kuwait's annual ammonia production capacity will be increased to about 700,000 tons. A third 800-ton-per-day plant was being considered for the near future.

Mexico.—Construction on two ammonia plants for Petroleos Mexicanos (PEMEX), was completed, one at Ciudad Camargo, Chihuahua, with a 330,000-ton annual capacity and the other at Guaymas, Sonora, with a 78,000-ton annual capacity. PEMEX also had a 330,000-ton-per-year ammonia plant under construction at Minatitlan and announced plans for a 220,000-ton-per-year plant to be established at Campeche.[10] The Minatitlan plant was scheduled for completion in March 1968.

Netherlands.—A 1,000-ton-per-day ammonia plant was completed and on stream at Pernis, Rotterdam, for Ammoniak Unie N.V. The plant was designed to use nat-

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[7] Commercial Fertilizer and Plant Food Industry. V. 115, No. 3, September 1967, p. 17.

[8] Chemical Age (London). Three-Fold Expansion of Trombay Fertiliser Unit Planned. V. 96, No. 2451, July 2, 1966, p. 25.

[9] Nitrogen. No. 50, November-December 1967, p. 13.

[10] European Chemical News (London). Pemex NH_3 Units Now Being Built. V. 10, No. 255, Dec. 9, 1966, p. 22.

ural gas as feed stock.

Nederlandse Stikstof Maatschappij N.V. brought on stream a 185,000-ton-per-year ammonia plant in 1966 and a second plant of the same size was completed late in 1967. In addition, the firm had a new urea plant under construction to provide an annual output of nearly 200,000 tons. The urea plant was scheduled for completion in the summer of 1968.

Esso Chemie N.V. announced that the 300,000-ton-per-year ammonia facility proposed in 1965 would be increased in size by 50 percent. Construction was started during the summer of 1966 and was scheduled for completion in 1968. The new facility was to include a nitric acid plant, a urea plant, and a 350,000-ton-per-year calcium ammonia nitrate unit.[11]

Norway.—Norsk Hydro-Elektrisk, A/S, producer of most of the nitrogenous products in Norway, completed an expansion of its complex fertilizer facility at Herøya early in 1966. The firm's annual urea capacity was increased from 150,000 to 250,000 tons. By the end of 1966, the company's total ammonia output per year was 560,000 tons, about one-third more than in 1965 due to its new 120,000-ton-per-year plant at Herøya. A second ammonia plant with an annual capacity of 350,000 tons was scheduled for initial production early in 1968.[12]

Pakistan.—A 115,000-ton-per-year ammonia plant and a 200,000-ton-per-year urea plant were being constructed at Daharki, West Pakistan, for Esso Pakistan Fertilizer Co., Ltd. Both units were due on stream by mid-1968.

Philippines.—Esso Standard Fertilizer & Agricultural Chemical Co. dedicated its new $31 million fertilizer plant at Limay in 1966. The plant was reported to have a daily capacity of more than 1,000 tons of ammonia, urea, ammonium phosphates, and complete fertilizers.[13]

Poland.—The nitrogen combine began ammonia production at its huge new plant in Pulawy in 1966, and by yearend 1967, three 330-ton-per-day units were operating. Two more 330-ton units were being constructed for operation in 1968. In addition, three 500-ton-per-day ammonia plants were planned for the Pulawy facility. Contracts were signed for constructing a large fertilizer complex at Wloclawek, 93 miles northwest of Warsaw, valued at about $61 million. The complex includes a 500,000-ton-per-year ammonia plant built in two streams of 250,000 tons each; two nitric acid units, each with an annual capacity of 300,000 tons; an ammonium nitrate plant with an annual output capacity of 800,000 tons, in two streams of 400,000 tons each.[14]

Rumania.—Masinimport (Rumanian State organization) signed a contract in 1966 with a Belgian engineering firm to supply and install two identical ammonia-based fertilizer plants; one at Craiova and the other at Turnu Magurele. Each plant was to have the following annual capacities: 300,000 tons of ammonia, 295,000 tons of urea, 238,000 tons of nitric acid, and 295,000 tons of ammonium nitrate. Both plants were scheduled for production near the end of 1968.[15] Engineering work was completed in 1967 and equipment was ordered for installation.

Saudi Arabia.—Saudi Arabian Fertilizers Co. (SAFCO) awarded a contract in 1966 for the design and construction of a $30 million nitrogenous fertilizer plant to be erected at Dammam, on the Arabian Gulf. The contract included a 600-ton-per-day ammonia plant and a 1,020-ton-per-day urea plant, both to be on stream in 1969. Occidental Petroleum Corp. was named to supervise the construction and operation of the project and to train Saudi technical and labor personnel. Occidental's subsidiary, International Ore & Fertilizer Corp., was selected to market the urea product.[16]

South Africa, Republic of.—A 600-ton-per-day single-train ammonia plant was completed for African Explosives & Chemical Industries Ltd., at Umbogintwini near Durban. A major portion of the ammonia output was planned for manufacturing urea at its 190,000-ton-per-year fertilizer urea plant at the same site. Fisons (Pty.) Ltd. also completed a nitrogenous fertilizer plant at Milnerton, near Cape Town. The new plant was designed for an eventual annual capacity of 85,000 tons of nitrogen as ammonia but was to produce only 50,000 tons initially.

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11 Chemical Age (London). Esso to Boost Dutch Ammonia Capacity. V. 95, No. 2449, June 18, 1966, p. 1116.

12 Bureau of Mines. Mineral Trade Notes. V. 64, No. 9, September 1967, pp. 35–36.

13 Commercial Fertilizer and Plant Food Industry. V. 112, No. 3, March 1966, p. 44.

14 Bureau of Mines. Mineral Trade Notes. V. 64, No. 8, August 1967, pp. 6–7.

15 European Chemical News (London). Sybetra Gives Details of $60 Million Rumanian Order. V. 9, No. 212, Feb. 11, 1966, p. 22.

16 Commercial Fertilizer and Plant Food Industry. V. 113, No. 5, November 1966, p. 58.

Sweden.—Stockholm Superfosfat Fabriks A.B. put its nitrogenous fertilizer plant on stream at Landskrona in 1966. The facility was reported capable of producing about 60,000 tons of nitric acid and 84,000 tons of calcium ammonium nitrate annually.

Turkey.—At yearend, two ammonia sulfate plants were producing, one at Kutahya with about a 200,000-ton-per-year and one at Karabuk with a 6,000-ton-per-year plant capacity. Also at Kutahya, an 88,-000-ton-per-year ammonium nitrate plant was in production. A large nitrogenous fertilizer plant was to be constructed at Mersin, Turkey, on the Mediterranean Sea. (See Section on Kuwait.)

United Kingdom.—A new 300,000-ton-per-year urea plant was put on stream in 1966 by Imperial Chemical Industries Ltd. (ICI) at its Billingham Works on the Tees estuary. In 1967, ICI put on stream three new 300,000-ton-per-year ammonia plants at Billingham and one new 200,000-ton-per-year ammonia plant at Immingham. The company was planning to phase out older plants (500,000 tons of product) as the four new ones were being brought up to full capacity. One of the facilities to be closed was said to be the firm's first-built ammonia plant at Castner-Kellner Works, Runcorn.

Shellstar Ldt., owned jointly by Shell Chemical Co., Ltd., and Armour & Co., awarded a contract in 1966, for a $50 million fertilizer complex to be built at Ellesmere Port. The facility scheduled to go on stream in 1968 included a 300,000-ton-per-year ammonia plant, a 280,000-ton-per-year nitric acid unit, and an ammonium nitrate plant with annual capacity of 330,-000 tons.

Yugoslavia.—A large nitrogenous fertilizer complex was scheduled to be built at Prestina near the Albanian border. A contract for design, engineering, and supervision of construction was signed with Montecatini, Soc. Generale per l'Industria Mineraria e Chimica (Italy). The plants to be included in the project were a 109,-000-ton-per-year ammonia unit, a 178,000-ton-per-year nitric acid unit, and a 274,-000-ton-per-year ammonium nitrate unit.[17]

Zambia.—It was reported that Kobe Steel Co. (Japan) was awarded a contract by the Zambian Government to erect a fertilizer plant at Kafue. The facility was to have an annual capacity of 26,000 tons of ammonia and to include nitric acid and ammonium nitrate units.[18] This will be the first fertilizer plant to be built in Zambia.

TECHNOLOGY

Reduction in production costs appeared to be the principal goal in the research and development on ammonia, nitric acid, and urea during the last 2 years. The trend of new ammonia plants remained with large-capacity, 1,000-ton-per-day single-train units using single centrifugal compressors. A high-discharge centrifugal compressor was developed by Norsk Hydro-Elektrisk A/S plant in Herøya. The new compressor was said to be capable of achieving a discharge pressure of 290 atmospheres compared with 160 atmospheres for other centrifugal compressors. Operating advantages as well as cost savings were claimed.[19]

A new design ammonia converter was installed in the Continental Oil Co., 1,000-ton-per-day plant at Blytheville, Ark. In the new converter, designed by Haldor Tøpsoe of Helbrup, Denmark, the synthesis gas flows radially through a smaller catalyst bed at a lower velocity and with a lower pressure drop than in the old conventional converters through which the gas flowed axially. The new converter may permit plants with capacity as large as 3,000 tons per day to operate with a single unit. Proponents of the Topsøe converter claim that power costs are less and that a single Topsøe unit can be erected cheaper than two smaller converters of the same total capacity. Some engineering firms, however, were not convinced.[20]

Toyo Koatsu Industries Ltd. (Japan), developed an integrated process which was said to reduce production costs for ammonia and urea. The company claimed the capital cost of a plant using the new process would be 5 to 10 percent less than one using the conventional process. Also the production cost for urea would be 6 to 7

[17] European Chemical News (London). Montecatini Fertilizer Plant for Yugoslavia. V. 9, No. 217, Mar. 18, 1966, p. 22.
[18] Nitrogen. No. 47, May-June 1967, p. 9.
[19] Cheaper Ammonia With Pignone Compressors. V. 10, No. 245, Sept. 30, 1966, p. 36.
European Chemical News (London). Pignone Compressor Lowers Ammonia Costs. V. 9, No. 209, Jan. 21, 1966, p. 30.
[20] Chemical Week. Cutting Big Plants Down to Size. V. 98, No. 9, Feb. 26, 1966, pp. 97–98.

percent less. The number of processes for making urea have been growing with the increased importance and demand for urea. An article was published which discussed a number of these processes including Chemico, Lonza-Lummus, Stamicarbon, SNAM, and Toyo Koatsu.[21]

Another new urea process, called the CPI-Allied Chemical process, was announced. The process is based on the recovery and recycle of unconverted NH_3 and CO_2 as pure components and does not involve a carbonate recycle. Corrosion is controlled by lining the synthesis reactor with zirconium. The reactor can operate at 380° to 450° F compared with 375° F for other processes permitting a higher conversion rate of CO_2 to urea. About 80 to 85 percent conversion was claimed.[22]

Another new improved urea process was developed by Societa Nazionale Metanodotti (SNAM), a division of Italy's ENI group. The new design was said to offer considerable heat economies and to achieve total recycle in a single-stage operation thus reducing production costs. A rather detailed report was published on the new process.[23]

Even though production costs for producing ammonia have been dropping mainly because of larger capacity plants and advanced equipment, recent research suggests that a radical processing change may be on its way which would cut both capital and production cost significantly. The new approach to nitrogen fixation, in the minds of some research scientists, is through the use of a homogeneous molecular catalyst.[24]

A possible new use for industrial ammonia was reported by a research team from the Pulp & Paper Research Institute of Canada. According to the Scientists, chlorinated chemical pulps exposed to a 1 to 2 percent mixture of ammonia in stream produces higher yields of pulps without loss of viscosity and at an estimated saving of 70 cents per ton in cost.[25]

A tremendous new market for nitrogen gas may be developing. Two big gas producers, Union Carbide Corp., Linde Division, and Big Three Industrial Gas & Equipment Co., were promoting the use of nitrogen gas as a replacement for air in motor vehicle tires. The producers claimed that tires inflated with nitrogen would wear longer, have more resistance to cracking, and enable the tires to hold up under conditions that normally would cause them to burst.[26]

[21] Chemical Engineering. Scanning the New Urea Processes, Side by Side. V. 73, No. 25, Dec. 5, 1966, pp. 76–78.

[22] Chemical Engineering. New Urea Process Boasts High Yields, Low Costs. V. 73, No. 20, Sept. 26, 1966, pp. 96–98.

[23] Chemical Engineering. Simplified Process Reduces Urea's Production Costs. V. 73, No. 16, Aug. 1, 1966, pp. 51–53.

[24] Chemical Week. New Route to Ammonia? V. 100, No. 3, Jan. 21, 1967, pp. 64–65.

[25] Chemical Week. V. 100, No. 19, May 13, 1967, p. 74.

[26] Chemical Week. Tires: New Market for Nitrogen? V. 101, No. 10, Sep. 2, 1967, p. 19.

Peat

By Eugene T. Sheridan [1]

Peat production increased 1 percent in 1967 although there were 13 fewer active operations than in 1966. Most of the increase was the result of larger outputs in Florida, Illinois, New Jersey, and Washington.

There were 131 active operations in 26 States. Michigan produced 38 percent, the largest share of total output. Illinois, New Jersey, Pennsylvania, Washington, Indiana, California, Florida, New York, and Colorado, in that order, yielded another 51 percent.

Fifty-three percent of the production was reedsedge peat, 25 percent was humus, and the remainder was moss peat. Fourteen percent was sold as excavated with no processing other than air drying. The remainder was shredded or pulverized, screened, and, in a few instances, subjected to thermal drying.

Virtually all peat was sold for agricultural and horticultural use. Producers reported that 94 percent was sold for general soil improvement. Fifty-one percent of the peat sold was packaged. Michigan produced more than one-half of the packaged material. Most of the remainder came from California, Illinois, Indiana, Iowa, Minnesota, New Jersey, New York, and Pennsylvania.

Total value of commercial sales was $6.8 million. All peat was sold at an average value of $10.92 per ton.

Imports decreased 4 percent, principally because of a decline in shipments from Canada. Imports from Europe, however, were 10 percent larger than in 1966.

World production was estimated at 202 million tons, excluding outputs from 13 countries that reportedly produced peat in 1966, but for which data were not available for 1967. The U.S.S.R. was the largest producer with an estimated output of 200 million tons, 99 percent of the estimated world total.

Table 1.—Salient peat statistics

	1964	1965	1966	1967
United States:				
Number of operations	142	146	144	131
Production short tons	649,033	604,082	611,085	617,172
Commercial sales do	639,690	630,746	605,858	619,687
Value of sales thousands	$6,199	$6,080	$6,501	$6,768
Average per ton	$9.69	$10.07	$10.73	$10.92
Imports short tons	270,419	275,462	r 293,843	290,842
Available for consumption [1] do	910,109	879,208	r 899,701	900,529
World production thousand short tons	183,827	188,643	210,586	201,991

r Revised.
[1] Commercial sales plus imports.

PRODUCTION

As a result of continued strong demand for soil improvement purposes, production of peat increased 1 percent to 617,172 tons although the number of operations decreased from 144 to 131. Most of the increase was the result of the larger outputs in Florida, Illinois, New Jersey, and Washington. However, production in 14 other States was less than in 1966.

Of the 26 peat-producing States in 1967, the industry concentrated in five States bordering the Great Lakes—Illi-

[1] Mineral specialist, Division of Mineral Studies.

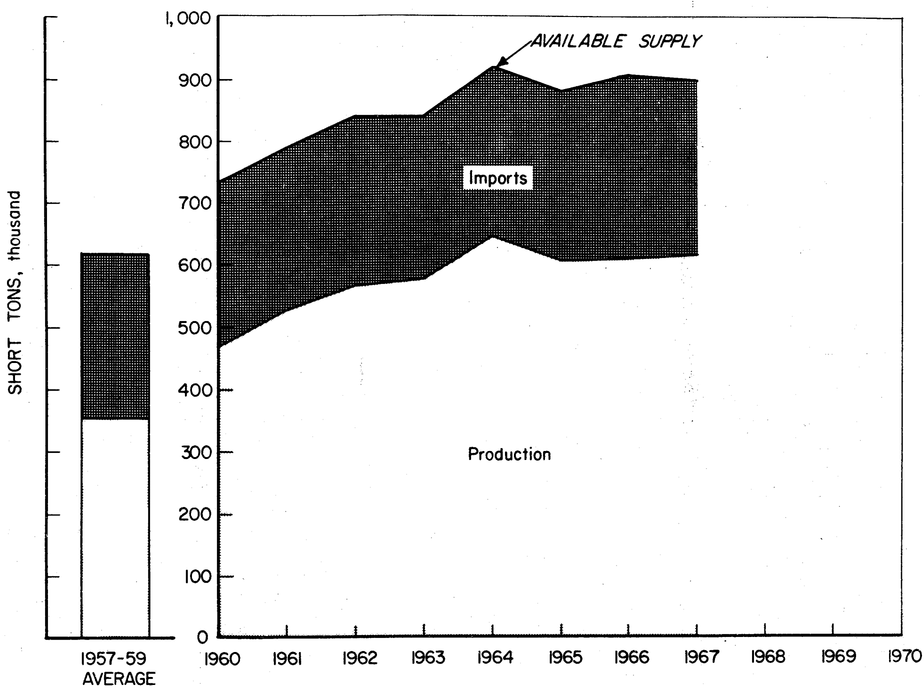

Figure 1.—Production, imports, and available supply of peat in the United States.

nois, Indiana, Michigan, New York, and Pennsylvania—and in New Jersey. The 54 active operations in these States produced 70 percent of the output.

Michigan was the largest producer of peat, with 26 operations and 38 percent of the production. Although two small operations that were active in 1966 did not produce peat in 1967, Michigan's output increased about 0.5 percent. Other major producing States in order of output were Illinois, New Jersey, Pennsylvania, Washington, Indiana, California, Florida, New York, and Colorado.

Except for a relatively few plants, peat operations were small; output per plant in 1967 averaged only 4,711 tons. Morc than one-third of the number of active plants, however, produced less than 1,000 tons, and only four produced more than 25,000 tons.

Of the reported production, 53 percent was reed-sedge peat, 25 percent was humus, and the remainder was moss peat. Before it was sold, 86 percent was subjected to processing, by either shredding and/or artificial drying.

Production methods varied, but virtually all peat was extracted mechanically. Equipment consisted mainly of conventional excavating and earth-moving machines. Specialized machines such as harvesters, cultivators, milling machines, ridgers, and scrapers also were employed. Processing machinery included a variety of shredders, pulverizers, grinders, hammermills, screens, artificial dryers, and hydraulic presses.

Table 2.—Peat produced in the United States in 1967, by kinds

(Short tons)

Kind	Unprepared	Processed		Total
		Shredded	Shredded and kiln-dried	
Moss	10,489	108,684	15,544	134,717
Reed-sedge	27,725	288,663	8,637	325,025
Humus	48,676	106,043	2,711	157,430
Total	86,890	503,390	26,892	617,172

Table 3.—Production and commercial sales of peat in the United States in 1967, by State

State	Active plants	Production (short tons)	Commercial sales: Short tons	Commercial sales: Value: Total (thousands)	Commercial sales: Value: Average
Alaska	1	1,528	1,528	$12	$8.00
California	4	30,014	30,014	396	13.21
Colorado	14	21,988	21,988	204	9.29
Florida	6	27,580	22,180	155	7.00
Georgia	2	W	W	W	W
Idaho	1	2,040	2,040	16	7.69
Illinois	5	49,716	49,716	697	14.01
Indiana	5	33,528	42,962	441	10.27
Iowa	2	W	W	W	W
Maine	2	W	W	W	W
Maryland	2	W	W	W	W
Massachusetts	2	W	W	W	W
Michigan	26	234,489	237,107	2,292	9.67
Minnesota	6	13,968	13,968	257	18.40
Montana	1	W	W	W	W
Nevada	1	W	W	W	W
New Hampshire	(1)	----------	50	(2)	9.70
New Jersey	5	45,045	43,045	542	12.60
New York	5	23,053	23,053	232	10.60
North Dakota	1	W	W	W	W
Ohio	15	7,405	7,301	100	13.68
Oregon	1	W	W	W	W
Pennsylvania	8	41,560	39,505	437	11.06
South Carolina	1	W	W	W	W
Vermont	1	280	280	4	14.29
Washington	[1] 11	40,869	40,608	181	4.45
Wisconsin	3	1,823	1,823	W	W
Total	131	617,172	619,687	6,768	10.92

W Withheld to avoid disclosing individual company confidential data; included in total.
[1] Excludes 1 plant which had sales but did not produce.
[2] Less than ½ unit.

Table 4.—Relative size of peat operations in the United States

Size	1966: Active plants: Number	1966: Active plants: Percent of total	1966: Production: Short tons	1966: Production: Percent of total	1967: Active plants: Number	1967: Active plants: Percent of total	1967: Production: Short tons	1967: Production: Percent of total
Under 500 tons	37	25.7	8,135	1.3	27	20.6	5,163	.8
500–999 tons	15	10.4	12,110	2.0	18	13.7	12,033	1.9
1,000–4,999 tons	63	43.8	149,349	24.4	53	40.5	118,252	19.2
5,000–14,999 tons	18	12.5	159,975	26.2	26	19.8	229,510	37.2
15,000–24,999 tons	6	4.1	99,895	16.4	3	2.3	64,143	10.4
Over 25,000 tons	5	3.5	181,621	29.7	4	3.1	188,071	30.5
Total	144	100.0	611,085	100.0	131	100.0	617,172	100.0

CONSUMPTION AND USES

The 13,829-ton increase in producers' sales of domestic peat was offset by a decrease in imports in 1967, placing a quantity of peat equal to that of 1966 on the market.

Although peat was used for a variety of purposes, 94 percent of the total was sold for general soil improvement. Among the principal markets, nurseries and greenhouses used the material as a mulch and as a medium for growing plants and shrubs; landscape gardeners and contractors used peat for building lawns and golf course greens and for transplanting trees and shrubs; and garden, hardware, variety, chain, and drug stores sold peat to homeowners for mulching and improving lawns and garden soils. The remainder was sold for use in potting soils, mixed fertilizers, packing flowers and shrubs, seed inoculant, and mushroom beds. No peat was reported sold for fuel or energy use.

Producers' sales were about evenly divided between the bulk and the packaged product. Bulk sales were about 2 percent, and packaged sales about 3 percent, higher than in 1966. Of the total packaged peat sold, about two-thirds was the reed-sedge type principally from Michigan. Other States leading in sales of packaged peat were Illinois, California, Indiana, New York, Minnesota, and New Jersey. Detailed data on bulk and packaged sales in each State were not shown because they would have revealed individual company confidential data.

Table 5.—Commercial sales of peat in the United States in 1967, by kinds and uses

Use	Moss		Reed-sedge		Humus	
	Short tons	Value [1] (thousands)	Short tons	Value [1] (thousands)	Short tons	Value [1] (thousands)
Bulk:						
Soil improvement	54,276	$496	96,598	$885	127,542	$807
Other uses	944	8	3,313	42	20,976	199
Total	55,220	504	99,911	927	148,518	1,006
Packaged:						
Soil improvement	80,273	1,361	205,798	1,980	17,233	266
Other uses	48	2	10,773	548	1,913	173
Total	80,321	1,363	216,571	2,529	19,146	440
Total:						
Soil improvement	134,549	1,858	302,396	2,865	144,775	1,073
Other uses	992	10	14,086	591	22,889	373
Grand total	135,541	1,867	316,482	3,456	167,664	1,446

[1] Data may not add exactly to totals shown owing to independent rounding.

Table 6.—Commercial sales of peat in the United States in 1967, by uses

Use	In bulk		In packages		Total	
	Short tons	Value [1] (thousands)	Short tons	Value [1] (thousands)	Short tons	Value [1] (thousands)
Soil improvement	278,416	$2,188	303,304	$3,608	581,720	$5,795
Potting soils	9,669	83	9,552	534	19,221	617
Packing flowers, shrubs, etc.[2]	8,652	88	1,269	16	9,921	104
Seed inoculant	290	4	1,913	173	2,203	178
Mushroom beds	741	8	---------	--------	741	8
In mixed fertilizers	5,881	67	---------	--------	5,881	67
Total	303,649	2,437	316,038	4,331	619,687	6,768

[1] Data may not add exactly to totals shown owing to independent rounding.
[2] Includes small amount sold for earthworm culture.

PRICES AND SPECIFICATIONS

In the United States, peat is generally classified as moss peat, reed-sedge peat, and humus. Moss peat is a type that has formed predominantly from sphagnum, hypnum, and/or other mosses, whereas reed-sedge peat has originated principally from reeds, sedges, and associated swamp plants. In both types the plant remains are identifiable. Humus includes all peat that is so decomposed that its botanical identity cannot be determined. 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. The latest specification, Q–P–166e, May

10, 1961, is in general conformity with the classification system, but the moss peat type is subdivided into "sphagnum-moss peat" and "other moss peats."

The total value, f.o.b. plant, of all peat sold in the United States in 1967 was $6.8 million, a 4-percent increase over the total value reported for 1966 and the highest value reported to date. The increase was the result of a 2-percent rise in sales and a $0.19-per-ton increase in the average value of all peat sold.

Prices varied greatly as the selling prices at individual plants were based on the type of peat, the amount of processing, and whether it was sold in bulk or packaged. The overall average value of bulk peat was $8.03 per ton, but bulk prices ranged from an average of $7.86 per ton for peat sold for general soil improvement to $14.17 per ton for peat sold for seed inoculant. The same criteria are applicable to packaged peat, which averaged $13.71 per ton but ranged in average plant price from $11.89 per ton to $90.68 per ton.

The total value of imported peat was $12.3 million, a 6-percent increase over that in 1966. This value, established at the port of embarkation, was roughly equal to prices paid by importers, minus transportation and other miscellaneous charges. In some instances, ocean freight and other nondutiable charges such as insurance may have been included in this value.

The average value per ton of imported peat was $43.71, an increase of about 10 percent over the 1966 average value. Most of this increase was the result of higher prices of peat imported from Canada.

The unit value of imported peat was 3.2 times that of packaged domestic peat. However, the values are not comparable because they were assigned at different marketing levels. Imported peat has different properties than most U.S. peat, and it is usually sold on a volume basis rather than by weight. Each 100 pounds of a typical air-dried, imported peat will measure approximately 12 bushels, whereas the same quantity of a typical domestic peat will measure only 3 or 4 bushels. Only a few U.S. peat operations produce peat with properties similar to those of the imported type.

Table 7.—U.S. imports for consumption of peat moss, by kinds and by countries

Country	Poultry and stable grade		Fertilizer grade		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1966:						
Belgium–Luxembourg	-----	------	22	$1	22	$1
Canada	3,468	$174	262,720	10,378	266,188	10,552
Denmark	-----	------	812	32	812	32
Germany, West	208	10	17,171	661	17,379	671
Ireland	304	11	2,325	95	2,629	106
Mexico	18	4	--------	--------	18	4
Netherlands	22	(1)	44	2	66	2
New Zealand	-----	------	82	5	82	5
Norway	-----	------	15	7	15	7
Poland and Danzig	-----	------	5,858	200	5,858	200
Sweden	-----	------	681	31	681	31
United Kingdom	-----	------	93	4	93	4
Total	4,020	199	289,823	11,416	293,843	11,615
1967:						
Cameroon	-----	------	46	2	46	2
Canada	3,272	172	247,155	10,849	250,427	11,021
Denmark	-----	------	936	30	936	30
Finland	13	1	76	9	89	10
Germany, West	269	13	22,005	890	22,274	903
Ireland	40	2	701	34	741	36
Mexico	7	1	--------	--------	7	1
Netherlands	-----	------	247	10	247	10
Norway	-----	------	64	14	64	14
Poland and Danzig	-----	------	5,285	209	5,285	209
Sweden	-----	------	726	41	726	41
Total	3,601	189	277,241	12,088	280,842	12,277

[1] Less than ½ unit.

FOREIGN TRADE

The quantity of peat imported in 1967 decreased 4 percent from that of 1966, mainly because of the 6-percent reduction in Canadian shipments. Canada, however, continued to supply the bulk of foreign peat providing 89 percent of the 280,842 tons imported. Virtually all of the remainder came from Europe, except for very small tonnages shipped from Africa and Mexico.

European imports increased 10 percent, owing mainly to increased shipments from West Germany. Poland and Danzig sent most of the remainder, but peat was also received from Ireland, the Netherlands, and the four Scandanavian countries. Ireland's contribution to 1967 imports dropped somewhat sharply to less than 1,000 tons, 72 percent less than 1966 shipments from that country.

Imported peat was classified according to use as either poultry and stable grade or fertilizer grade. Of the total, 98.7 percent was fertilizer grade which entered the United States duty free. A duty of $0.25 per long ton was levied on poultry and stable grade peat.

Most of the imports entered the United States through customs districts at Ogdensburg and Buffalo, N.Y., Seattle, Wash., St. Albans, Vt., Detroit, Mich., and Pembina, N. Dak. Most of this peat was fertilizer-grade material produced in Canada. West German shipments, also chiefly fertilizer grade, passed principally through eastern and gulf-coast ports.

Table 8.—U.S. imports for consumption of peat moss in 1967, by kinds and by 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	-----	------	2,322	$105	2,322	$105
Boston, Mass	-----	------	678	26	678	26
Buffalo, N.Y	120	$7	26,159	1,131	26,279	1,138
Charleston, S.C	-----	------	819	27	819	27
Chicago, Ill	-----	------	12	1	12	1
Cleveland, Ohio	-----	------	48	2	48	2
Detroit, Mich	801	33	40,312	1,782	41,113	1,815
Duluth, Minn	-----	------	1,446	58	1,446	58
Galveston, Tex	31	2	-------	-------	31	2
Great Falls, Mont	-----	------	5,753	259	5,753	259
Honolulu, Hawaii	4	(1)	208	12	212	12
Houston, Tex	-----	------	757	30	757	30
Laredo, Tex	7	1	40	1	47	2
Los Angeles, Calif	118	6	1,436	70	1,554	76
Miami, Fla	13	1	760	30	773	31
Milwaukee, Wis	-----	------	131	4	131	4
Minneapolis, Minn	-----	------	9	(1)	9	(1)
Mobile, Ala	-----	------	2,194	94	2,194	94
New Orleans, La	-----	------	3,195	129	3,195	129
New York City	40	2	4,598	204	4,638	206
Nogales, Ariz	33	3	-------	-------	33	3
Norfolk, Va	93	4	2,650	103	2,743	107
Ogdensburg, N.Y	38	4	62,357	2,413	62,395	2,414
Pembina, N. Dak	1,568	98	15,642	656	17,210	754
Philadelphia, Pa	27	1	2,994	115	3,021	116
Portland, Maine	-----	------	3,128	153	3,128	153
Portland, Ore	-----	------	148	4	148	4
St. Albans, Vt	575	20	44,403	1,751	44,978	1,771
San Francisco, Calif	-----	------	1,029	39	1,029	39
San Juan, P.R	-----	------	108	6	108	6
Savannah, Ga	-----	------	880	35	880	35
Seattle, Wash	133	10	47,675	2,629	47,808	2,639
Tampa, Fla	-----	------	5,281	216	5,281	216
Wilmington, N.C	-----	------	69	3	69	3
Total	3,601	189	277,241	12,088	280,842	12,277

[1] Less than ½ unit.

Table 9.—Peat moss imported from Canada and West Germany for consumption in the United States in 1967, by kind and by 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	-----	-----	--------	--------	-----	----	1,344	$53
Boston, Mass	-----	-----	--------	--------	-----	----	319	14
Buffalo, N.Y	120	$7	26,159	$1,131	-----	----	--------	-----
Charleston, S.C	-----	-----	--------	--------	-----	----	695	22
Chicago, Ill	-----	-----	12	1	-----	----	--------	-----
Cleveland, Ohio	-----	-----	--------	--------	-----	----	48	2
Detroit, Mich	801	33	40,312	1,782	-----	----	--------	-----
Duluth, Minn	-----	-----	1,446	58	-----	----	--------	-----
Galveston, Tex	-----	-----	--------	--------	31	$2	--------	-----
Great Falls, Mont	-----	-----	5,753	259	-----	----	--------	-----
Honolulu, Hawaii	4	(1)	208	12	-----	----	--------	-----
Houston, Tex	-----	-----	--------	--------	-----	----	396	17
Laredo, Tex	-----	-----	--------	--------	-----	----	40	1
Los Angeles, Calif	-----	-----	13	1	118	6	934	43
Miami, Fla	-----	-----	--------	--------	-----	----	547	22
Milwaukee, Wis	-----	-----	38	2	-----	----	93	2
Minneapolis, Minn	-----	-----	9	(1)	-----	----	--------	-----
Mobile, Ala	-----	-----	--------	--------	-----	----	2,173	93
New Orleans, La	-----	-----	--------	--------	-----	----	1,963	79
New York City	-----	-----	--------	--------	-----	----	2,911	122
Nogales, Ariz	33	3	--------	--------	-----	----	--------	-----
Norfolk, Va	-----	-----	--------	--------	93	4	1,708	69
Ogdensburg, N.Y	38	1	62,357	2,413	-----	----	--------	-----
Pembina, N. Dak	1,568	98	15,642	656	-----	----	--------	-----
Philadelphia, Pa	-----	-----	--------	--------	27	1	1,964	81
Portland, Maine	-----	-----	3,128	153	-----	----	--------	-----
Portland, Ore	-----	-----	--------	--------	-----	----	148	4
St. Albans, Vt	575	20	44,403	1,751	-----	----	--------	-----
San Francisco, Calif	-----	-----	--------	--------	-----	----	1,021	38
San Juan, P.R	-----	-----	--------	--------	-----	----	91	5
Savannah, Ga	-----	-----	--------	--------	-----	----	785	31
Seattle, Wash	133	10	47,675	2,629	-----	----	--------	-----
Tampa, Fla	-----	-----	--------	--------	-----	----	4,803	191
Wilmington, N.C	-----	-----	--------	--------	-----	----	22	1
Total	3,272	172	247,155	10,848	269	13	22,005	890

1 Less than ½ unit.

WORLD REVIEW

World production of peat in 1967 was estimated at 202 million tons, 4 percent less than that estimated for 1966. However, 10 countries that had production in 1966 were not included in the 1967 figures because of inadequate data.

The U.S.S.R. remained the largest producer of peat with an estimated output of 200 million tons. An estimated one-third was used for fuel and the remainder for agricultural purposes. 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. As in the United States, peat was added directly to the soil for various soil improvement purposes. The Soviets, however, use large quantities of agricultural peat as a base material for producing peat-mineral-ammonia fertilizers that are used extensively in lieu of regular animal and chemical fertilizers.

Ireland is the second largest producer of peat, with current annual production estimated at between 4 and 5 million tons. No exact data on production in 1967 were available. Although production was small when compared with that of the U.S.S.R., peat supplied a substantial part of Ireland's energy requirement and was used both as a domestic fuel and for generating electric power. Of approximately 1,050 megawatts of total installed generating capacity, about 40 percent was at seven plants fired with peat. The total consumption of peat at these plants was nearly 3 million tons. In addition, three plants with a rated annual output of 300,000 tons produced briquets, and two bogs produced an estimated 400,000 bales of peat moss for use as a soil conditioner. Approximately 75 percent of the peat moss was exported.

Data on the total output of West Germany, the third largest producer, were similarly unavailable, but it was estimated that about 500,000 tons of peat was produced for fuel. At least twice this amount probably was produced for agricultural use in 1967, maintaining the 2–to–1 ratio of agricultural peat to fuel peat in the past few years.

East Germany, the Netherlands, Canada, Sweden, and Finland are the other major world producers, but data on production in some of these countries were not available. All, however, probably had more than 100,000 tons of output.

Table 10.—World production of peat, by countries [1] [2]

(Thousand short tons)

Country	1963	1964	1965	1966	1967 [p]
Argentina; Fuel	12	4	4	[r] 8	NA
Austria; Fuel [e]	6	6	6	2	2
Canada; Agricultural use	244	255	288	[r] 285	277
Denmark; Fuel	55	[r] 44	[r] 22	[r] 11	[e] 11
Finland:					
Agricultural use	[r] 20	[r] 37	[e r] 55	[e r] 72	[e] 66
Fuel	88	79	72	[r] 76	[e] 72
France:					
Agricultural use	35	52	49	50	NA
Fuel [e]	3	3	3	3	NA
Germany, West:					
Agricultural use	884	1,085	1,156	[r] 1,250	NA
Fuel	837	773	484	[r] 524	[e] 495
Hungary; Agricultural use [e]	65	70	70	70	NA
Ireland:					
Agricultural use	28	26	31	32	NA
Fuel	3,918	4,208	4,157	4,639	NA
Israel; Agricultural use [e]	13	15	17	22	NA
Japan [e]	80	75	75	75	NA
Korea, South; Agricultural use	128	[r] 68	[r] 118	[r] 83	NA
Netherlands [e]	440	440	440	440	440
Norway:					
Agricultural use	[r] 12	[r] 10	[r] 9	[e r] 9	[e] 9
Fuel	[r] 3	[r] 2	[r] 2	[e r] 2	[e] 2
Poland; Fuel	112	110	86	[r] 66	NA
Sweden:					
Agricultural use	61	71	[r] 93	[e r] 88	NA
Fuel	234	158	[r] 96	[e r] 77	NA
U.S.S.R.:					
Agricultural use [e]	100,000	110,000	130,000	130,000	130,000
Fuel	64,485	65,587	50,706	[r] 72,091	[e] 70,000
United States; Agricultural use	579	649	604	611	617
Total [3]	[r] 172,342	[r] 183,827	[r] 188,643	[r] 210,586	201,991
Fuel peat (included in total)	[r] 69,753	[r] 70,974	[r] 55,638	[r] 77,499	70,582

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] Compiled from data available April 1968.
[2] In addition, Canada, Iceland, Italy, and Spain produced a negligible quantity of fuel peat. No data were available on East Germany, a major producer.
[3] Total is of listed figures only; no undisclosed data included.

TECHNOLOGY

A recent British patent [2] describes a method for preparing a granular fertilizer having a low bulk density by combining peat with fertilizer salts other than nitrates. A granular peat fertilizer with an analysis of 20 percent nitrogen, 10 percent phosphorus, and 5 percent potash can be prepared by mixing 20 parts of dibasic ammonium phosphate, 10 parts of potassium sulfate, 33.7 parts of urea, and 62.6 parts of peat containing 50 percent water. Additional water is used to induce granule formation; the granules are dried at 60° C to a moisture content of 5 percent, after which they are screened.

[2] Palmer, R. W., and F. N. Wilson. Granular Fertilizer Containing Peat and Fertilizer Salts. British Pat. 1,048,254, Nov. 16, 1966; Chem. Abs., v. 66, No. 7, Feb. 13, 1967, col. 28109d.

A new type of peat fertilizer[3] (geksatorf) developed in the U.S.S.R. is prepared by adding a 20 percent urotropine solution, prepared from ammonium hydroxide and formaldehyde, to a mixture of relatively decomposed, low-ash peat, powdered triple superphosphate, and ground potassium chloride. The mixture is granulated by extruding, and dried at 75–to–80° C in a two-stage, fluidized-bed dryer until the moisture is reduced to 15 or 20 percent. The product is a noncaking, stable, and dense fertilizer material that slowly releases nutrients to the soil.

A U.S. patent[4] describes the use of peat as a filler for aqueous phenolic adhesives that are used for bonding. Sphagnum-moss peat, when used in this manner, provides for a high water absorbency and retains the adhesive at the glue line long enough to permit assembly of the materials being bonded, such as in the manufacture of plywood. It also makes possible the use of fast curing adhesives.

An East German patent[5] gives details on the use of organic substances, such as peat and lignite, as additives to cement mixtures for the production of aerated concrete. Such substances are first neutralized with aqueous alkali solutions and the unsaponifiable products separated. The active material, obtained as a liquid or dried, is then used in proportions of 0.1–to–5.0 percent, the amount varying according to the dry cement mixture.

A method for preparing a material from peat and rubber wastes that is suitable for use in road and building construction is described in a Polish patent.[6] In this process, used tires and other rubber waste materials are powdered or dissolved and mixed with powdered peat and synthetic resins in proportions of 20–to–40 percent rubber, 50–to–80 percent peat, and 6–to–8 percent resins. The material is formed by heating the mixture to 100° to 120° C and compressing at a pressure of from 10–to–15 kilograms per square centimeter (142–to–213 pounds per square inch.) The material can be made incombustible with the addition of 1 to 2 percent boron salts, ammonium sulfate, or phosphates.

A Soviet patent[7] details a method for producing activated carbon from peat. The material, prepared from peat and potassium sulfide, is granulated and subjected to a thermal treatment. The mechanical strength of the product is improved when the peat is treated before processing with a solvent to remove bitumen.

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[3] Ryashentsev K. V., S. G. Solopov, V. D. Gvozdev, L. M. Monogova, G. N. Kornilov, and V. I. Tsvetkov. [Production of a New Peat Fertilizer.] Torf. Prom., v. 43, No. 7, 1966; Chem. Abs. v. 66, No. 17, Apr. 24, 1967, col. 75401c.

[4] Wilson, G. S. Peat as Filler for Aqueous Phenolic Adhesives. U.S. Pat. 3,231,526, Jan. 25, 1966; Chem. Abs. v. 64 No. 12, June 6, 1966, col. 17816b.

[5] Kleinert, H. [Air-Pore Forming Materials for Aerated Concrete.] *East Ger.* Pat. 32,730, Jan. 5, 1966; Chem. Abs. v. 65, No. 2 July 18, 1966, col. 1948a.

[6] Sawicki, R., A Augustynowicz, and L. Dzwonnik. [A Material From Rubber Wastes and Peat.] Pol. Pat. 50, 119, Sept. 30, 1965; Chem. Abs. v. 65, No. 1, July 4, 1966, col. 903a.

[7] Rakovskii, V. E., G. A. Bessmertnova, N. G. Lyubchenko, Y. M. Fedorov V. N. Drozdov, V. M. Kondraten, N. A. Ivanova, and O. I. Mazina. [Activated Carbon.] U.S.S.R. Pat. 178,797, Feb. 3, 1966; Chem. Abs. v. 65, No. 3, Aug. 1 1966, col. 3392f.

Perlite

By Timothy C. May [1]

Domestic crude perlite production in 1967 was 16 percent higher than in 1966. The total amount sold or used increased 2 percent in quantity and value compared with the perlite sold or used in 1966. Expanded perlite sold or used in 1967 declined 10 percent in quantity and 9 percent in value from 1966 because of decreased activity in the construction industry.

DOMESTIC PRODUCTION

Sixteen companies with 18 operations produced crude perlite in 1967 compared with 19 companies and 20 operations in 1966. The mines owned by Western Gravel Co., Esmeralda County, Nev., and A. M. Matlock, Lake County, Oreg., were closed in 1967. The quantity of perlite sold to expanders was 3,000 tons less than in 1966, and the quantity used in producers' plants was 12,000 tons above 1966. New Mexico continued to be the leading producing State with an output of 567,000 short tons. Other producing States in descending order of output were Arizona, Nevada, California, Idaho, Colorado, Texas, Utah, and Oregon.

Expanded perlite was produced by 78 companies at 91 plants, a decrease of four companies and four plants from 1966. Total output was 9 percent lower than in 1966. Perlite expanders maintained facilities in 32 States. Major producing States were Illinois with six plants, Mississippi with one plant, Texas with two plants, Kentucky with two plants, and Colorado with three plants. These five States produced 62 percent of the total perlite production.

General Refractories Co. (Grefco) completed construction of a perlite filter aid plant in Antonito, Colo., that will increase capacity 40 percent.[2]

[1] Commodity specialist, Division of Mineral Studies.
[2] Chemical Week. Perlite Filter Aid Plant To open. V 100, No. 18, May 6, 1967, p. 37.

Table 1.—Crude and expanded perlite produced and sold or used by producers in the United States

(Thousand tons and thousand dollars)

Year	Crude perlite: Quantity mined	Crude perlite: Sold: Quantity	Crude perlite: Sold: Value	Crude perlite: Used at own plant to make expanded material: Quantity	Crude perlite: Used at own plant to make expanded material: Value	Crude perlite: Total quantity sold and used	Expanded perlite: Quantity produced	Expanded perlite: Sold: Quantity	Expanded perlite: Sold: Value
1963	404	203	$1,631	122	$1,096	325	272	270	$14,497
1964	427	211	1,845	139	1,228	350	320	319	14,533
1965	502	231	1,731	161	1,621	392	343	344	15,391
1966	548	193	1,799	211	2,108	404	394	394	16,403
1967	638	190	1,802	223	2,171	413	358	356	15,115

Table 2.—Expanded perlite produced and sold by producers in the United States

State	1966				1967			
	Quantity produced (short tons)	Sold or used			Quantity produced (short tons)	Sold or used		
		Quantity (short tons)	Value (thousands)	Average value per ton		Quantity (short tons)	Value (thousands)	Average value per ton
California	26,950	26,680	$1,434	$53.75	17,630	18,020	$1,223	$67.87
Florida	8,180	8,160	602	73.77	8,720	7,900	539	68.23
Illinois	(1)	(1)	(1)	(1)	(1)	(1)	2,660	(1)
Kansas	750	750	50	66.67	880	880	67	76.14
Maryland	(1)	(1)	(1)	(1)	7,890	6,700	(1)	(1)
New Jersey	(1)	(1)	(1)	(1)	5,590	6,320	381	60.28
New York	(1)	(1)	(1)	(1)	6,180	6,200	375	60.48
Ohio	26,080	26,070	1,420	54.47	9,290	9,290	728	78.36
Oregon	(2)	(2)	(2)	(2)	470	470	(2)	(2)
Pennsylvania	11,640	11,860	781	65.85	13,100	13,070	959	73.37
Tennessee	5,900	5,900	(1)	(1)	(1)	(1)	(1)	(1)
Texas	41,610	41,610	1,960	47.10	39,690	39,600	2,329	58.81
Other Eastern States [3]	213,640	213,770	7,960	36.24	194,040	193,950	3,976	[4] 33.07
Other Western States [5]	59,550	59,540	2,196	36.88	54,080	53,550	1,878	[6] 34.76
Total	394,300	394,340	16,403	41.60	357,560	[7] 355,940	15,115	42.46

[1] Included with "Other Eastern States."
[2] Included with "Other Western States."
[3] Includes Georgia, Illinois (1966; 1967 quantity), Indiana, Kentucky, Maryland (1966; 1967 value), Massachusetts, Michigan, Mississippi, New Hampshire, New Jersey (1966), New York (1966), North Carolina, Tennessee (1966 value; 1967), Virginia, and Wisconsin.
[4] Based on quantity of 200,650 tons (193,950 tons "Other Eastern States" plus 6,700 tons from Maryland).
[5] Includes Arizona, Colorado, Idaho, Iowa, Louisiana, Minnesota, Missouri, Nebraska, Nevada, Oregon (1966; 1967 value) Utah, and Washington.
[6] Based on quantity of 54,020 tons (53,550 tons "Other Western States" plus 470 tons from Oregon).
[7] Data do not add to total shown due to independent rounding.

CONSUMPTION AND USES

The consumption and use of expanded perlite as reported by the producers are shown in table 3.

Table 3.—Consumption and end-uses of expanded perlite

(Percent)

Use	1966	1967
Building plaster aggregate	36	31
Filter aid	17	18
Concrete aggregate	11	8
Loose fill insulation	5	5
Soil conditioning	2	3
Filler	1	2
Other	28	33

PRICES

The average value of crushed, cleaned, and sized perlite sold to expanders in 1967 was $9.48 per short ton compared with $9.32 per short ton in 1966. The average value of crude perlite used by producers in their own expanding plants was $9.74 per ton in 1967 compared with $9.98 per ton in 1966. A weighted average of both categories was $9.62 in 1967 versus $9.67 in 1966.

The average value of all expanded perlite sold was $42.46 per ton in 1967 compared with $41.60 per ton in 1966.

WORLD REVIEW

Canada.—Crude perlite was imported from the United States and expanded at the following plants:

Domtar Construction Materials Ltd	Calgary, Alberta.
Western Insulation Products Ltd	Edmonton, Alberta.
Vantec Industries Ltd	Richmond, British Columbia.
Western Gypsum Products Ltd	Vancouver, British Columbia.
P. & V. Products	St. Boniface, Manitoba.
Canadian Gypsum Co., Ltd	Hagersville, Ontario.
Domtar Construction Materials Ltd	Caledonia, Ontario.
Laurentide Perlite Inc	Charlesbourg West, Quebec.
Perlite Industries Reg'd	Ville St. Pierre, Quebec.

In 1966, plaster consumed 71 percent of the expanded perlite produced; 13 percent was used as aggregate in refractory products; 7 percent in insulating concrete, and 9 percent as loose insulation and in horticultural applications. Expanded perlite was sold at 30 to 40 cents per cubic foot, f.o.b. plant.[3]

France.—Johns-Manville Corp. completed a new facility at Wissenbourg, for the manufacture of perlite roof insulation board.[4]

Japan.—General Refractories Co. (Grefco) started construction of a filter aid plant near Tokyo, which is expected to be completed by yearend. The operation, known as Dicalite Orient Co., Ltd., is a joint venture between Grefco and Mitsui Mining & Smelting Co., Ltd. of Japan. Output of the plant will serve markets in Japan, Taiwan, the Philippines, Hong Kong, Korea, and Malaysia.[5]

Mexico.—Production of crude perlite in 1966 was 11,128 short tons, a 20-percent increase over the 1965 production of 9,203 short tons.

Morocco.—In 1966, Morocco exported 269 short tons of crude perlite.

United Kingdom.—Perlite production in Northern Ireland in 1967 was 130 short tons, compared with 289 tons in 1966, a decrease of 55 percent.[6]

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[3] Wilson, H. S. Lightweight Aggregates, 1965. Mineral Processing Division, Mines Branch, Dept. of Energy (Ottawa), June 1967, 4 pp.
[4] Johns-Manville Corp. Annual Report 1967, p. 6.
[5] Pit and Quarry. General Refractories Begins Construction On New Plant. v. 59, No. 11, May 1967, p. 28.
[6] U.S. Consulate, Belfast, North Ireland. Department of State, Airgram A-7, Apr. 24, 1968, p. 2, enc. 1.

Crude Petroleum and Petroleum Products

By James G. Kirby [1] and Betty M. Moore [2]

The general outlook for the petroleum industry was not too optimistic during the first half of 1967. Demand was lagging and crude oil and refined product stocks were building up. The outbreak of the Arab-Israeli conflict and the blocking of the Suez Canal early in June caused a sudden change in the situation. Immediate steps were taken to furnish the east coast area of the United States and Canada and Western Europe with crude oil and refined products to replace supplies normally received from the Arab nations. Crude oil production in the United States was stepped up and reached a peak level of

[1] Industry economist, Division of Mineral Studies.
[2] Statistical assistant, Division of Statistics.

Table 1.—Salient statistics of crude petroleum, refined products, and natural gas liquids in the United States

	1963	1964	1965	1966	1967 p
Crude petroleum:					
Domestic production thousand barrels [1]	2,752,723	2,786,822	2,848,514	3,027,763	3,215,742
World production do	9,538,948	10,311,060	11,057,489	12,015,830	12,889,705
United States proportion percent	29	27	26	25	25
Imports [2] thousand barrels [1]	412,660	438,643	452,040	447,120	411,649
Exports [3] do	1,698	1,363	1,097	1,477	26,502
Stocks, end of year do	237,361	230,057	220,289	238,391	248,970
Runs to stills do	3,170,652	3,223,329	3,300,842	3,447,193	3,582,594
Value of domestic product at wells:					
Total thousands	$7,965,742	$8,017,078	$8,158,298	$8,726,423	$9,375,727
Average per barrel	$2.89	$2.88	$2.86	$2.88	$2.92
Total producing oil wells December 31	588,657	588,225	589,203	583,302	573,159
Total oil wells completed during year (successful wells)	20,288	20,620	18,761	16,780	15,329
Refined products:					
Imports [4] thousand barrels [1]	362,053	388,093	448,732	492,042	514,157
Exports [3] do	74,216	72,516	67,191	r 70,923	85,414
Stocks, end of year do	564,451	573,499	580,188	595,651	623,702
Completed refineries, end of year	304	300	286	281	291
Daily crude-oil capacity thousand barrels [1]	10,385	10,775	10,493	10,760	11,533
Natural gas liquids:					
Production do	400,886	422,471	441,556	468,635	514,456
Stocks, end of year do	33,747	35,679	35,867	40,423	65,742
All oils:					
Total demand thousand barrels [1]	3,927,139	4,032,382	4,193,746	4,397,469	4,592,142
Exports do	75,914	73,879	68,288	r 72,400	111,916
Domestic demand do	3,851,225	3,958,503	4,125,458	r 4,325,069	4,480,226

p Preliminary (except for crude production and value). r Revised.
[1] 42 gallons per barrel.
[2] Bureau of Mines data for crude oil and unfinished oils.
[3] U.S. Department of Commerce data.
[4] U.S. Department of Commerce data, except for unfinished oils.

9,435,000 barrels per day in August. Exports during the third quarter averaged 510,000 barrels daily compared with normal exports for that period of about 200,000 barrels daily, and imports declined almost 393,000 barrels daily. Supplies from South America and the Far East were diverted to Europe and Japan to relieve shortages in these areas. The Arab nations resumed crude oil production but boycotted shipments to nations friendly to the Israeli Government. No attempt was made to reopen the Suez Canal, and the longer haul around Africa kept tankers in tight supply and shipping rates high for the balance of the year. The shortage of tankers delayed the shipments of heating oils from the gulf to the east coast to build up inventories for the peak winter demands. However, despite exceptional cold weather no serious shortages occurred.

DEMAND BY PRODUCTS

As most of the indicated consumption of crude oil in the United States is converted into refined products before sale to ultimate consumers, the analysis of demand trends involves consideration of each major product. The fuel oils (residual, distillate, and kerosine) compete directly with natural gas or coal in heating, cooking, and industrial uses. Gasoline and diesel fuel are the major fuels used in the transportation field, followed by jet fuel (a blend of low-grade gasoline, kerosine, and distillate) used in military jetplanes, and straight kerosine which is used as fuel by commercial jetplanes. The other products serve a wide variety of uses and are in competition with other refined products both for fuel and nonfuel use.

Gasoline.—The total demand for motor gasoline was 1,810 million barrels in 1967; this gain of 3.1 percent was below the normal growth rate of 4.0 percent as a result of low demand in the second and third quarters. The continuing shift from propeller driven [gasoline-fueled] aircraft to jet aircraft made further inroads on the domestic demand for aviation gasoline. The decrease for 1967 was 14.5 percent. In the export market, aviation gasoline sales have been steady.

Distillate Fuel Oil.—Although the weather in 1967 was colder than the previous year, a slowdown in the growth of industrial activity limited the increase in demand for distillate fuel oil to 2.4 percent. Total demand for distillate fuel oil was 821 million barrels.

Residual Fuel Oil.—The 4.1-percent increase in domestic demand for residual was limited primarily to the east coast market. Domestic demand in the United States was 65.2 million barrels and the east coast district accounted for 70 percent of this total. Residual fuel used for the generation of electric power increased from 138.0 million barrels in 1966 to 158.4 million in 1967. Exports of residual fuel oil were 22 million barrels in 1967 compared with 12.9 million barrels in 1966. Most of the additional exports were to Japan and Canada.

Kerosine.—After a 2-year increase, demand for kerosine for uses other than jet fuel reverted to its usual downward trend. Total demand for the year was 100.2 million barrels, 1.1 million barrels below the 1966 level.

Jet Fuels.—The domestic demand for jet fuels in 1967 was 300.8 million barrels, a gain of 56.4 million barrels or 23.1 percent for the year. The demand for naphtha-type jet fuel was 111.5 million barrels and for the kerosine type, 189.2 million barrels. The naphtha-type jet fuel is generally used by the military while commercial jet aircraft used the kerosine-type jet fuel.

Other products.—The total demand for all other products including crude oil exports and losses and refinery overage in 1967 was 846.1 million compared with 811.3 million barrels in 1966. Liquefied gases are the largest segment in this group and include liquefied gases for fuel and for chemical use. Demand for this product in 1967 was 353.7 million barrels, an increase for the year of 6.5 percent. A delay in the release of Federal funds for the interstate highway construction program caused a slowdown in several road building projects. As a result, asphalt demand for the year declined 2.2 percent to 131.6 million barrels. The demand for petroleum coke increased in both the domestic and export markets and totaled 91.4 million barrels for the year. The demand for petrochemical feedstocks from products other than liquefied gases was 86.9 million barrels, 13.6 percent higher than in 1966. Refineries utilized 140,034,000 million barrels of still gas for fuel in 1967 and had a refinery overage of 106,592,000 million barrels. The demands for other products in this group (special naphtha, lubricants, wax, and miscellaneous finished products) were all below the 1966 level.

Total demand[3] for all oils in 1967 averaged 12,581,000 barrels daily, a gain of 4.4 percent, and crude oil production for the year increased 6.2 percent to 8,810,000 barrels daily.

CONSUMPTION

The total demand for crude oil in the United States in 1967 averaged 9.9 million barrels daily. Domestic crude oil supplied 8.8 million barrels and foreign crude oil, 1.1 million barrels. The demand for domestic crude oil increased at the rate of 543,000 barrels daily while the demand for foreign crude oil declined 105,000 barrels daily.

Runs to Stills.—Crude runs to stills averaged 9.8 million barrels daily in 1967 compared with 9.4 million barrels daily in 1966. Domestic crude runs were 8.7 million barrels daily and foreign crude runs, 1.1 million barrels daily.

Demand by States of Origin.—Distribution of domestic crude oil by refining States and districts can be analyzed from receipts of crude oil at refineries. When long-distance shipments are involved,

[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 decrease 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 in all states of the United States less exports.
Shipments to U.S. Territories and Possessions.—Shipments from the United States to territories and possessions are included in 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.
New supply of all oils.—The sum of crude oil, natural gas liquids, and benzol (coke-oven) used for motor fuel, production 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.

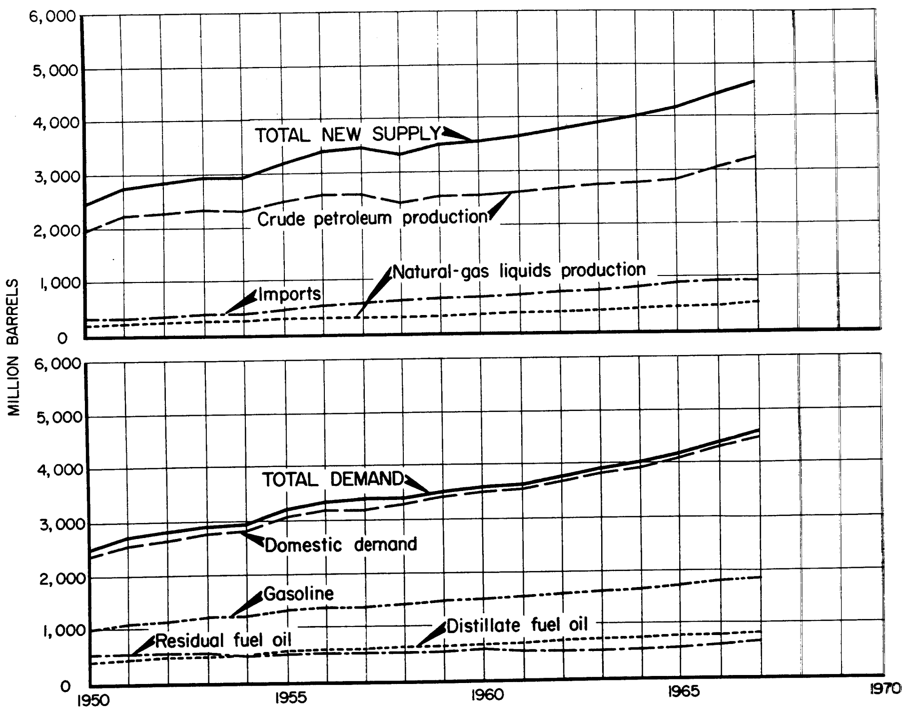

Figure 1.—Supply and demand of all oils in the United States.

various crude oils may be mixed in transit or storage and identification by origin may be only approximate.

SCOPE OF REPORT

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 the next 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.

Most of the data were compiled from detailed reports, submitted on a voluntary basis by the various companies and include production, stocks, and refinery operations. These data are also published monthly.

The Bureau of Mines uses crude oil production data 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. The crude production figure includes field condensate.

Individual refineries reported monthly receipts, input, stocks at the beginning and end of the month, refinery production, and deliveries. Data on both product stocks at refineries and pipeline and bulk terminal stocks are collected.

Annual canvasses provide supplemental information on the value of crude petroleum at wells, the number of producing wells, sales of fuel oils, asphalt and road oils by uses, and refinery capacity.

The import data on crude oil and unfinished oils is that reported by the refineries whereas other product imports and all export data are taken from records of the U.S. Department of Commerce.

The table showing world crude oil production by countries is based on monthly reports that also include data on crude movements and refinery operations.

DISTRICTS

Production of crude petroleum and natural gas liquids and the number of wells drilled is reported by State, with data for Louisiana, New Mexico, and Texas 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, Rico 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 Louisiana gulf coast, including the offshore area.

Refinery operations are grouped into another set of districts called refining districts. These districts correspond with the groupings of the Petroleum Administration for Defense (PAD districts).

PAD district	*Refining districts*
1	*East Coast*—District of Columbia and Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida, and the following counties of New York: Cayuga, Tompkins, Chemung, and all counties east and north thereof, and the following counties of Pennsylvania: Bradford, Sullivan, Columbia, Montour, Northumberland, Dauphin, York, and all counties east thereof.
1	*Appalachian No. 1*—West Virginia and those parts of Pennsylvania and New York not included in the East Coast district.
2	*Appalachian No. 2*—The following counties of Ohio: Erie, Huron, Crawford, Marion, Delaware, Franklin, Pickaway, Ross, Pike, Scioto, and all counties east thereof.
2	*Indiana-Illinois-Kentucky*—Indiana, Illinois, Kentucky, Tennessee, Michigan, and that part of Ohio not included in the Appalachian district.
2	*Oklahoma-Kansas-Missouri* — Oklahoma, Kansas, Missouri, Nebraska, and Iowa.
2	*Minnesota-Wisconsin-North Dakota-South Dakota*—Minnesota, Wisconsin, North Dakota, and South Dakota.
3	*Texas Inland*—Texas, except Texas Gulf Coast district.
3	*Texas Gulf Coast*—The following counties of Texas: Newton, Orange, Jefferson, Jasper, Tyler, Hardin, Liberty, Chambers, Polk, San Jacinto, Montgomery, Harris, Galveston, Waller, Fort Bend, Brazoria, Wharton, Matagorda, Jackson, Victoria, Calhoun, Refugio, Aransas, San Patricio, Nueces, Kleberg, Kenedy, Willacy, and Cameron.
3	*Louisiana Gulf Coast*—The following parishes of Louisiana: Vernon, Rapides, Avoyelles, Pointe Coupee, West Feliciana, East Feliciana, Tangipahoa, St. Helena, Washington, and all parishes south thereof; the following counties of Mississippi: Pearl River, Stone, George, Hancock, Harrison, and Jackson; and Mobile and Baldwin Counties, Ala.
3	*North Louisiana-Arkansas*—Arkansas and those parts of Louisiana, Mississippi, and Alabama not included in the Louisiana Gulf Coast district.
3	*New Mexico*—New Mexico.
4	*Rocky Mountain*—Montana, Idaho, Wyoming, Utah, and Colorado.
5	*West Coast*—Washington, Oregon, California, Nevada, Alaska, Arizona, and Hawaii.

WELLS

The downward trend in drilling activity continued through 1967. Total wells drilled, exclusive of service wells, was 32,234 which was 4,150 less than 1966. Eight States reported increased drilling activity for the year but only three had any sizable increase. They were Kansas, an increase of 571; California, 226; and New York, 145. Among the States where drilling activity showed the largest decline were Texas, 1,612; Oklahoma, 881; Louisiana, 799; Kentucky, 571; and West Virginia, 320.

The average footage drilled per well declined from 4,383 feet in 1966 to 4,298 feet in 1967.

The number of producing oil wells in the United States as of December 31, 1967, was 573,159 compared with the 583,302 reported in operation at the end of 1966.

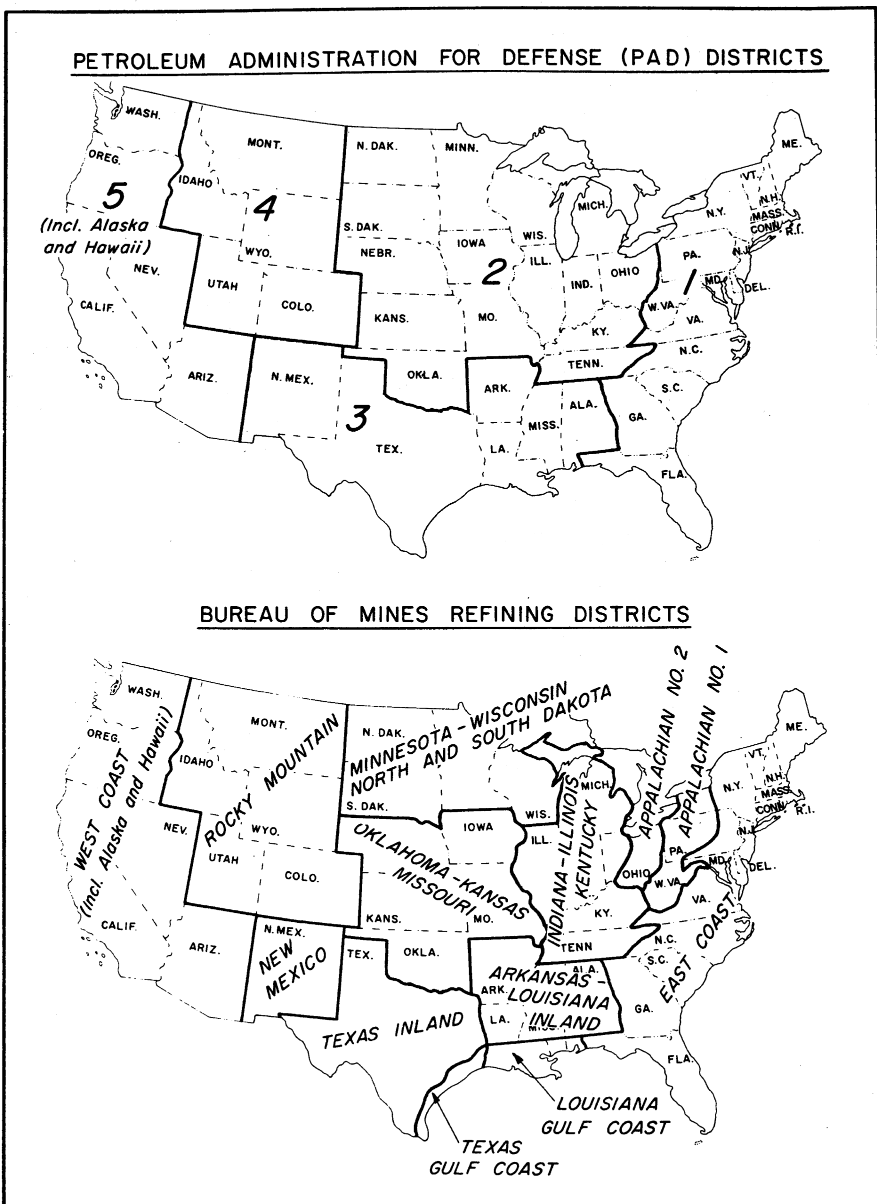

Figure 2.—Map of PAD Districts and Bureau of Mines Refining Districts.

RESERVES

The American Petroleum Institute Committee on Petroleum Reserves estimated proved reserves of crude oil in the United States as of December 31, 1967, to be 31,376.67 million barrels, a decrease of 75.5 million barrels for the year. States reporting the largest declines for the year were California, 238.6 million barrels; Kansas, 101.3 million barrels; and New Mexico, 98.8 million barrels. The only major addition to reserves for the year was reported for the West Texas district where reserves increased 569.9 million barrels due primarily to revisions of previous estimates.

The estimate of crude-oil reserves includes only oil recoverable under existing economic and operating conditions. Reserves of natural gas liquids are given in the natural gas liquids chapter.

PRODUCTIVE CAPACITY

According to the American Petroleum Institute the maximum crude oil production that could be attained in the United States, as of January 1, 1968, was 12.3 million barrels daily. This 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 the time period.

CRUDE PETROLEUM

SUPPLY AND DEMAND

The new supply of crude petroleum was derived primarily from domestic production augmented by imports. Crude oil imports represented only 11.3 percent of new supply in 1967 compared with 12.9 percent in 1966. The decrease in the import share of new supply resulted from the disruption created by the Middle East conflict in June and the resulting tanker shortage that existed through the balance of the year. When the import allocations for 1967 expired on December 31, importers were left with unused licenses for crude oil and unfinished oil totaling 53.7 million barrels. Provisions were made by the Secretary of the Interior to permit the use of these licenses in 1968 and 1969. Under the mandatory import control program, which became effective in March 1959, imports of crude oil, unfinished oils, and refined products other than residual fuel oil are limited to 12.2 percent of the estimated total domestic production of crude oil and natural gas liquids in all States east of the Rocky Mountains. In States west of the Rocky Mountains, including Alaska and Hawaii, the import quota is based on the difference between the estimated available domestic supply and the estimated total demand. Overland receipts (imports from Canada and Mexico) are exempted from provisions of the program; however, before setting the allocations for crude and unfinished oils in the States an estimate of probable overland receipts from Canada and Mexico and subtracted from the allocations. Vessel and aircraft fuels imported in bond for use as fuel outside the United States are also exempted from provisions of the program. All refineries and petrochemical plants of record are granted an allocation based on their refinery or plant throughput with certain special provisions under the last quota issued under the voluntary input program in the latter part of 1958 and the early quarter of 1959.

PRODUCTION

The United States produced 3,215,742,000 barrels of crude oil in 1967, a gain of 6.2 percent for the year. Production during the first quarter exceeded demand requirements and stocks built up rapidly. States with proration controls lowered production allowables for the second quarter, but stocks continued to climb. The Middle East conflict early in June changed the entire crude oil supply situation. East coast refineries lost their crude oil supplies from the Middle East countries and production in the Gulf Coast States was stepped up to record high levels to meet the east coast demand. Crude oil was also exported to western Europe and Canada to ease the supply problems in these areas. While production was resumed in the

Arab nations the Egyptians did not reopen the Suez Canal. The additional time and mileage required to bring cargoes around Africa caused a shortage of tankers and higher shipping costs. Crude oil imports were low for the balance of the year; therefore production continued at a high level. Crude oil production for Louisiana averaged 247,000 barrels per day more than in 1966 and Texas production increased 170,000 barrels daily. On the west coast, Alaska more than doubled production with a daily output of 80,000 barrels daily and California production increased 40,000 barrels daily to 986,000 barrels. Additional data on crude oil production, by States, can be found in the State chapters of Volume III of the 1967 Minerals Yearbook.

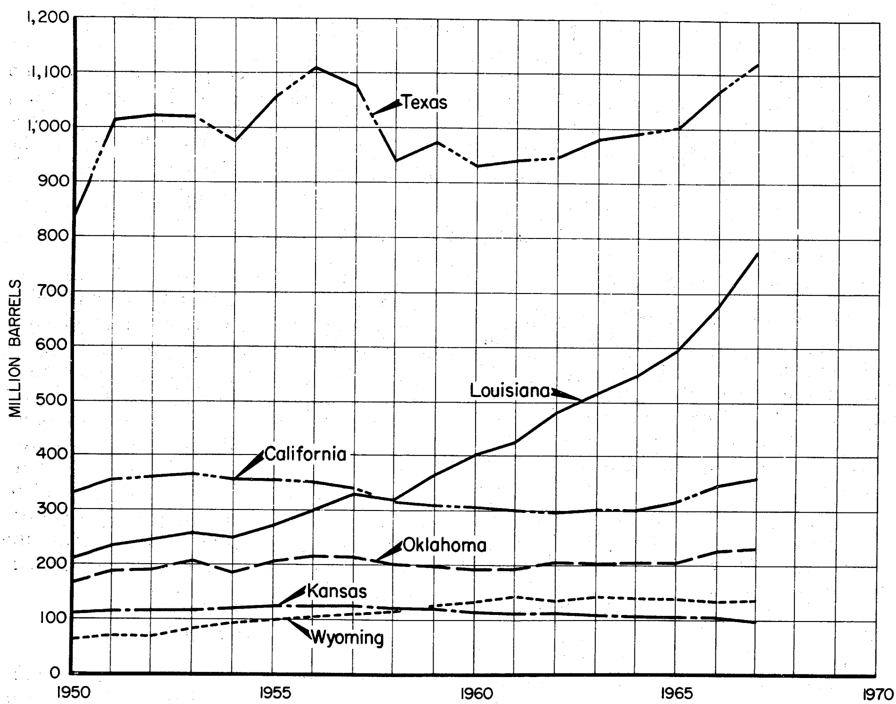

Figure 3.—Production of crude petroleum in the United States, by principal producing States.

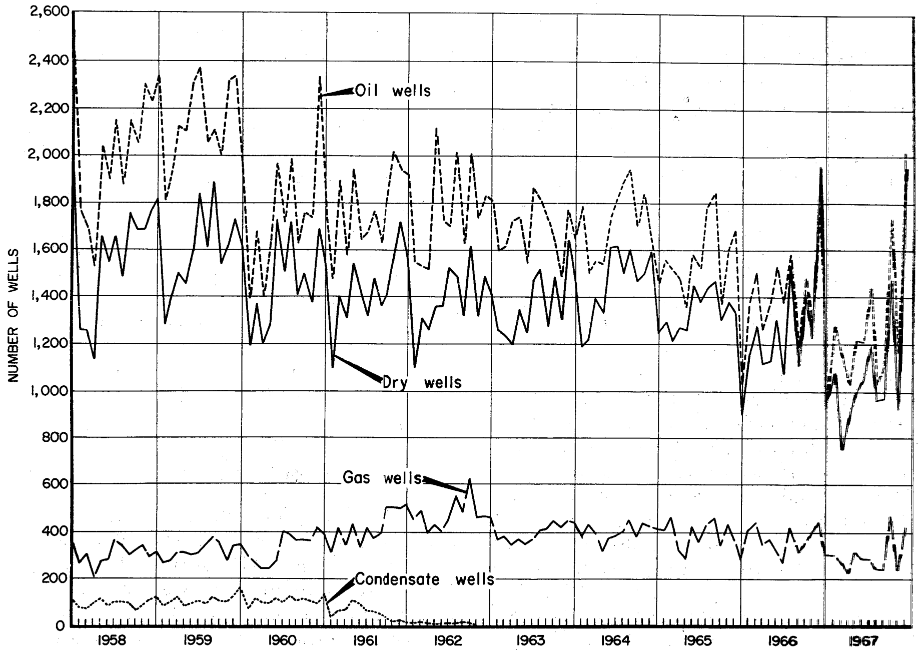

Figure 4.—Wells drilled for oil and gas in the United States, by months.

TRANSPORTATION AND DISTRIBUTION

CRUDE OIL

A transportation system consisting of pipelines, tankers, barges, tank cars, and tank trucks moves the crude petroleum to refineries for processing. Refineries received 75.8 percent of their crude oil supply by pipeline, 22.9 percent by water and the remaining 1.3 percent by tank cars and tank trucks in 1967.

The largest domestic market for petroleum is the group of eastern seaboard States (PAD district 1), while the second largest market is in the midwest area (PAD district 2). Most of the domestic supply of crude oil, as well as refined products, are obtained from PAD district 3. Shipments of crude oil and refined products to other PAD districts from district 3 in 1967 amounted to 4.9 million barrels a day, with district 1 receiving 3.1 million barrels or 63 percent of the total. District 2 received an average of 1.6 million barrels a day, or 33 percent of the total shipped from district 3.

Data collected on receipts of domestic and foreign crude petroleum at refineries in the United States shows receipts from local production (intrastate), receipts from other States—(interstate) and receipts of imported crude. These data by method of transportation indicate the final receipts of water, pipelines and tank car and truck. Receipts of domestic crude by water usually are moved by pipeline from the point of production to the point of water shipment.

The total receipts of crude oil at refineries in 1967 were 3,592.1 million barrels, an increase of 141.1 million barrels for the year. Receipts from domestic sources increased 175.9 million barrels in 1967 and overland receipts of foreign crude oil were 20.6 million barrels higher, but foreign receipts from overseas sources were down 55.4 million barrels.

During 1967 refineries processed 3,582.6 million barrels of crude oil, reported a net of 100,000 barrels used for refinery fuel and losses, and added 9.4 million barrels to inventories.

Because PAD district 1 is a deficit area and obtains most of its supply of oil from PAD district 3, the major waterborne shipments are from the gulf coast to the east coast. In addition, there is some waterborne traffic between States in the gulf coast districts; also, interstate and intrastate shipments by water on the west coast from Alaska to refinery complexes in the States of Washington and California. In addition, there is a sizable volume of petroleum transported on the Ohio and Mississippi Rivers and rivers flowing into the Mississippi.

Most of the foreign crude oil imports to the east coast district 1 are received by water but the movement of Canadian crude oil by pipelines into refineries near Buffalo, New York, is becoming significant. Until 1960 the source of crude oil for the Buffalo refineries was about 40 percent from district 2, 40 percent from district 3, and the remainder from district 4. Canadian crude oil entered the market in 1961 and has since virtually replaced the crude from districts 3 and 4. District 3 is the major outside source of crude oil for district 2, with the balance coming from district 4 and from Canada. Only 6.4 million barrels of 36.4 million barrels of crude oil run through Montana refineries are imported from Canada. West Coast refineries received 51.6 percent of their foreign crude oil by tanker, and the balance was moved overland from Canada by pipeline for use of refineries relatively close to the Canadian border. Refinery receipts of foreign crude oil in the United States totaled 411.8 million barrels, which represented 11.5 percent of the total refinery receipts in 1967.

PIPELINES

Pipelines are a vital factor in the production of crude oil and the marketing of the refined petroleum products.

Gathering and trunk lines move the crude oil from the fields directly to refineries or to tankers and barges for shipment to refineries by water. Product pipelines transport the lighter finished products, such as gasoline, jet fuels, kerosine and diesel fuels, and the lighter distillate heating oils from refineries or marine terminals to the marketing area for distribution to the ultimate consumer.

There were 216,700 miles of pipeline in all types of service, exclusive of natural gas transportation, at the beginning of 1967. Growth also has been impressive in product pipelines. From about 9,000 miles in service before World War II, the mileage of product pipelines had increased more than sevenfold by the beginning of 1967. Significant, moreover, has been the growth in pipeline capacity, particularly in more recent years. Pipeline fill for petroleum product lines aggregated 23.5 million barrels at the beginning of 1962, and there were 53,200 miles of line in operation. Three years later, the mileage had increased to 61,443 miles, or 15.5 percent, but the pipeline fill had expanded from 23.5 million barrels to 35.8 million, or 52.0 percent.

REFINED PRODUCTS

Almost 5.0 million barrels of petroleum per day was needed to meet the demand requirements in PAD district 1 during 1967 and more than 60 percent of this was supplied from PAD district 3, primarily by means of water transport—tankers and ocean and river barges. Waterborne shipment of petroleum products from district 3 to district 1 reached a peak of 1,636,000 barrels per day in 1963 while pipeline shipments that year were 311,000 barrels per day. The construction of the Colonial pipeline from Houston, Texas, to the vicinity of New York Harbor and the subsequent extension of the Plantation pipeline to the vicinity of Washington, D. C., has changed the transportation pattern significantly over the 4 years through 1967. Pipelines are now moving nearly 1.2 million barrels per day from district 3 to district 1, as compared with 311,000 barrels daily in 1963, and shipments of gasoline by pipelines have more than tripled; from a daily average of 202,000 barrels per day to 667,000 barrels. At the same time, the daily average receipts of gasoline by tanker and barge dropped from 700,000 to 485,000 barrels as a result of competition from the pipelines.

Although the immediate reaction would be that tanker rates would soften by reason of intensifying competition from pipelines, the disruption to transportation caused by blocking the Suez Canal coupled with demand for smaller tankers by the military caused the tanker rates to jump sharply in 1967.

RAIL, LAKE, AND RIVER SHIPMENTS

Rail Transportation.—Interdistrict shipments of petroleum by rail represent only a small part of the total volume of crude oil and refined products transported. Liquefied petroleum gases, gasoline and lubricants comprise the major part of these shipments.

Lake and river shipments.—There is some movement of crude petroleum and petroleum products via lake and river from district 2 to district 1. The latest year for which data are available was 1964 and during that year lake shipments averaged 17,000 barrels daily and river shipments averaged 77,000 barrels per day. The lake shipments consisted of refined products while the river shipments were primarily crude oil. In 1967 district 3 shipped 46,000 barrels a day of refined products to district 1 and 261,000 barrels daily of crude oil and refined products to district 2 by river barge on the Mississippi and Ohio Rivers.

STOCKS

Total stocks of all oils at the end of 1967 were 938.4 million barrels. There was an increase of 63.9 million barrels for the year. Crude oil stocks, which aggregated nearly 249 million barrels, were 10.6 million barrels higher than the year before, and refined product stocks at 623.7 million had increased 28.1 million barrels, almost half of which was in stocks of gasoline. The bulk of the increase in the remainder was scattered primarily among distillates, lubricants, jet fuels, and asphalt.

Crude oil stocks built up rapidly during the first half of 1967 when production exceeded the demand for domestic crude oil by almost 98,000 barrels per day. Production was increased during the third quarter to meet the additional export demand and offset the loss of imports to the east coast market which resulted from the Middle East crisis. Although production was cut back in the fourth quarter, stocks continued to increase.

PRICES

Crude oil.—The year 1967 saw a continuation of the upward adjustment in crude oil prices that started in the Illinois basin and spread to all producing areas east of the Rocky Mountains. The 1966 increases in posted prices were mostly in the 5- to 8-cent range, while the 1967 adjustments were about 5 cents. The overall effect on the average value per barrel of crude oil in the United States was an increase of 2 cents in 1966 and 4 cents in 1967.

The Bureau of Labor Statistics (BLS) collects prices on crude oil from six oil-producing areas equally divided between sweet and sour crudes. The latter denotes crude wth a high sulfur content. From these data BLS compiles a wholesale price index (1957–59=100). This index for crude oil averaged 98.6 in 1967, which was the highest yearly average since 1957. The description "wholesale", it should be noted, denotes sales in quantities and not to an index of prices by wholesalers, jobbers and distributors.

Refined Products.—Prices of the principal petroleum products have been in an upward trend since 1964, but only kerosine established new highs above the postwar peaks reached in 1957. Posted prices for residual fuel oils for ships' bunkers recovered from the low levels reached after 1964. The price of No. 5 residual fuel oil, which dropped from $2.85 a barrel in 1963 to $2.76 a barrel by 1966, had recovered to $2.83 by 1967. No. 6 fuel oil in cargo lots without a sulfur guarantee has felt the impact of air pollution regulations. From $2.10 a barrel in 1963, the price of this residual fuel oil dropped to $1.95 a barrel by 1967. In the barge market, the decline has been even more drastic, from $2.36 a barrel in 1963 to $2.16 a barrel by 1967.

The price of gasoline to the consumer, as reported for 55 representative cities by Platt's Oilgram Price Service, was 1.08 cents higher in 1967. This was due to increased charges to the dealers (the tank wagon price), and because of wider mar-

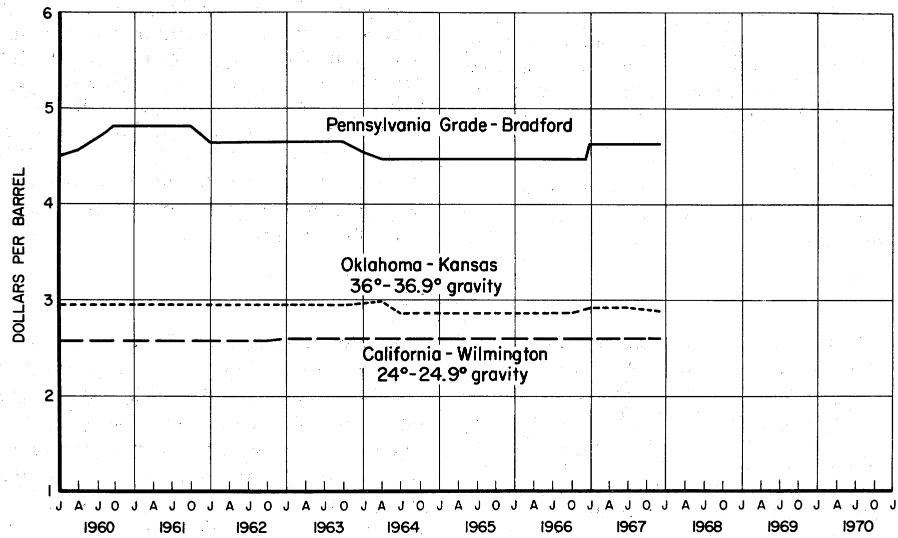

Figure 5.—Posted prices of selected grades of crude petroleum in the United States, by quarters.

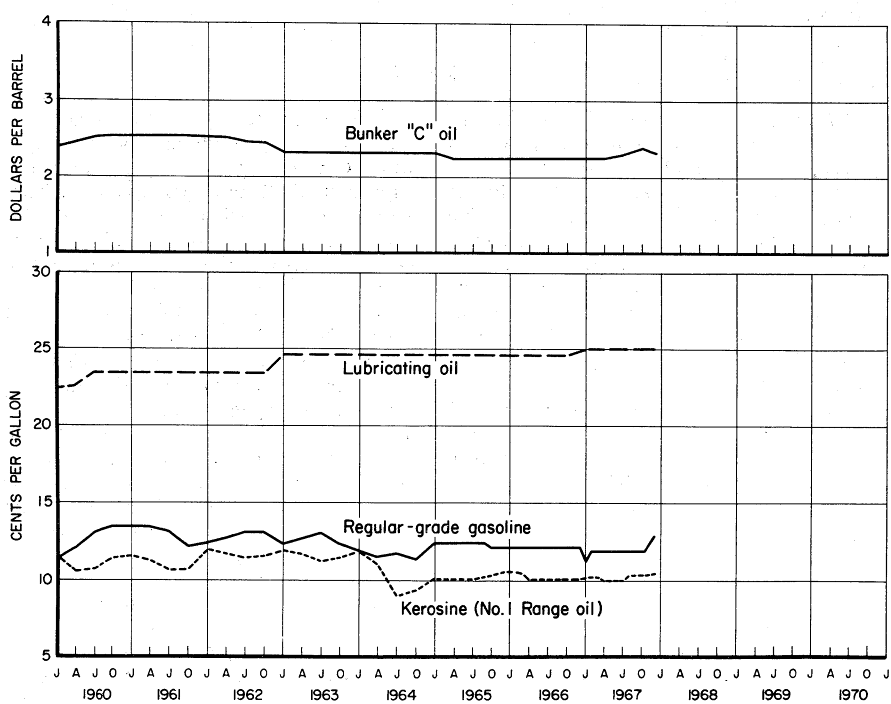

Figure 6.—Prices of Bunker "C" oil at New York Harbor, bright stock at Oklahoma refineries, No. 1 range oil atChicago district, and regular-grade gasoline at refineries in Oklahoma, by quarters.

gins to dealers, and increased State and local gasoline taxes. The Federal gasoline tax of 4 cents per gallon has remained unchanged since 1960. The average price per gallon paid by the consumer for regular grade gasoline in 1967 was 33.16 cents, and taxes accounted for 10.61 cents or 32 percent of this price.

REFINED PRODUCTS

Although the primary market for the many finished products of petroleum is in the fuel and energy field, they also are widely used as the base stock in the manufacturing of several other products.

Gasoline is consumed principally in highway transport, aviation, mechanized farming, and power boating. Kerosine (other than the straight runs 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 and 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 all oils averaged 12.6 million barrels daily in 1967, including a domestic demand of 12.3 million barrels daily and exports of 307,000 barrels daily. On a percentage basis, total demand increased 4.4 percent; domestic demand, 3.6 percent; and exports, 54.6 percent.

The new supply of refined products comes from crude oil processed at refineries, natural gas liquids, and imports of products from foreign countries. The new supply exceeded demand resulting in an increase of 28.1 million barrels to stocks of refined products.

GASOLINE

The domestic demand for gasoline averaged 5,048,000 barrels daily in 1967. Motor gasoline averaged 4,958,000 barrels daily, an increase of 150,000 barrels daily or 3.1 percent over 1966. Aviation gasoline continued to lose out to jet fuel. Domestic demand for aviation gasoline during 1967 averaged 90,000 barrels daily which was a decline of 14.5 percent from 1966. Imports of gasoline decreased slightly, whereas exports of gasoline showed a slight increase over 1966.

The new supply of motor gasoline in 1967 totaled 1,824 million barrels, of which 1,802 million barrels was produced at petroleum refineries, 7 million barrels at natural gasoline plants, and 15 million barrels imported from foreign countries.

Gasoline price wars raged in all PAD districts off and on during the year, but the basic price of gasoline remained relatively constant. The average price of major brand regular gasoline, excluding taxes, sold in the United States was 22.55 cents per gallon. This is a 0.98-cent increase over the average price per gallon in 1966. Independent house brands and rebranded gasolines in service stations usually are 1 to 2 cents cheaper per gallon than the major brand regular gasolines. Because of price wars, the price range for 1967 was from a low of 13.9 cents per gallon to a high of 25.9 cents per gallon, excluding Federal and State tax.

Stocks of gasoline at the beginning of the year totaled 194.2 million barrels and increased at the rate of 37,090 barrels daily, totaling 207.7 million barrels at the end of the year. This includes stocks held at refineries and at bulk terminals operated by refineries and pipeline companies but does not include those held by secondary distributors, by consumers, or in military custody. The Bureau of Mines definition of a bulk terminal installation is any storage facility operated by a refinery or pipeline companies which receives its principal products by tanker, barge, or pipeline or any storage point which has a combined capacity for storing refined products of 50,000 barrels or more regardless of transportation means by which products are received.

KEROSINE

Kerosine demand, exclusive of that used as commercial jet fuel, declined slightly in 1967. Total demand in 1967 was 100.2 million barrels compared with 101.4 million in 1966.

Kerosine used for commercial jet aircraft is now reported under another section of this chapter, along with military jet fuel. Stock at the beginning and closing of the year show an increase of only 4,000 barrels.

DISTILLATE FUEL OIL

The total demand for distillate fuel oil averaged 2,249,000 barrels daily in 1967 and represented a gain of 2.4 percent for the year. This gain was in domestic demand, as exports were slightly below the 1966 level. The weather in the east coast district was much colder than normal for the months of March, April, and May and a heavy withdrawal from stocks occurred in this area. The transportation difficulties arising from the Middle East crisis caused a shortage of tankers in the coastal trade, and this delayed the usual summer stock build up on the east coast. Concerned with the inability to meet demand re-

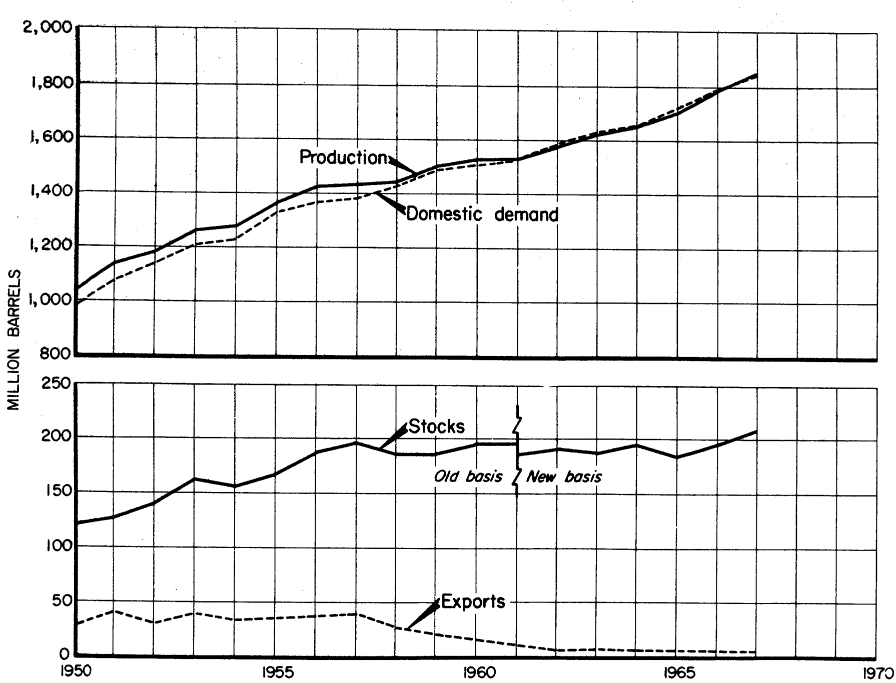

Figure 7.—Production, domestic demand, stocks, and exports of gasoline in the United States.

quirements during the 1967–68 heating season, several New England distributors requested a study of the situation by the Secretary of the Interior. The supply problem eased up during the last quarter when some vessels were returned to the coastal trade and additional pipeline capacity was placed in service. The Oil Imports Appeal Board granted import allocations to some distributors who were unable to obtain supplies from domestic sources. The Secretary of the Interior also took some additional steps to assure an adequate supply of distillate fuel oil. Presidential Proclamation 3794 was amended to include No. 4 distillate fuel oil in the same category as residual fuel, thus eliminating this from the refined products allocations and permitting its importation by license based on sales and contractual commitments. Since No. 4 is a blend of No. 2 distillate and residual fuel oil, this created an additional supply of light domestic distillate for the home heating market. When the proclamation was revised in December to grant an allocation for refined product imports from the Virgin Islands, it specified that for the months of December, January, and February, the shipments will be No. 2 heating oil. Although the 1967–68 heating season was colder than normal, no shortage developed.

RESIDUAL FUEL OIL

The total demand for residual fuel oil increased at the rate of 96,000 barrels daily in 1967 or 5.5 percent. Domestic demand increased 71,000 barrels per day and export demand increased 25,000 barrels daily. The use of residual fuel oil by the electric utilities increased 56,000 barrels daily in 1967. The sharp increase in exports was a result of the Middle East conflict.

The future market for residual fuel oil in the United States hinges on the ability to supply a product that will meet sulfur standards. The Department of Health, Education, and Welfare (HEW) under the Clean Air Act, has issued strict regulations to cut the sulfur oxide emissions from fuels burned in Federal installations. In addition certain States, counties, and cities have passed similar regulations. Those most affected by these regulations are the electric utilities, industrial users, refiners, and commercial users who use residual for heat and power. At the present time very little of the residual fuel oil produced in or imported into this country will meet the specifications which HEW has established as guidelines. New York City regulations call for a 2.2 percent maximum sulfur content for residual fuel oil at the present time, with the limit dropping to 2 percent in May 1969 and 1 percent in May 1971. Crude oil in the Caribbean area is mostly high sulfur content and that is the major source of foreign crude oil and residual fuel oil used or processed in the East Coast district, which is the largest market for residual fuel oil. North African crude oils have a low sulfur content, but this crude oil is also in demand in European countries which have also established air pollution standards. East Coast district refiners are faced with the problem of discontinuing the production of residual fuel oil by installing facilities to further process the oil into light end products or by installing costly facilities to desulfurize the product and still have a fuel oil that can compete in price with natural gas. In the past bituminous coal has also been a competitor of residual fuel oil, however, it too will have problems meeting the sulfur emission regulations.

On the west coast, refiners are faced with a similar problem, especially in the Los Angeles area. There is an abundance of residual fuel oil refined from the heavy crude oils produced in the area, but the majority will not meet the low sulfur standards. Sumatra crude oil imported into the area has a very low sulfur content but it is also in demand in Japan to meet restrictions in that country. As an incentive to produce more low-sulfur residual fuel oil on the west coast, the oil imports regulations were amended on October 4, 1967, to provide an additional allocation of crude oil to refiners in District 5 who produce a low-sulfur residual fuel oil. A similar proposal is under consideration for refiners in Districts 1–4.

JET FUELS

The domestic demand for jet fuels continued to grow at a rapid pace, exceeding the 1966 level by 23.1 percent. The demand for naphtha-type jet increased from 278,000 barrels daily in 1966 to 306,000 barrels daily in 1967, and the kerosine-type jet increased from an average 391,000 barrels daily to 518,000 barrels daily. Naphtha-type jet fuels are used principally by the military while commercial aviation uses the kerosine-type jet fuels. While jet fuel imported for use in the United States is subject to import control regulations, that imported for fuel used by aircraft destined for ports outside the United States is not subject to the regulations. The use of duty-free bonded jet fuel has been expanding rapidly and is now averaging 85,000 barrels daily compared with 58,000 barrels daily in 1966.

LUBRICANTS

The total demand for lubricating oils and greases was 62.8 million barrels in 1967, a decline of 4.9 percent for the year. The export market showed some improvement over 1966, but the domestic demand was down 4.7 million barrels.

LIQUEFIED GASES, ETHANE, AND ETHYLENE

Liquefied gases are derived from two sources. Those produced at refineries are called liquefied refinery gases to distinguish them from liquefied petroleum gases produced from natural gas. The liquefied petroleum gases (LPG) are all saturated (propane, butane, etc.). The liquefied refinery gases (LRG) may contain unsaturated compounds or olefins (propylene, butylene, etc). The olefins are used as feedstocks for chemical plants. The saturated gases may be used as chemical raw material or as fuel. Beginning with 1963, separate data have been collected on LRG 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. Although ethane and ethylene are not defined as liquefied gases, the statistics on these products are in some cases reported with those of LPG and LRG.

The total demand for liquefied gases in 1967, exclusive of that blended into other products at refineries or terminals, was 353.7 million barrels. This includes a domestic demand of 344.4 million barrels and exports of 9.3 million barrels.

More detailed information on liquefied gases may be found in the chapter on natural gas liquids.

ASPHALT AND ROAD OIL

For the first time in several years there was a decline in the demand for asphalt. Sales of asphalt for paving use were 4 percent below the 1966 level. This is attributed to a delay in the release of Federal highway funds to the States, which slowed down the interstate highway building program. Total demand for petroleum asphalt was 23.9 million short tons compared with 24.5 million in 1966. A total of 478,000 short tons of asphalt was added to stocks during 1967. On April 12, 1967, an amendment was made to the Presidential proclamation pertaining to oil import controls which will permit the Secretary of the Interior to relax import controls of finished asphalt in the event a shortage of that material occurs in District 1.

Shipments of road oil were 1.0 million short tons which was slightly below the 1966 level.

OTHER PRODUCTS

Special Naphthas.—This product is used primarily for paint thinners, cleaning agents, and solvents. The total demand for special naphthas in 1967 was 27.2 million barrels.

Waxes.—The production of petroleum wax in 1967 was 5.7 million barrels which was 53,000 barrels below the 1966 production. There was a decline in both the domestic and export market.

Coke.—The production of petroleum coke increased 3.3 percent in 1967 to 18.2 million short tons. This included 8.6 million short tons of marketable coke and 9,598,000 short tons that was burned off the catalytic cracking units and utilized as refinery fuel. Both domestic and export demand continued to increase, especially for petroleum coke with low sulfur content for use in the manufacture of electrodes required in the electrolytic production of aluminum. Total demand in 1967 was 18.3 million short tons, of which 3.3 million tons was exported to foreign countries.

Still Gas.—Refineries used 140,034,000 barrels of still gas as fuel in 1967 and an additional 9.5 million barrels was used as petrochemical feedstocks.

Petrochemical Feedstocks.—The petroleum refineries supplied the petrochemical industry with 86.9 million barrels of feedstocks other than liquefied refinery gases in 1967. This was a 13.6-percent increase over 1966. According to a recent survey by the Oil and Gas Journal, the petrochemical industry is expanding rapidly. This should assure a continuing high growth rate for base feedstocks from petroleum refineries.

Miscellaneous Finished Products.—Refineries and natural gas liquids plants cut back the production of the miscellaneous finished products by 10.6 percent in 1967. Principal cutbacks were in the petrochemical products and specialty oils. The domestic demand for the miscellaneous oils declined 6.6 percent and exports were down 8.7 percent.

Unfinished Oils.—Unfinished oils include all oils that will be cracked or further distilled at refineries. The rerun (net) of unfinished oils represents imports plus or minus the change in stocks.

Imports of unfinished oils are included with crude oil under the quota established by the Oil Import Administration. By regulation imports of unfinished oils are restricted to 15 percent of the crude oil and unfinished oils quota in Districts 1-4 and 25 percent in District 5.

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 petroleum products and exports are compiled by Bureau of the Census.

Total imports of crude oil and refined products in 1967 were 925.8 million barrels, down 13.4 million barrels from 1966. The unusual decline resulted from transportation difficulties caused by the Middle East crisis and the shutdown of the Suez Canal. Importers were unable to bring in approximately 56 million barrels of petroleum for which they held licenses. The Secretary of the Interior extended the expiration date on these unused import licenses for 2 years, permitting part of the unused quota to be used in 1968 and the balance in the following year. Refined products imports were 22 million barrels higher for the year, with residual fuel oil accounting for almost 19 million barrels of the increase and distillate fuel oil the balance. In July the import control program was amended to permit an additional supply of No. 4 distillate fuel oil to be imported into the east coast area. This product can now be imported by license, the same as residual fuel oil. Licenses are issued on the basis of actual sales, bills of sales, and contractual commitments. The purpose of this order was to increase the availability of low-sulfur fuels to abate air pollution. Two other amendments to the proclamation were made in 1967. One would permit the Secretary of the Interior to relax import controls of finished asphalt into District 1 in the event a shortage of that material occurs. The other permits imports of 15,000 barrels daily of refined products from the Virgin Islands into Districts 1-4, a result of which is a desirable accrual of economic benefits to the islands.

While imports declined as a result of the Middle East crisis, exports benefited by a 55-percent increase. Crude petroleum exports increased from 1.5 million barrels in 1966 to 26.5 million in 1967, and refined product exports increased from 70.9 million barrels to 85.4 million barrels. The surge in exports began the middle of June and continued through October when Eastern Canada, Western Europe, and Japan were again able to establish more normal supply patterns.

NATIVE ASPHALT

Bituminous Limestone, Sandstone, and Gilsonite.—To avoid disclosure of individual company data, it is necessary to report a combined production and value for these commodities. Production in 1967 was 1,866,666 short tons, compared with 2,041,271 short tons in 1966. The limestone was produced in Alabama and Texas; the sandstone in Kentucky and Missouri; and the gilsonite in Utah. The value for the year was $8,136,000 compared with $8,438,000 a year ago.

Table 2.—Supply and demand of all oils in the United States, by months

(Thousand barrels)

	1966												
	January	February	March	April	May	June	July	August	September	October	November	December	Total
New supply:													
Domestic production:													
Crude petroleum	249,459	230,733	257,107	248,155	258,677	250,391	255,121	255,812	247,632	258,008	252,825	263,843	3,027,763
Natural gas liquids	38,908	36,030	39,531	38,756	39,369	37,919	38,855	39,299	37,998	40,406	40,005	41,559	468,635
Benzol, etc	1	1	-------	-------	1	2	4	-------	5	5	5	6	30
Total production	288,368	266,764	296,638	286,911	298,047	288,312	293,980	295,111	285,635	298,419	292,835	305,408	3,496,428
Imports: [1]													
Crude petroleum	41,956	34,658	38,765	36,508	37,330	38,959	39,062	41,458	36,004	36,019	34,413	31,988	447,120
Refined products	46,893	44,460	53,058	37,562	37,234	37,366	37,619	39,835	35,176	37,747	39,204	45,888	492,042
Total new supply	377,217	345,882	388,461	360,981	372,611	364,637	370,661	376,404	356,815	372,185	366,452	383,284	4,435,590
Increase (+) or decrease (−) in stocks	−17,642	−24,094	+8,398	+9,926	+29,049	+8,352	+29,068	+13,390	+12,562	+11,594	−11,225	−31,257	+38,121
Demand:													
Total demand	394,859	369,976	380,063	351,055	343,562	356,285	341,593	363,014	344,253	360,591	377,677	414,541	4,397,469
Exports: [2]													
Crude petroleum	135	-------	108	290	1	130	240	186	83	95	88	121	1,477
Refined products	5,099	5,684	6,108	5,748	5,665	6,082	5,733	5,863	7,083	6,093	5,696	6,069	70,923
Domestic demand:													
Gasoline:													
Motor gasoline	129,104	123,440	142,371	144,236	149,633	161,764	156,221	161,580	146,931	147,680	144,533	147,439	1,754,932
Aviation gasoline	3,424	2,462	3,119	3,130	3,843	3,627	3,612	2,959	2,847	3,181	3,494	2,751	38,449
Total	132,528	125,902	145,490	147,366	153,476	165,391	159,833	164,539	149,778	150,861	148,027	150,190	1,793,381
Special naphthas	2,732	2,267	2,881	2,422	2,851	2,607	2,353	2,568	2,623	2,447	2,375	2,135	30,261
Kerosine	14,122	12,079	8,659	6,108	5,851	4,875	4,562	5,873	7,460	7,854	10,660	13,013	101,116
Distillate fuel oil	96,112	88,395	76,486	63,330	53,228	48,503	43,434	51,331	50,395	58,586	74,664	92,916	797,380
Residual fuel oil	65,880	64,660	65,895	49,121	43,216	44,398	43,003	45,232	41,914	47,285	52,945	62,881	626,430

Jet fuel:													
Naphtha type	7,404	6,372	7,791	8,712	8,900	8,061	8,730	9,996	8,961	9,184	8,888	8,636	101,635
Kerosine type	11,271	11,224	12,133	12,768	11,450	12,638	9,012	9,473	12,091	13,687	12,660	14,344	142,751
Total	18,675	17,596	19,924	21,480	20,350	20,699	17,742	19,469	21,052	22,871	21,548	22,980	244,386
Lubricants	4,058	3,590	4,587	4,408	4,399	4,228	4,133	4,338	3,968	4,266	3,484	3,490	48,949
Wax	347	302	403	356	363	342	287	318	277	298	335	290	3,918
Coke	6,504	6,003	6,225	5,772	6,092	5,802	6,098	6,372	5,725	6,008	6,470	6,609	73,680
Asphalt	3,629	3,458	6,135	8,107	12,107	17,192	17,534	19,556	16,499	15,830	9,216	4,807	134,070
Road oil	63	53	142	295	604	1,122	1,404	1,472	875	525	229	128	6,912
Still gas	11,179	10,453	10,060	11,143	11,412	11,577	12,296	11,990	11,609	11,022	11,111	11,607	135,459
Liquefied gases (including ethane):													
LRG [3] for fuel use	6,133	5,205	5,183	4,778	4,765	4,645	4,553	5,009	4,547	4,580	4,854	5,524	59,776
LRG for chemical use	4,389	3,803	3,985	4,303	4,455	3,526	3,802	3,961	3,605	3,473	3,863	3,606	46,771
LPG [4] for fuel and chemical use	24,250	21,508	18,035	14,894	13,720	13,409	13,313	14,511	15,963	19,085	22,505	26,196	217,389
Total	34,772	30,516	27,203	23,975	22,940	21,580	21,668	23,481	24,115	27,138	31,222	35,326	323,936
Petrochemical feedstocks: [5]													
Still gas	742	648	927	941	774	813	739	894	864	951	824	951	10,068
Naphtha-400°	2,720	2,159	2,613	3,660	2,865	3,411	3,686	3,779	3,496	3,794	3,667	4,004	39,854
Other	2,118	1,541	2,082	1,689	2,070	2,124	1,893	2,134	2,105	1,825	1,961	2,332	23,874
Total	5,580	4,348	5,622	6,290	5,709	6,348	6,318	6,807	6,465	6,570	6,452	7,287	73,796
Miscellaneous products	1,349	1,125	1,436	1,532	1,313	1,607	1,404	1,603	1,425	1,273	1,495	1,560	17,122
Total domestic product demand	397,530	370,747	381,148	351,705	343,911	356,271	342,069	364,949	344,180	362,834	380,233	415,219	4,410,796
Crude losses	321	292	315	302	320	316	330	328	320	325	311	328	3,808
Less net processing gain	8,226	6,747	7,616	6,990	6,335	6,514	6,779	8,312	7,413	8,756	8,651	7,196	89,535
Total domestic demand	389,625	364,292	373,847	345,017	337,896	350,073	335,620	356,965	337,087	354,403	371,893	408,351	4,325,069
Stocks:													
Crude petroleum	220,302	223,422	233,224	245,232	250,418	253,388	246,877	245,347	238,198	236,092	241,692	238,391	238,391
Natural gas liquids	28,854	24,744	26,432	30,565	36,400	41,422	46,334	50,631	52,389	52,203	47,903	40,423	40,423
Refined products	569,546	546,442	543,350	537,135	555,163	555,523	586,190	596,813	614,766	628,652	616,127	595,651	595,651
Total	818,702	794,608	803,006	812,932	841,981	850,333	879,401	892,791	905,353	916,947	905,722	874,465	874,465

See footnotes at end of table.

Table 2.—Supply and demand of all oils in the United States, by months—Continued

(Thousand barrels)

	1967 p												
	January	February	March	April	May	June	July	August	September	October	November	December	Total
New supply:													
Domestic production:													
Crude petroleum	265,577	241,366	264,854	254,252	259,923	256,174	283,776	292,495	272,845	278,997	269,348	276,135	3,215,742
Natural gas liquids	43,457	39,309	43,147	42,544	43,259	41,455	42,655	43,249	41,556	44,673	44,015	45,137	514,456
Benzol, etc	8	7	7	6	7	7	11	6	6	7	8	7	87
Total production	309,042	280,682	308,008	296,802	303,189	297,636	326,442	335,750	314,407	323,677	313,371	321,279	3,730,285
Imports: [1]													
Crude petroleum	41,107	29,220	37,585	38,219	39,880	33,640	30,092	31,458	31,458	31,890	29,622	37,478	411,649
Refined products	55,333	46,587	52,029	46,353	40,450	37,012	31,943	35,349	32,736	46,546	40,435	49,384	514,157
Total new supply	405,482	356,489	397,622	381,374	383,519	368,288	388,477	402,557	378,601	402,113	383,428	408,141	4,656,091
Increase (+) or decrease (−) in stocks	+1,422	−18,412	−12,826	+33,404	+12,478	+5,028	+20,981	+18,747	+23,358	+11,551	−23,292	−8,490	+63,949
Demand:													
Total demand	404,060	374,901	410,448	347,970	371,041	363,260	367,496	383,810	355,243	390,562	406,720	416,631	4,592,142
Exports: [2]													
Crude petroleum	27	-------	87	251	-------	1,830	8,526	8,188	5,994	1,421	124	54	26,502
Refined products	5,669	6,587	6,341	6,839	6,930	6,952	7,700	8,110	8,389	7,576	8,372	5,949	85,414
Domestic demand:													
Gasoline:													
Motor gasoline	134,710	126,273	148,941	143,166	157,901	162,528	160,005	168,059	150,020	157,649	151,998	148,539	1,809,789
Aviation gasoline	2,561	2,641	3,224	2,504	3,199	3,000	2,723	2,986	2,538	2,942	2,543	2,024	32,885
Total	137,271	128,914	152,165	145,670	161,100	165,528	162,728	171,045	152,558	160,591	154,541	150,563	1,842,674
Special naphthas	1,988	2,032	2,343	2,061	2,237	2,150	1,877	2,265	2,019	2,336	2,155	1,741	25,204
Kerosine	13,574	12,397	9,573	5,702	6,171	4,274	5,461	6,101	7,141	7,704	10,544	11,436	100,078
Distillate fuel oil	92,546	89,128	90,224	58,265	60,446	49,248	48,580	47,279	47,743	60,268	80,347	92,674	816,748
Residual fuel oil	70,480	62,811	67,669	52,680	49,753	45,505	41,529	44,363	40,794	56,216	56,801	63,525	652,126

Jet fuel:													
Naphtha type	7,753	7,224	8,820	9,568	8,695	9,483	10,042	9,730	11,040	9,975	10,356	8,862	111,548
Kerosine type	13,554	13,040	15,026	14,758	15,936	16,075	17,150	16,589	14,915	18,369	15,989	17,821	189,222
Total	21,307	20,264	23,846	24,326	24,631	25,558	27,192	26,319	25,955	28,344	26,345	26,683	300,770
Lubricants	3,814	3,012	3,883	3,585	3,840	4,142	3,440	4,012	3,943	3,483	3,628	3,470	44,252
Wax	316	291	329	341	309	322	292	344	346	344	366	267	3,867
Coke	6,706	5,227	7,161	5,711	6,377	5,886	6,220	6,650	6,059	6,188	6,286	6,659	75,130
Asphalt	4,721	3,106	5,926	7,789	11,920	15,518	16,316	20,327	16,733	15,035	9,348	4,424	131,163
Road oil	101	168	170	178	636	968	1,381	1,465	833	704	335	154	7,093
Still gas	11,241	10,004	10,941	10,551	12,485	12,646	12,550	12,547	12,192	12,249	11,307	11,321	140,034
Liquefied gases (including ethane):													
LRG [3] for fuel use	5,796	5,172	5,759	5,192	5,414	5,507	5,695	5,544	5,484	4,901	5,531	5,983	65,978
LRG for chemical use	3,887	3,263	3,972	4,084	3,717	3,796	3,477	3,242	3,648	3,378	3,480	4,006	43,950
LPG [4] for fuel and chemical use	25,813	22,491	20,253	14,803	15,174	14,293	15,072	16,188	16,659	20,845	26,259	26,656	234,506
Total	35,496	30,926	29,984	24,079	24,305	23,596	24,244	24,974	25,791	29,124	35,270	36,645	344,434
Petrochemical feedstocks: [5]													
Still gas	896	690	836	705	659	643	751	843	819	931	868	891	9,532
Naphtha-400°	4,135	3,592	4,469	3,762	3,842	4,261	3,758	4,033	3,830	5,011	4,754	4,902	50,349
Other	1,959	1,923	1,974	1,941	2,097	1,769	2,125	1,957	2,485	1,894	1,933	1,997	24,054
Total	6,990	6,205	7,279	6,408	6,598	6,673	6,634	6,833	7,134	7,836	7,555	7,790	83,935
Miscellaneous products	1,591	1,252	1,340	1,237	1,513	1,285	1,266	1,232	1,218	1,306	1,535	1,220	15,995
Total domestic product demand	408,142	375,737	412,833	348,583	372,321	363,299	359,710	375,756	350,459	391,728	406,363	418,572	4,583,503
Crude losses	311	179	247	298	326	278	251	305	250	282	300	288	3,315
Less net processing gain	10,089	7,602	9,060	8,001	8,536	9,099	8,691	8,549	9,849	10,445	8,439	8,232	106,592
Total domestic demand	398,364	368,314	404,020	340,880	364,111	354,478	351,270	367,512	340,860	381,565	398,224	410,628	4,480,226
Stocks:													
Crude petroleum	250,646	252,388	258,106	266,755	268,845	261,615	256,242	261,566	257,286	255,114	254,185	248,970	248,970
Natural gas liquids	35,613	33,326	35,757	44,345	52,721	59,338	66,011	71,715	75,873	76,275	70,435	65,742	65,742
Refined products	589,628	571,761	550,786	566,953	568,965	574,606	594,287	602,006	625,486	638,807	622,284	623,702	623,702
Total	875,887	857,475	844,649	878,053	890,531	895,559	916,540	935,287	958,645	970,196	946,904	938,414	938,414

p Preliminary.
[1] Bureau of Mines data for crude oil and unfinished oils, U.S. Department of Commerce data for all other imports.
[2] U.S. Department of Commerce data.
[3] Liquefied refinery gas.
[4] Liquefied petroleum gas.
[5] Produced at petroleum refineries. Data for LRG for petrochemical feedstocks are included with those for "Liquefied gases".

Table 3.—Estimates of proved crude-oil reserves in the United States on December 31, by States [1]

(Million barrels)

State	1963	1964	1965	1966	1967
Eastern States:					
Illinois	417	391	371	362	336
Indiana	63	61	57	48	47
Kentucky	100	118	108	101	94
Michigan	69	58	53	71	63
New York	18	14	12	10	15
Ohio	88	100	101	101	114
Pennsylvania	92	87	77	73	63
West Virginia	57	59	55	57	56
Total	904	888	834	823	788
Central and Southern States:					
Alabama	45	50	66	85	79
Arkansas	225	205	201	181	176
Kansas	841	797	752	726	625
Louisiana [2]	5,089	5,162	5,246	5,408	5,456
Mississippi	385	357	360	374	357
Nebraska	84	71	71	57	63
New Mexico	1,011	957	895	1,025	926
North Dakota	389	377	395	321	290
Oklahoma	1,628	1,586	1,517	1,518	1,459
Texas [2]	14,573	14,300	14,303	14,077	14,494
Total	24,270	23,862	23,806	23,772	23,925
Mountain States:					
Colorado	368	346	327	344	340
Montana	271	252	274	282	308
Utah	220	219	197	213	201
Wyoming	1,254	1,204	1,169	1,073	1,044
Total	2,113	2,021	1,967	1,912	1,893
Pacific Coast States:					
Alaska	([3])	83	160	322	381
California [2]	3,600	4,125	4,567	4,608	4,369
Total [1]	3,600	4,208	4,727	4,930	4,750
Other States [4]	83	12	18	15	21
Total United States	30,970	30,991	31,352	31,452	31,377

[1] From reports of Committee of Petroleum Reserves, American Petroleum Institute. Includes crude oil that may be extracted by present methods from fields completely developed or sufficiently explored to permit reasonably accurate calculations. The change in reserves during any year represents total new discoveries, extensions, and revisions, minus production.

[2] Includes offshore reserves; the December 31, 1967 total for Louisiana and Texas was 2,375.

[3] Included with "Other States."

[4] Includes Alabama, Alaska 1963 only, Arizona, Florida, Missouri, Nevada, South Dakota, Tennessee, and Virginia.

Table 4.—Supply and demand for crude petroleum in the United States

(Thousand barrels)

	1963	1964	1965	1966	1967 p
Production	2,752,723	2,786,822	2,848,514	3,027,763	3,215,742
Imports [1]	412,660	438,643	452,040	447,120	411,649
Total new supply	3,165,383	3,225,465	3,300,554	3,474,883	3,627,391
Increase (+) or decrease (−) in stocks, end of year	−14,650	−7,304	−9,768	+18,102	+10,579
Demand:					
Domestic crude	2,767,129	2,795,130	2,856,918	3,009,900	3,207,943
Foreign crude	412,904	437,639	453,404	446,881	408,869
Total demand	3,180,033	3,232,769	3,310,322	3,456,781	3,616,812
Runs to stills:					
Domestic	2,758,168	2,785,895	2,847,821	3,000,789	3,174,004
Foreign	412,484	437,434	453,021	446,404	408,590
Exports [2]	1,698	1,363	1,097	1,477	26,502
Transfer to fuel oil:					
Distillate	807	755	773	752	730
Residual	3,305	3,720	3,950	3,551	3,671
Other fuel losses	3,571	3,602	3,660	3,808	3,315
Total demand	3,180,033	3,232,769	3,310,322	3,456,781	3,616,812

p Preliminary.
[1] Bureau of Mines data.
[2] U.S. Department of Commerce data.

Table 5.—Supply of and demand for crude petroleum in the United States, by months

(Thousand barrels)

	January	February	March	April	May	June	July	August	September	October	November	December	Total
1966:													
Supply:													
Production	249,459	230,733	257,107	248,155	258,677	250,391	255,121	255,812	247,632	258,008	252,825	263,843	3,027,763
Imports [1]	41,956	34,658	38,765	36,508	37,330	38,959	39,062	41,458	36,004	36,019	34,413	31,988	447,120
Total new supply	291,415	265,391	295,872	284,663	296,007	289,350	294,183	297,270	283,636	294,027	287,238	295,831	3,474,883
Change in stocks, end of period:													
Domestic	−2,670	+2,497	+9,318	+9,954	+6,272	+1,672	−5,592	−3,962	−6,588	−66	+6,943	+85	+17,863
Foreign	+2,683	+623	+484	+2,054	−1,086	+1,298	−919	+2,432	−561	−2,040	−1,343	−3,386	+239
Demand:													
Domestic	252,129	228,236	247,789	238,201	252,405	248,719	260,713	259,774	254,220	258,074	245,882	263,758	3,009,900
Foreign	39,273	34,035	38,281	34,454	38,416	37,661	39,981	39,026	36,565	38,059	35,756	35,374	446,881
Runs to stills:													
Domestic	251,325	227,527	247,109	237,265	251,691	247,917	259,783	258,902	253,711	257,350	245,183	263,026	3,000,789
Foreign	39,293	34,104	38,163	34,444	38,429	37,648	39,986	39,003	36,361	38,031	35,705	35,237	446,404
Exports [2]	135	-------	108	290	1	130	240	186	83	95	88	121	1,477
Transfers:													
Distillate	62	60	66	62	59	64	63	65	62	60	65	64	752
Residual	266	288	309	292	321	305	292	316	248	272	286	356	3,551
Losses	321	292	315	302	320	316	330	328	320	325	311	328	3,808
1967: p													
Supply:													
Production	265,577	241,366	264,854	254,252	259,923	256,174	283,776	292,495	272,845	278,997	269,348	276,135	3,215,742
Imports [1]	41,107	29,220	37,585	38,219	39,880	33,640	30,092	31,458	31,458	31,890	29,622	37,478	411,649
Total new supply	306,684	270,586	302,439	292,471	299,803	289,814	313,868	323,953	304,303	310,887	298,970	313,613	3,627,391
Change in stocks, end of period:													
Domestic	+9,801	+1,745	+3,484	+7,282	−537	−4,202	−1,278	+6,318	−5,778	−1,919	+811	−7,928	+7,799
Foreign	+2,454	−3	+2,234	+1,367	+2,627	−3,028	−4,095	−994	+1,498	−253	−1,740	+2,713	+2,780
Demand:													
Domestic	255,776	239,621	261,370	246,970	260,460	260,376	285,054	286,177	278,623	280,916	268,537	284,063	3,207,943
Foreign	38,653	29,223	35,351	36,852	37,253	36,668	34,187	32,452	29,960	32,143	31,362	34,765	408,869
Runs to stills:													
Domestic	255,130	239,192	260,742	246,025	259,873	257,899	275,874	277,278	272,054	278,822	267,711	283,404	3,174,004
Foreign	38,642	29,185	35,319	36,840	37,220	36,682	34,154	32,465	29,903	32,114	31,369	34,697	408,590
Exports [2]	27	-------	87	251	-------	1,830	8,526	8,188	5,994	1,421	124	54	26,502
Transfers:													
Distillate	63	57	66	58	61	60	63	64	60	61	60	57	730
Residual	256	231	260	350	233	295	373	329	322	359	335	328	3,671
Losses	311	179	247	298	326	278	251	305	250	282	300	288	3,315

p Preliminary.
[1] Bureau of Mines data.
[2] U.S. Department of Commerce.

Table 6.—Production of crude petroleum in the United States, by States and months [1]

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1966:													
Alabama	729	652	723	666	687	644	679	671	654	668	638	619	8,030
Alaska	993	955	972	919	1,146	1,068	1,220	1,306	1,231	1,444	1,508	1,596	14,358
Arkansas	1,874	1,921	2,051	2,075	2,096	2,001	2,028	2,014	1,932	1,973	1,901	1,958	23,824
California, total	28,044	25,748	28,889	28,126	29,404	28,312	29,397	29,669	28,739	29,997	29,236	29,734	345,295
Coastal Region	5,629	5,256	5,985	5,712	5,968	5,599	5,930	6,021	5,791	5,967	5,860	5,756	69,474
Los Angeles	9,805	9,008	10,208	9,950	10,472	10,095	10,617	10,717	10,507	11,029	10,604	11,015	124,027
San Joaquin Valley Region	12,610	11,484	12,696	12,464	12,964	12,618	12,850	12,931	12,441	13,001	12,772	12,963	151,794
Colorado	2,834	2,560	2,902	2,768	2,814	2,758	2,823	2,825	2,716	2,875	2,782	2,835	33,492
Florida	176	161	171	160	153	147	148	144	131	137	132	139	1,799
Illinois	5,131	4,584	5,369	5,034	5,265	5,090	5,154	5,360	5,106	5,273	5,101	5,194	61,661
Indiana	854	762	993	948	926	964	908	681	839	950	907	885	10,617
Kansas	8,560	8,022	9,016	8,696	8,928	8,671	8,726	8,910	8,622	8,717	8,586	8,284	103,738
Kentucky	1,595	1,419	1,668	1,500	1,564	1,511	1,507	1,550	1,455	1,476	1,409	1,412	18,066
Louisiana, total	55,418	51,563	56,454	54,570	56,911	55,412	56,681	56,924	55,276	57,441	57,412	60,256	674,318
Gulf Coast	50,737	47,284	51,720	50,117	52,413	51,028	52,153	52,387	50,868	52,932	52,919	55,543	620,101
Rest of State	4,681	4,279	4,734	4,453	4,498	4,384	4,528	4,537	4,408	4,509	4,493	4,713	54,217
Michigan	1,197	1,124	1,212	1,207	1,226	1,191	1,175	1,221	1,162	1,206	1,147	1,205	14,273
Mississippi	4,851	4,140	4,697	4,546	4,661	4,528	4,685	4,740	4,367	4,677	4,549	4,786	55,227
Montana	2,908	2,728	2,981	2,969	3,053	2,927	3,017	3,024	2,912	2,941	2,870	3,050	35,380
Nebraska	1,260	1,127	1,205	1,162	1,179	1,123	1,143	1,164	1,131	1,136	1,091	1,129	13,850
New Mexico, total	10,363	9,589	10,531	10,227	10,504	10,109	10,306	10,298	10,112	10,584	10,590	10,941	124,154
Southeastern	9,268	8,621	9,531	9,306	9,567	9,221	9,383	9,364	9,218	9,665	9,680	9,974	112,798
Northwestern	1,095	968	1,000	921	937	888	923	934	894	919	910	967	11,356
New York	125	121	140	143	155	155	144	158	150	151	146	147	1,735
North Dakota	2,340	2,192	2,415	2,170	2,218	2,211	2,279	2,283	2,199	2,378	2,166	2,275	27,126
Ohio	961	898	1,025	950	948	978	884	907	872	822	830	824	10,899
Oklahoma	18,178	16,987	19,290	18,484	19,374	18,754	19,039	18,863	18,218	19,088	18,618	19,946	224,839
Pennsylvania	320	324	376	348	370	381	369	386	371	373	361	358	4,337
Texas, total	87,457	80,192	90,287	87,067	91,255	88,133	89,143	88,770	85,779	89,710	87,631	92,282	1,057,706
Gulf Coast	16,296	14,816	16,633	16,331	17,097	16,363	16,616	16,426	15,957	16,819	16,123	17,216	196,693
West Texas	41,031	37,638	42,022	40,746	42,560	41,307	41,664	41,526	39,902	41,906	40,554	42,805	493,661
East Texas field	3,742	3,409	3,802	3,696	3,922	3,759	3,780	3,746	3,654	3,807	3,749	4,042	45,108
Panhandle	2,863	2,640	3,020	2,853	3,003	2,897	2,939	2,937	2,850	2,949	2,952	3,062	34,965
Rest of State	23,525	21,689	24,810	23,441	24,673	23,807	24,144	24,135	23,416	24,229	24,253	25,157	287,279
Utah	2,063	1,813	1,902	1,935	2,007	1,950	2,036	2,107	2,078	2,126	2,017	2,078	24,112
West Virginia	247	251	315	289	304	265	325	330	336	334	339	339	3,674
Wyoming	10,928	10,854	11,461	11,118	11,444	11,056	11,233	11,444	11,173	11,465	10,793	11,501	134,470
Other states	53	46	62	78	85	52	72	63	71	66	65	70	[2] 783
Total:													
1966	249,459	230,733	257,107	248,155	258,677	250,391	255,121	255,812	247,632	258,008	252,825	263,843	3,027,763
1965	240,946	218,612	243,763	236,844	238,253	232,440	237,606	240,180	222,529	244,122	239,685	253,584	2,848,514
Daily average, 1966	8,047	8,240	8,294	8,272	8,344	8,346	8,230	8,252	8,254	8,323	8,427	8,511	8,295
Pennsylvania grade (included above)	827	829	999	938	985	1,006	1,013	1,068	1,054	1,043	1,043	1,033	11,838

See footnotes at end of table.

Table 6.—Production of crude petroleum in the United States, by States and months [1]—Continued

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1967:													
Alabama	646	569	626	615	614	593	611	613	610	609	607	635	7,348
Alaska	1,645	1,538	1,606	1,568	1,890	2,076	2,230	2,381	2,743	3,448	4,016	3,985	29,126
Arkansas	1,902	1,712	1,865	1,770	1,813	1,718	1,757	1,754	1,690	1,744	1,651	1,699	21,075
California, total	29,548	26,840	29,973	29,237	30,295	29,361	30,412	30,548	29,821	31,294	30,315	31,575	359,219
Coastal Region	5,853	5,213	5,937	5,781	5,983	5,799	6,059	5,914	5,763	5,920	5,740	5,778	69,740
Los Angeles	10,897	9,988	11,227	10,923	11,401	11,199	11,604	11,952	11,731	12,480	12,187	12,982	138,571
San Joaquin Valley Region	12,798	11,639	12,809	12,533	12,911	12,363	12,749	12,682	12,327	12,894	12,388	12,815	150,908
Colorado	2,866	2,621	2,903	2,849	2,975	2,814	2,915	2,915	2,778	2,941	2,415	2,913	33,905
Florida	146	129	142	137	137	135	137	130	123	126	116	110	1,568
Illinois	5,287	4,429	5,222	4,935	5,188	4,957	4,883	5,014	4,786	4,964	4,808	4,669	59,142
Indiana	929	798	879	853	868	831	864	843	796	835	806	779	10,081
Kansas	8,595	7,782	8,675	8,137	8,557	8,218	8,283	8,463	8,061	8,288	8,082	8,059	99,200
Kentucky	1,401	1,198	1,358	1,267	1,352	1,290	1,281	1,311	1,247	1,317	1,277	1,236	15,535
Louisiana, total	62,429	57,393	61,759	59,658	60,626	61,212	70,508	73,085	65,897	67,445	66,279	68,236	774,527
Gulf Coast	57,513	53,029	57,184	55,058	55,954	56,707	66,102	68,263	61,277	62,828	61,821	63,754	719,490
Rest of State	4,916	4,364	4,575	4,600	4,672	4,505	4,406	4,822	4,620	4,617	4,458	4,482	55,037
Michigan	1,154	1,076	1,184	1,115	1,182	1,120	1,140	1,179	1,120	1,154	1,119	1,121	13,664
Mississippi	4,660	4,295	4,816	4,631	4,762	4,675	4,916	4,920	4,803	4,968	4,813	4,888	57,147
Montana	2,823	2,603	2,844	2,693	2,783	2,751	2,858	2,916	2,941	3,066	3,212	3,469	34,959
Nebraska	1,114	1,003	1,109	1,091	1,141	1,083	1,133	1,140	1,120	1,166	1,125	1,148	13,373
New Mexico, total	10,913	9,992	10,866	10,358	10,540	10,039	10,274	10,723	10,616	10,796	10,447	10,580	126,144
Southeastern	9,884	9,068	9,863	9,366	9,580	9,148	9,398	9,842	9,775	9,927	9,551	9,656	115,058
Northwestern	1,029	924	1,003	992	960	891	876	881	841	869	896	924	11,086
New York	155	146	175	167	182	172	176	172	161	162	150	154	1,972
North Dakota	2,235	2,000	2,239	2,146	1,673	1,952	2,201	2,158	2,147	2,229	2,138	2,197	25,315
Ohio	843	723	857	797	829	807	792	903	833	870	823	847	9,924
Oklahoma	20,038	18,267	20,115	18,988	19,385	18,596	19,508	19,604	18,902	19,468	18,835	19,043	230,749
Pennsylvania	372	327	375	365	399	397	373	395	360	378	329	317	4,387
Texas, total	93,106	83,372	90,891	86,750	88,151	87,256	102,215	107,200	96,693	97,570	92,318	94,440	1,119,962
Gulf Coast	17,225	15,357	16,812	16,036	16,241	16,233	20,266	21,522	19,014	18,901	17,726	20,483	215,816
West Texas	43,323	38,910	42,405	40,568	41,121	40,658	46,904	49,223	45,305	45,513	43,155	43,909	520,994
East Texas Field	4,404	3,899	4,045	3,835	3,864	3,922	4,992	5,401	4,657	4,446	4,147	4,303	51,915
Panhandle	2,996	2,674	2,977	2,849	2,890	2,797	2,949	2,998	2,870	2,944	2,823	2,940	34,707
Rest of State	25,158	22,532	24,652	23,462	24,035	23,646	27,104	28,056	24,847	25,766	24,467	22,805	296,530
Utah	2,046	1,910	2,104	2,056	2,097	2,062	1,775	2,043	1,983	2,048	1,989	1,935	24,048
West Virginia	347	293	306	303	227	362	296	312	265	316	254	280	3,561
Wyoming	10,311	10,282	11,843	11,547	11,926	11,362	11,866	11,303	11,948	11,407	11,055	11,462	136,312
Other States	66	68	122	219	331	335	372	470	401	388	369	358	[3] 3,499
Total:													
1967	265,577	241,366	264,854	254,252	259,923	256,174	283,776	292,495	272,845	278,997	269,348	276,135	3,215,742
1966	249,459	230,733	257,107	248,155	258,677	250,391	255,121	255,812	247,632	258,008	252,825	263,843	3,027,763
Daily average, 1967	8,567	8,620	8,544	8,475	8,385	8,539	9,154	9,435	9,095	9,000	8,978	8,908	8,810
Pennsylvania grade (included) above)	1,075	938	1,061	1,032	1,006	1,137	1,054	1,095	989	1,058	908	942	12,295

[1] Includes field condensate.
[2] Includes Arizona (132), Missouri (97), Nevada (307), South Dakota (239), Tennesse (7), and Virginia (1).
[3] Includes Arizona (2,924), Missouri (75), Nevada (279), South Dakota (211), Tennesse (7), and Virginia (3).

Sources:

Alabama —State Oil and Gas Board of Alabama.
Alaska —Division of Mines and Minerals, 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 —The Oil and Gas Conservation Commission of the State of Colorado.
Florida —Division of Geology, Florida Board of Conservation.
Indiana —Petroleum Section, Indiana Geological Survey.
Kansas —Kansas Corporation Commission.
Kentucky —Kentucky Geological Survey.
Louisiana —Louisiana Department of Conservation.
Michigan —Geological Survey Division, Department of Conservation, State of Michigan
Mississippi—Mississippi State Oil and Gas Board.
Missouri —Missouri Division of Geological Survey and Water Resources.
Montana —Montana Oil and Gas Conservation Commission.
Nebraska —Nebraska Oil and Gas Conservation Commission.
Nevada —Nevada Oil and Gas Commission.
New Mexico —New Mexico Oil Conservation Commission.
New York —Geological Survey, New York State Museum and Science Service.
North Dakota—State Geological Survey of North Dakota.
Ohio —Division of Oil and Gas, Ohio Department of Natural Resources.
Pennsylvania —Pennsylvania Geological Survey, Department of Internal Affairs.
South Dakota—South Dakota State Geological Survey.
Tennesse —Department of Conservation, State of Tennessee.
Texas —The Railroad Commission of Texas.
Utah —Utah Oil and Gas Conservation Commission.
Virginia —Division of Mines and Quarries, Virginia Department of Labor and Industry.
West Virginia—West Virginia Geological and Economic Survey.
Wyoming —Wyoming State Board of Equalization, Ad Valorem Tax Division and the Wyoming Oil and Gas Conservation Commission.

Table 7.—Percentage of total crude petroleum produced in the United States, by States

State	1963	1964	1965	1966	1967
Texas	35.5	35.5	35.1	34.9	34.8
Louisiana	18.7	19.7	20.9	22.3	24.1
California	10.9	10.8	11.1	11.4	11.2
Oklahoma	7.3	7.3	7.1	7.4	7.2
Wyoming	5.2	5.0	4.9	4.4	4.2
New Mexico	4.0	4.1	4.1	4.1	3.9
Kansas	4.0	3.8	3.7	3.4	3.1
Illinois	2.7	2.5	2.3	2.0	1.8
Mississippi	2.1	2.0	1.9	1.8	1.8
Montana	1.1	1.1	1.2	1.2	1.1
Colorado	1.4	1.2	1.2	1.1	1.1
Alaska	.4	.4	.4	.5	.9
North Dakota	.9	.9	.9	.9	.8
Utah	1.2	1.0	.9	.8	.7
Arkansas	1.0	1.0	.9	.8	.7
Kentucky	.7	.7	.7	.6	.5
Michigan	.6	.6	.5	.5	.4
Nebraska	.8	.7	.6	.5	.4
Other States	1.5	1.7	1.6	1.4	1.3
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	1966	1967	Total since discovery [2]	Estimated reserves
Wilmington	California	47,116	58,652	1,156,485	1,443,603
East Texas	Texas	45,988	48,460	3,760,209	1,349,791
Kelly-Snyder	do	22,011	37,075	409,424	778,876
Caillou-Island	Louisiana	26,521	33,040	322,856	177,144
Timbalier Bay	do	23,775	33,033	192,220	107,780
Sho-Vel-Tum	Oklahoma	30,712	32,232	775,067	126,056
Bay Marchand, Block 2	Louisiana	27,211	30,908	214,442	386,094
Midway-Sunset	California	25,952	29,258	990,899	192,640
Seeligson (All fields)	Texas	25,211	29,015	317,264	141,314
Wasson	do	13,170	28,299	472,128	177,872
Sprayberry Trend	do	19,867	27,810	251,921	28,223
Goldsmith	do	13,608	25,915	412,117	80,000
Slaughter	do	13,461	24,471	361,436	78,564
West Delta Block 30	Louisiana	20,556	23,744	145,390	254,610
Kern River	California	19,625	23,677	450,948	168,755
South Pass, Block 24	Louisiana	22,163	23,568	279,593	470,407
South Pass, Block 27	do	20,179	22,955	134,300	176,700
Panhandle	Texas	22,976	21,337	1,179,651	467,333
Huntington Beach	California	22,107	20,711	792,802	143,113
Elk Basin	Montana, Wyoming	19,889	19,800	328,141	71,859
San Ardo	California	17,529	18,329	193,220	108,036
Hawkins	Texas	10,788	17,637	340,345	185,606
Sooner-Trend (Dover-Hennessey)	Oklahoma	11,496	16,753	67,892	32,751
Rangeley	Colorado	16,182	16,579	409,509	190,491
Lake Barre	Louisiana	15,049	16,228	119,986	130,014
Tom O'Connor	Texas	10,295	16,183	321,064	129,609
West Ranch	do	7,667	15,320	201,746	77,071
Hastings, East and West	do	9,918	15,062	380,136	119,864
Vacuum	New Mexico	13,812	14,879	160,442	124,558
Salt Creek	Wyoming	12,916	14,689	456,274	53,726
Ward-Estes N	Texas	16,917	14,408	239,112	67,888
Grand Isle Block 16	Louisiana	12,963	14,212	80,136	94,864
Borregos	do	7,355	13,558	76,357	74,643
Garden Island Bay	Louisiana	8,772	13,541	77,657	42,343
West Delta Block 73	do	10,689	13,249	31,829	68,171
South Timbalier Block 135	do	9,310	13,114	39,058	60,942
Main Pass Block 41	do	8,486	13,111	27,237	72,763
Swanson River	Alaska	10,406	12,985	74,956	125,044
Golden Trend	Oklahoma	13,440	12,952	323,252	171,748
Main Pass, Block 69	Louisiana	11,807	12,832	115,794	184,206
West Bay	do	10,692	12,587	112,135	97,865
Sand Hills	Texas	8,766	12,579	145,134	51,866
Lake Washington	Louisiana	10,203	12,371	139,187	162,576

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	1966	1967	Total since discovery [2]	Estimated reserves
Headlee and North	Texas	13,484	12,307	78,839	122,813
McElroy	do	8,843	12,239	250,878	99,122
Cowden (and Foster and Johnson)	do	8,380	12,188	237,479	82,521
Pegasus	do	8,021	12,131	96,269	40,731
Means and North	do	5,692	11,396	98,436	31,564
Webster	do	6,830	11,217	301,440	148,560
Midland Farms (all)	do	9,187	11,182	136,873	74,946
Levelland	do	7,611	11,104	166,188	84,508
Diamond M	do	6,463	10,999	147,295	347,705
Conroe	do	6,632	10,709	440,700	163,864
Oregon Basin	Wyoming	8,712	10,628	150,558	46,442
Keystone	Texas	7,819	10,518	225,580	77,420
Cogdell Area	do	6,070	10,279	113,563	43,300
Fullerton (all)	do	6,928	10,273	196,720	78,280
Cowden, North	do	7,271	10,268	208,193	51,807
La Fitte	Louisiana	7,642	10,203	143,865	76,134
Grand Isle, Block 43	do	6,645	10,124	24,845	75,155
Old Illinois	Illinois	10,476	9,958	642,952	32,048
Coalinga, East and West	California	9,470	9,895	577,849	72,244
Aneth	Utah	10,280	9,803	203,257	248,743
Thompson (all)	Texas	6,445	9,786	284,459	60,541
Bayou Sale	Louisiana	9,325	9,767	122,434	77,576
Katy, North	Texas	9,251	9,048	30,555	50,952
Ventura	California	13,215	9,023	723,695	87,926
Bay St. Elaine	Louisiana	7,447	9,023	95,545	57,455
Howard Glasscock	Texas	7,696	8,833	249,313	34,017
Burbank	Oklahoma	10,655	8,795	466,676	33,324
Quarantine Bay	Louisiana	6,708	8,768	106,830	44,170
Sheridan	Texas	4,951	8,641	57,909	22,091
Fairway	do	5,205	8,637	33,813	167,330
Yates	do	6,273	8,462	511,876	139,999
Agua Dulce-Stratton	do	7,326	8,333	206,110	54,890
Van and Van Shallow	do	5,748	8,327	333,051	72,949
Russell and North	do	5,523	8,298	85,168	44,832
Weeks Island	Louisiana	6,883	8,247	152,768	84,232
Kelsey (all fields)	Texas	4,347	8,121	75,403	50,839
Belridge South	California	7,662	8,070	132,707	69,008
Coalings Nose	do	8,282	8,060	433,856	85,703
Dune	Texas	5,786	7,781	63,922	87,543
TXL and North	do	6,466	7,683	209,565	75,435
Grand Bay	Louisiana	6,374	7,523	110,442	105,558
Loudon	Illinois	8,533	7,288	327,927	22,073
Venice	Louisiana	5,803	7,220	121,864	53,136
Tijerina-Canales-Blucher	Texas	3,212	7,119	66,772	33,228
Anahauac	do	4,466	7,095	187,579	78,421
Seminole and West	do	5,105	7,037	144,050	55,950

[1] Fields under 7 million barrels not shown for current year.
[2] Includes revisions, if any.

Source: Oil and Gas Journal.

Table 9.—Well completions in the United States, by quarters [1]

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total Number	Total Percent
1966:						
Oil	3,961	3,684	4,188	4,947	16,780	46.1
Gas [2]	1,114	935	985	1,343	4,377	12.0
Dry	2,980	3,674	3,539	5,034	15,227	41.9
Total	8,055	8,293	8,712	11,324	36,384	100.0
1967:						
Oil	3,400	3,487	3,540	4,902	15,329	47.5
Gas [2]	891	841	783	1,144	3,659	11.4
Dry	2,799	2,983	3,090	4,374	13,246	41.1
Total	7,090	7,311	7,413	10,420	32,234	100.0

[1] Excludes service wells.
[2] Includes condensate wells.

Source: American Association of Petroleum Geologists and American Petroleum Institute.

Table 10.—Well completions in the United States, by States and districts [1]

State and district	1966				1967			
	Oil	Gas [2]	Dry	Total	Oil	Gas [2]	Dry	Total
Alabama	6	------	21	27	9	------	29	38
Alaska	15	5	30	50	37	4	33	74
Arizona	------	------	17	17	6	2	16	24
Arkansas	177	56	272	505	132	70	205	407
California	1,832	63	413	2,308	2,045	72	417	2,534
Colorado	122	53	363	538	145	45	349	539
Florida	4	------	13	17	------	------	11	11
Georgia	------	------	1	1	------	------	------	------
Idaho	------	------	1	1	------	------	------	------
Illinois	730	3	658	1,391	598	1	590	1,189
Indiana	140	12	382	534	148	5	321	474
Iowa	------	------	1	1	------	------	1	11
Kansas	1,079	130	1,427	2,636	1,264	147	1,796	3,207
Kentucky	674	168	1,273	2,115	528	200	816	1,544
Louisiana:								
North	510	172	701	1,383	325	175	605	1,105
South	654	205	711	1,570	464	164	556	1,184
Offshore	488	123	379	990	372	126	357	855
Total	1,652	500	1,791	3,943	1,161	465	1,518	3,144
Maryland	------	3	------	3	------	------	------	------
Michigan	64	44	294	402	65	26	273	364
Mississippi	250	41	544	835	226	15	474	715
Missouri	------	------	5	5	------	------	4	4
Montana	214	11	327	552	194	22	338	554
Nebraska	62	1	226	289	42	1	136	179
Nevada	------	------	------	------	1	------	8	9

New Mexico:								
West	21	295	99	415	52	231	62	345
East	545	47	230	822	542	26	178	746
Total	566	342	329	1,237	594	257	240	1,091
New York	6	19	41	66	163	13	35	211
North Carolina	--------	--------	11	11	--------	--------	--------	--------
North Dakota	78	--------	107	185	72	--------	81	153
Ohio	674	236	402	1,312	792	214	255	1,261
Oklahoma	1,843	561	1,329	3,733	1,377	443	1,032	2,852
Oregon	--------	--------	3	3	--------	--------	1	1
Pennsylvania	279	306	104	689	273	271	79	623
South Dakota	2	--------	12	14	--------	--------	4	4
Tennessee	4	1	57	62	3	1	43	47
Texas:								
Gulf Coast	488	274	814	1,576	587	213	621	1,421
West	2,014	228	711	2,953	1,600	170	636	2,406
East	333	93	285	711	324	78	272	674
Other districts	2,686	575	2,247	5,508	2,216	491	1,928	4,635
Total	5,521	1,170	4,057	10,748	4,727	952	3,457	9,136
Utah	69	7	66	142	59	10	73	142
Washington	--------	--------	3	3	--------	--------	3	3
West Virginia	370	594	130	1,094	269	384	121	774
Wyoming	347	51	517	915	399	39	487	925
Total United States	16,780	4,377	15,227	36,384	15,329	3,659	13,246	32,234

[1] Excludes service wells.
[2] Includes condensate wells.

Source: American Association of Petroleum Geologists and American Petroleum Institute.

Table 11.—Producing oil wells in the United States and average production per well per day, by States

State	Producing oil wells			
	1966		1967	
	Approximate number of producing oil wells, Dec. 31	Average production per well per day (barrels) [1]	Approximate number of producing oil wells, Dec. 31	Average production per well per day (barrels) [1]
Alabama	524	42.2	532	38.1
Alaska	72	609.9	94	961.4
Arizona	6	45.2	20	616.2
Arkansas	6,372	10.5	6,459	9.0
California	41,348	23.0	41,608	23.7
Colorado	2,371	42.6	1,730	45.3
Illinois	28,608	5.9	27,887	5.7
Indiana	5,300	5.5	[2] 4,831	5.5
Kansas	46,016	6.1	47,597	5.8
Kentucky	14,800	3.3	13,255	3.0
Louisiana:				
Gulf Coast	16,804	104.4	16,867	117.1
Northern	14,259	10.4	13,803	10.7
Total	31,063	60.3	30,670	68.7
Michigan	4,141	9.6	4,004	9.2
Mississippi	2,549	59.8	2,557	61.3
Montana	3,507	26.5	3,390	27.8
Nebraska	1,511	24.3	1,430	24.9
New Mexico:				
Southeastern	14,981	19.9	15,210	20.9
Northwestern	1,523	18.0	1,535	19.9
Total	16,504	19.7	16,745	20.8
New York	[2] 11,832	.4	12,582	.4
North Dakota	2,017	37.2	2,063	34.0
Ohio	14,192	2.1	14,638	1.9
Oklahoma	80,583	7.6	80,970	7.8
Pennsylvania	[2] 50,645	.2	[2] 45,426	.3
South Dakota	29	23.0	28	20.3
Texas: [3]				
Gulf Coast	19,255	27.8	18,925	31.0
East Texas Field	16,843	7.0	16,328	8.6
West Texas	66,910	20.2	66,002	21.5
Panhandle	13,923	6.9	13,862	6.8
Other disticts	79,377	9.9	76,884	10.4
Total	196,308	14.7	192,001	15.8
Utah	867	77.4	869	75.9
West Virginia	13,467	.8	12,989	.7
Wyoming	8,434	44.6	8,547	44.0
Other States:				
Florida	42	123.2	41	103.5
Missouri	150	1.8	146	1.4
Nevada	10	88.5	13	66.5
Tennessee	32	.6	33	.6
Virginia	2	.7	4	2.7
Total	236	26.1	237	22.4
Total United States	583,302	14.2	573,159	15.2

[1] Based on the average number of wells during the year.
[2] Compiled by Bureau of Mines, all other number of producing oil wells furnished by State agencies.
[3] Division of the Texas Railroad Commission.

Table 12.—Daily average total demand for crude petroleum in the United States, by State of origin and months

(Thousand barrels)

State	January	February	March	April	May	June	July	August	September	October	November	December	Year
1966:													
Alabama	16.4	14.8	21.4	37.6	16.2	26.8	15.7	23.7	28.6	20.9	20.8	20.2	21.9
Alaska	37.8	32.2	30.0	32.4	35.5	38.0	43.6	36.0	41.7	45.8	44.9	58.3	39.8
Arkansas	60.4	67.5	65.0	70.4	67.2	66.4	66.0	62.3	61.7	63.2	57.0	70.4	64.8
California	887.2	919.6	855.5	955.0	962.0	954.5	1,011.4	938.3	963.6	945.0	974.0	929.9	941.3
Colorado	88.4	96.6	91.0	89.4	82.7	92.1	91.3	89.2	90.1	98.4	92.1	91.0	91.0
Florida	6.5	12.8	0.2	6.4	6.0	3.8	9.0	6.2	0.1	6.0	6.2	0.3	5.2
Illinois	173.1	169.8	181.7	142.0	158.1	166.5	139.5	185.4	182.6	179.7	173.0	176.4	169.0
Indiana	26.9	29.1	28.6	27.0	30.8	33.4	33.5	20.9	25.7	31.0	30.0	29.5	28.9
Kansas	291.3	272.1	281.8	271.7	277.6	285.4	308.0	268.9	296.1	296.9	293.5	286.9	286.0
Kentucky	58.3	45.0	58.5	32.9	52.3	46.6	42.0	53.7	50.6	55.9	32.9	49.5	48.3
Louisiana	1,819.3	1,848.3	1,772.1	1,773.3	1,863.4	1,865.2	1,835.5	1,840.2	1,860.0	1,813.9	1,770.6	2,050.0	1,842.9
Michigan	35.0	39.0	39.5	40.4	32.7	41.4	40.2	41.0	41.3	38.5	41.1	38.2	39.0
Mississippi	160.3	151.0	156.3	133.5	158.6	133.4	152.1	159.9	144.1	149.8	154.5	149.8	150.4
Montana	97.1	98.0	88.2	82.0	101.6	108.0	99.1	103.2	97.3	91.1	97.2	101.1	97.0
Nebraska	54.0	34.1	37.6	48.3	40.8	39.8	33.4	34.7	45.2	23.1	34.7	38.2	38.7
New Mexico	358.5	342.6	343.5	325.1	337.1	336.2	333.8	339.6	296.4	371.1	319.3	375.0	340.0
New York	4.0	4.3	4.5	4.8	5.0	5.2	4.6	5.1	5.0	4.9	4.9	4.7	4.8
North Dakota	86.6	76.3	74.8	72.7	70.7	79.3	73.0	73.9	69.4	80.5	74.1	74.0	75.4
Ohio	33.0	28.9	30.2	30.7	30.1	31.4	23.7	29.3	29.6	26.4	26.8	29.7	29.1
Oklahoma	588.2	615.3	580.1	581.5	592.6	601.4	625.6	651.8	634.8	599.0	602.2	631.2	608.6
Pennsylvania	14.5	10.0	12.4	12.8	8.9	15.5	9.0	7.7	13.5	13.3	8.2	12.5	11.5
Texas	2,824.0	2,815.9	2,797.9	2,780.2	2,792.6	2,868.2	2,942.7	2,945.0	3,027.0	2,897.2	2,915.1	2,854.2	2,871.8
Utah	68.4	55.0	62.7	65.6	69.8	62.2	71.4	63.1	65.0	75.0	73.4	75.2	67.3
West Virginia	10.6	10.3	9.9	9.5	9.9	5.3	7.9	11.4	7.6	8.3	10.1	9.7	9.2
Wyoming	331.7	361.1	367.7	312.2	337.2	382.8	395.8	387.3	394.6	388.0	337.3	350.2	362.2
Other States	1.7	1.7	2.1	2.6	2.7	1.8	2.3	2.0	2.4	2.1	2.2	2.2	[1] 2.2
Total domestic crude	8,133.2	8,151.3	7,993.2	7,940.0	8,142.1	8,290.6	8,410.1	8,379.8	8,474.0	8,325.0	8,196.1	8,508.3	8,246.3
Foreign crude	1,266.9	1,215.5	1,234.9	1,148.5	1,239.2	1,255.4	1,289.7	1,258.9	1,218.8	1,227.7	1,191.8	1,141.1	1,224.3
Grand total 1966	9,400.1	9,366.8	9,228.1	9,088.5	9,381.3	9,546.0	9,699.8	9,638.7	9,692.8	9,552.7	9,387.9	9,649.4	9,470.6
Pennsylvania grade (included above)	33.9	28.4	31.3	32.0	28.3	30.9	25.9	31.2	33.6	31.8	27.9	33.2	30.7

See footnotes at end of table.

Table 12.—Daily average total demand for crude petroleum in the United States, by State of origin and months—Continued

(Thousand barrels)

State	January	February	March	April	May	June	July	August	September	October	November	December	Year
1967:													
Alabama	12.3	24.0	17.8	30.0	20.8	18.1	16.6	13.7	15.8	22.7	29.5	17.6	19.8
Alaska	34.0	69.6	57.4	39.2	59.8	79.2	75.8	72.2	89.9	112.9	120.2	85.9	74.6
Arkansas	57.3	59.6	61.3	54.7	61.7	55.8	59.4	58.9	49.8	55.2	59.5	58.2	57.6
California	912.8	914.9	915.4	947.7	978.9	978.5	951.0	1,011.6	992.5	1,015.3	988.0	974.3	965.4
Colorado	95.6	99.6	80.7	73.8	112.2	106.9	91.5	96.2	101.0	86.4	81.1	103.6	94.0
Florida	6.1	6.7	0.2	10.3	2.7	-------	3.1	9.5	5.7	0.7	5.9	1.3	4.3
Illinois	150.8	159.6	157.4	169.9	168.9	147.0	219.7	127.0	166.0	175.0	155.8	159.0	163.1
Indiana	29.1	30.6	26.9	25.0	28.3	28.1	23.9	37.2	21.7	29.1	28.9	24.5	27.8
Kansas	257.0	268.5	301.5	246.0	259.3	283.7	293.4	281.3	262.3	270.5	243.4	269.2	269.8
Kentucky	40.7	49.9	47.4	39.0	38.1	55.9	37.0	45.9	31.9	43.4	48.9	40.1	43.1
Louisiana	1,902.3	2,072.5	2,038.0	2,024.2	1,968.2	1,994.4	2,196.0	2,288.4	2,285.5	2,237.2	2,198.5	2,260.6	2,122.5
Michigan	39.6	37.5	38.5	37.1	37.6	35.6	31.2	34.7	45.6	33.2	42.0	37.4	37.5
Mississippi	142.6	177.1	161.3	131.3	159.2	172.2	165.2	153.0	152.3	168.7	159.5	152.8	157.8
Montana	75.4	101.9	94.7	86.0	80.9	93.4	106.1	81.8	109.7	103.2	93.9	111.8	94.8
Nebraska	41.5	23.4	54.6	39.1	22.0	38.8	42.3	31.4	41.9	42.5	33.7	31.8	37.0
New Mexico	348.8	345.0	315.9	363.7	353.4	348.5	319.0	325.7	353.2	329.3	359.5	355.6	343.0
New York	5.0	5.2	5.6	5.6	5.9	5.7	5.7	5.6	5.4	5.2	5.0	5.0	5.4
North Dakota	73.2	75.4	73.5	61.0	34.7	65.9	78.7	74.9	70.4	75.8	79.7	76.1	69.9
Ohio	25.5	24.9	30.3	27.5	30.9	23.8	26.8	28.0	28.2	28.9	30.4	26.4	27.7
Oklahoma	644.6	648.8	672.3	568.3	626.4	658.5	642.8	647.2	620.5	676.6	597.5	630.7	636.4
Pennsylvania	10.8	9.1	9.9	10.0	8.6	12.9	7.0	5.9	12.2	11.4	10.4	14.3	10.2
Texas	2,949.0	2,953.8	2,866.0	2,835.1	2,906.3	2,973.1	3,274.8	3,294.0	3,278.5	3,121.4	3,149.1	3,286.3	3,075.1
Utah	58.9	71.6	68.9	61.9	72.7	68.2	60.8	66.0	70.6	67.3	66.4	58.9	66.0
West Virginia	12.4	8.7	9.7	10.7	6.3	12.9	7.7	8.5	13.0	6.6	9.4	7.1	9.4
Wyoming	323.4	317.5	322.2	327.8	347.5	411.2	449.8	421.6	449.8	330.9	341.7	363.6	367.5
Other States	2.1	2.4	3.9	7.4	10.6	10.9	10.0	11.3	14.0	12.4	13.3	11.2	[2] 9.2
Total domestic crude	8,250.8	8,557.8	8,431.3	8,232.3	8,401.9	8,679.2	9,195.3	9,231.5	9,287.4	9,061.8	8,951.2	9,163.3	8,788.9
Foreign crude	1,246.9	1,043.7	1,140.3	1,228.4	1,201.7	1,222.3	1,102.8	1,046.8	998.7	1,036.9	1,045.4	1,121.5	1,120.2
Grand total 1967	9,497.7	9,601.5	9,571.6	9,460.7	9,603.6	9,901.5	10,298.1	10,278.3	10,286.1	10,098.7	9,996.6	10,284.8	9,909.1
Pennsylvania grade (included above)	35.0	29.4	31.9	32.5	28.3	35.4	28.5	26.4	37.2	31.0	31.3	33.0	31.6

[1] Arizona, 0.4; Missouri, 0.3; Nevada, 0.9; South Dakota, 0.7; Tennessee and Virginia less than 0.05.
[2] Arizona, 7.6; Missouri, 0.2; Nevada, 0.8; South Dakota, 0.6; Tennessee and Virginia less than 0.05.

Table 13.—Total demand for crude petroleum in the United States, by States of origin and months

(Thousand barrels)

	January	February	March	April	May	June	July	August	September	October	November	December	Total
1966:													
Alabama	509	413	663	1,128	501	803	486	736	858	649	623	627	7,996
Alaska	1,172	901	931	973	1,100	1,141	1,351	1,116	1,251	1,419	1,347	1,807	14,509
Arkansas	1,873	1,890	2,015	2,114	2,083	1,993	2,047	1,931	1,850	1,960	1,709	2,181	23,646
California	27,503	25,749	26,519	28,649	29,821	28,636	31,353	29,088	28,908	29,294	29,221	28,827	343,568
Colorado	2,740	2,704	2,821	2,684	2,563	2,764	2,830	2,766	2,702	3,050	2,763	2,821	33,208
Florida	201	359	7	192	186	113	279	192	4	185	186	8	1,912
Illinois	5,367	4,756	5,631	4,262	4,900	4,994	4,323	5,747	5,479	5,571	5,190	5,467	61,687
Indiana	835	816	887	809	955	1,003	1,038	648	771	960	899	914	10,535
Kansas	9,029	7,619	8,737	8,153	8,606	8,562	9,548	8,336	8,883	9,204	8,806	8,893	104,376
Kentucky	1,807	1,261	1,814	988	1,622	1,398	1,302	1,664	1,519	1,734	986	1,534	17,629
Louisiana	56,399	51,752	54,934	53,199	57,766	55,954	56,902	57,047	55,800	56,230	53,117	63,549	672,649
Michigan	1,086	1,091	1,226	1,212	1,013	1,243	1,245	1,270	1,238	1,192	1,234	1,186	14,236
Mississippi	4,968	4,227	4,846	4,005	4,916	4,003	4,715	4,957	4,322	4,643	4,640	4,644	54,886
Montana	3,011	2,745	2,733	2,459	3,153	3,240	3,071	3,199	2,920	2,825	2,916	3,135	35,407
Nebraska	1,673	954	1,166	1,448	1,264	1,194	1,034	1,075	1,356	715	1,040	1,185	14,104
New Mexico	11,112	9,593	10,647	9,753	10,450	10,086	10,349	10,527	8,892	11,505	9,578	11,626	124,118
New York	125	121	140	143	155	155	144	158	150	151	146	147	1,735
North Dakota	2,686	2,136	2,319	2,180	2,191	2,379	2,262	2,290	2,082	2,496	2,222	2,293	27,536
Ohio	1,022	808	936	920	934	941	736	910	888	819	805	920	10,639
Oklahoma	18,233	17,229	17,983	17,447	18,370	18,042	19,394	20,207	19,044	18,569	18,065	19,567	222,150
Pennsylvania	450	279	385	383	276	466	280	238	406	413	246	387	4,209
Texas	87,543	78,845	86,735	83,406	86,572	86,047	91,223	91,295	90,808	89,815	87,452	88,482	1,048,223
Utah	2,121	1,539	1,945	1,967	2,164	1,865	2,214	1,957	1,951	2,324	2,202	2,330	24,579
West Virginia	330	289	306	284	307	159	245	353	229	256	304	302	3,364
Wyoming	10,282	10,111	11,398	9,365	10,452	11,485	12,270	12,005	11,838	12,029	10,119	10,856	132,210
Other States	52	49	65	78	85	53	72	62	71	66	66	70	[1] 789
Total domestic crude	252,129	228,236	247,789	238,201	252,405	248,719	260,713	259,774	254,220	258,074	245,882	263,758	3,009,900
Foreign crude	39,273	34,035	38,281	34,454	38,416	37,661	39,981	39,026	36,565	38,059	35,756	35,374	446,881
Grand total 1966	291,402	262,271	286,070	272,655	290,821	286,380	300,694	298,800	290,785	296,133	281,638	299,132	3,456,781
Daily average:													
Domestic crude	8,133	8,151	7,993	7,940	8,142	8,291	8,410	8,380	8,474	8,325	8,196	8,508	8,246
Domestic and foreign crude	9,400	9,367	9,228	9,089	9,381	9,546	9,700	9,639	9,693	9,533	9,388	9,649	9,471
Pennsylvania grade (included above)	1,051	794	970	961	876	927	804	967	1,009	985	838	1,030	11,212

See footnotes at end of table.

Table 13.—Total demand for crude petroleum in the United States, by States of origin and months—Continued

(Thousand barrels)

	January	February	March	April	May	June	July	August	September	October	November	December	Total
1967:													
Alabama	380	673	553	900	645	542	514	425	474	702	884	546	7,238
Alaska	1,055	1,950	1,779	1,176	1,853	2,375	2,349	2,238	2,698	3,499	3,604	2,663	27,239
Arkansas	1,776	1,668	1,900	1,640	1,912	1,673	1,842	1,827	1,495	1,711	1,785	1,804	21,033
California	28,296	25,616	28,378	28,433	30,347	29,355	29,480	31,360	29,775	31,474	29,641	30,204	352,359
Colorado	2,965	2,788	2,501	2,213	3,477	3,208	2,837	2,981	3,029	2,679	2,433	3,212	34,323
Florida	190	187	7	308	85	-------	96	293	171	23	176	39	1,575
Illinois	4,676	4,469	4,878	5,098	5,237	4,411	6,810	3,937	4,982	5,424	4,675	4,928	59,525
Indiana	901	857	833	751	878	842	741	1,153	652	901	866	760	10,135
Kansas	7,967	7,518	9,347	7,382	8,037	8,512	9,094	8,720	7,869	8,385	7,303	8,345	98,479
Kentucky	1,262	1,398	1,469	1,170	1,182	1,677	1,148	1,424	957	1,346	1,466	1,244	15,743
Louisiana	58,972	58,030	63,177	60,728	61,013	59,832	68,077	70,939	68,567	69,352	65,956	70,079	774,722
Michigan	1,227	1,051	1,194	1,113	1,166	1,069	967	1,076	1,367	1,029	1,260	1,160	13,679
Mississippi	4,421	4,960	5,000	3,938	4,936	5,165	5,120	4,743	4,568	5,231	4,785	4,737	57,604
Montana	2,338	2,852	2,937	2,579	2,508	2,801	3,288	2,537	3,290	3,200	2,817	3,466	34,613
Nebraska	1,287	655	1,694	1,174	682	1,163	1,312	973	1,256	1,316	1,010	985	13,507
New Mexico	10,812	9,660	9,792	10,911	10,956	10,456	9,889	10,097	10,595	10,209	10,786	11,024	125,187
New York	155	146	175	167	182	172	176	172	161	162	150	154	1,972
North Dakota	2,269	2,111	2,278	1,830	1,077	1,977	2,441	2,323	2,113	2,349	2,391	2,360	25,519
Ohio	789	698	938	825	958	713	829	868	846	896	912	819	10,091
Oklahoma	19,982	18,166	20,842	17,049	19,417	19,757	19,928	20,063	18,615	20,976	17,926	19,553	232,274
Pennsylvania	336	254	307	299	265	386	218	183	365	354	312	444	3,723
Texas	91,418	82,707	88,845	85,053	90,095	89,195	101,520	102,114	98,355	96,764	94,474	101,874	1,122,414
Utah	1,827	2,005	2,137	1,857	2,254	2,046	1,884	2,046	2,118	2,087	1,992	1,825	24,078
West Virginia	383	244	301	321	196	388	239	263	390	203	282	220	3,430
Wyoming	10,026	8,890	9,988	9,834	10,772	12,335	13,945	13,071	13,495	10,259	10,252	11,271	134,138
Other States	66	68	120	221	330	326	310	351	420	385	399	347	[2] 3,343
Total domestic crude	255,776	239,621	261,370	246,970	260,460	260,376	285,054	286,177	278,623	280,916	268,537	284,063	3,207,943
Foreign crude	38,653	29,223	35,351	36,852	37,253	36,668	34,187	32,452	29,960	32,143	31,362	34,765	408,869
Grand total 1967	294,429	268,844	296,721	283,822	297,713	297,044	319,241	318,629	308,583	313,059	299,899	318,828	3,616,812
Daily average:													
Domestic crude	8,251	8,558	8,431	8,232	8,402	8,679	9,195	9,232	9,287	9,062	8,951	9,163	8,789
Domestic and foreign crude	1,247	1,044	1,140	1,228	1,202	1,222	1,103	1,047	999	1,037	1,045	1,121	1,120
Pennsylvania Grade (included above)	1,084	824	988	975	876	1,063	883	819	1,115	960	939	1,024	11,550

[1] Arizona, 134; Missouri, 97; Nevada, 311; South Dakota, 239; Tennessee, 7; and Virginia 1.
[2] Arizona, 2,769; Missouri, 74; Nevada, 279; South Dakota, 211; Tennessee, 7; and Virginia, 3.

Table 14.—Receipts of domestic and foreign crude petroleum at refineries in the United States

(Million barrels)

Method of transportation	1963	1964	1965	1966	1967 p
By water:					
Intrastate	129.8	125.9	147.3	152.0	129.1
Interstate	307.1	285.9	296.6	347.7	428.4
Foreign	322.2	337.1	344.4	320.7	265.3
Total	759.1	748.9	788.3	820.4	822.8
By pipeline:					
Intrastate	1,377.2	1,426.0	1,407.0	1,465.8	1,581.1
Interstate	900.8	929.4	955.8	996.2	995.9
Foreign	90.1	101.7	107.4	126.0	146.6
Total	2,368.1	2,457.1	2,470.2	2,588.0	2,723.6
By tank cars and trucks:					
Intrastate	36.2	34.4	34.8	38.1	40.0
Interstate	4.5	4.3	3.5	4.5	5.7
Foreign	0.1	-------	-------	-------	-------
Total	40.8	38.7	38.3	42.6	45.7
Grand total	3,168.0	3,244.7	3,296.8	3,451.0	3,592.1

p Preliminary.

Table 15.—Refinery receipts of domestic

(Thousand

Receiving district and State	Total domestic receipts	Intra-state receipts	Interstate receipts from— Ala. and Miss.	Ark.	Calif. Nev., and Alaska	Colo.	N.Y. and Fla.	Ill.
District 1:								
Delaware, Maryland	13,345	------	------	------	------	------	700	------
Florida, Georgia, and Virginia	3,849	------	1,389	------	------	------	------	------
New Jersey	89,762	------	15,323	------	807	------	814	------
New York	5,311	------	------	------	------	------	------	775
Pennsylvania:								
East	119,119	------	1,660	------	------	------	------	------
West	16,869	4,560	------	------	------	------	1,882	365
West Virgina	2,604	1,515	------	------	------	------	------	------
Total	250,859	6,075	18,372	------	807	------	3,396	1,140
District 2:								
Illinos	240,346	23,562	------	------	------	305	------	------
Indiana	164,524	1,899	------	------	------	1,257	------	7,647
Kansas	129,612	82,099	------	------	------	1,797	------	------
Kentucky, Tennessee	54,116	12,011	1,842	------	------	------	[2] 12	7,741
Michigan	42,004	12,800	------	------	------	------	------	4,543
Minnesota, Wisconsin	7,772	------	------	------	------	------	------	------
Missouri Nebraska	25,525	------	------	------	------	------	------	------
North Dakota	17,039	16,640	------	------	------	------	------	------
Ohio								
East	21,808	5,720	------	------	------	2,399	------	10,757
West	126,165		4,340	------	------	5,062	------	17,456
Okahoma	155,056	115,427	------	------	------	957	------	------
Total	983,967	270,158	6,182	------	------	11,777	12	48,144
District 3:								
Alabama	4,115	1,035	2,809	------	------	------	------	------
Arkansas	28,183	22,123	------	------	------	------	------	------
Louisiana	355,295	296,144	22,075	284	------	------	------	------
Mssissippi	62,124	12,021	------	------	------	------	------	------
New Mexico	12,420	12,420	------	------	------	------	------	------
Texas	961,954	710,489	1,248	------	------	------	------	------
Total	1,424,091	1,054,232	26,132	284	------	------	------	------
District 4:								
Colorado	13,157	1,291	------	------	------	------	------	------
Montana	30,251	11,960	------	------	------	------	------	------
Utah	36,081	9,731	------	------	71	18,550	------	------
Wyoming	39,469	37,741	------	------	------	1,532	------	------
Total	118,958	60,723	------	------	71	20,082	------	------
District 5:								
California	387,994	352,323	------	------	[4]17,813	------	------	------
Other States [1]	14,373	6,730	------	------	7,643	------	------	------
Total	402,367	359,053	------	------	25,456	------	------	------
Total United States	3,180,242	1,750,241	50,686	284	26,334	31,859	3,408	49,284
Daily average	8,713	4,795	139	1	72	87	9	135

[1] Alaska, Hawaii, Oregon, and Washington.
[2] Oil from Virginia.

crude oil by States and districts in 1967

barrels)

Interstate receipts from—												
Ind. and Mich.	Kans.	Ohio and Ky.	La.	Mont.	Nebr., N. Dak. and S. Dak.	New Mex.	Okla.	Texas	Utah	W. Va.	Wyo.	Total receipts
------	------	------	7,089	-------	-------	-------	-------	5,556	------	------	-------	13,345
------	------	------	1,119	-------	-------	-------	-------	508	------	------	833	3,849
------	------	------	47,706	-------	-------	819	815	23,368	------	------	110	89,762
------	------	90	-------	-------	-------	-------	4,363	83	------	------	-------	5,311
------	------	------	60,864	-------	-------	308	-------	56,287	------	------	-------	119,119
------	------	3,035	-------	4,410	-------	-------	741	-------	------	1,876	-------	12,309
------	------	1,089	-------	-------	-------	-------	-------	-------	------	------	-------	1,089
------	------	4,214	116,778	4,410	-------	1,127	5,919	85,802	------	1,876	943	244,784
639	5,194	------	4,194	631	698	30,900	36,373	127,051	576	------	10,223	216,784
123	15,393	6	-------	13,686	4,899	11,649	38,842	39,589	------	------	29,534	162,625
------	------	------	-------	1,319	1,595	6,275	18,726	15,138	------	------	2,663	47,513
------	------	[3] 12	32,498	-------	-------	-------	-------	-------	------	------	-------	42,105
------	------	------	-------	-------	-------	-------	-------	15,673	------	------	8,988	29,204
------	------	------	-------	-------	7,763	-------	-------	-------	------	------	9	7,772
------	80	------	-------	-------	-------	9,483	2,356	8,379	------	------	5,227	25,525
------	------	------	-------	399	-------	-------	-------	-------	------	------	-------	399
------	------	------	1,642	-------	-------	-------	-------	-------	------	------	1,316	16,114
25	452	------	31,965	-------	3,629	2,247	8,236	47,903	------	------	4,824	126,139
------	4,768	------	1,397	-------	-------	4,432	-------	27,527	548	------	-------	39,629
787	25,887	18	71,696	16,035	18,584	64,986	104,533	281,260	1,124	------	62,784	713,809
------	------	------	234	-------	-------	-------	-------	37	------	------	-------	3,080
------	------	------	2,631	-------	-------	-------	-------	3,429	------	------	-------	6,060
------	------	------	-------	-------	-------	-------	28	36,764	------	------	-------	59,151
------	------	------	50,103	-------	-------	-------	-------	-------	------	------	-------	50,103
------	23	------	206,746	-------	-------	40,199	1,160	-------	2,089	------	-------	251,465
------	23	------	259,714	-------	-------	40,199	1,188	40,230	2,089	------	-------	369,859
------	------	------	-------	720	-------	7	-------	-------	16	------	11,123	11,866
------	------	------	-------	-------	-------	-------	-------	-------	------	------	18,291	18,291
------	------	------	-------	-------	-------	140	-------	-------	------	------	7,589	26,350
------	------	------	-------	161	35	-------	-------	-------	------	------	-------	1,728
------	------	------	-------	881	35	147	-------	-------	16	------	37,003	58,235
------	------	------	-------	-------	-------	6,449	-------	-------	11,409	------	-------	35,671
------	------	------	-------	-------	-------	-------	-------	-------	------	------	-------	7,643
------	------	------	-------	-------	-------	6,449	-------	-------	11,409	------	-------	43,314
787	25,910	4,232	448,188	21,326	18,619	112,908	111,640	407,292	14,638	1,876	100,730	1,430,001
2	71	12	1,228	58	51	309	306	1,116	40	6	276	3,918

[3] Oil from Tennessee
[4] Includes 2,768,000 barrels from Arizona.

Table 16.—Crude runs to stills and refinery receipts of crude oil by origin of the crude and method of transportation 1967

(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 Pipelines	Intrastate Tank cars and trucks	Intrastate Tankers and barges	Interstate Pipelines	Interstate Tank cars and trucks	Interstate Tankers and barges	Refinery receipts of foreign crude: Pipelines	Tankers and barges
District 1:												
Delaware, Maryland	39,028	−14	-------	+390	-------	-------	-------	-------	-------	13,345	-------	26,059
Florida, Georgia, Virginia	15,310	-------	1,526	+196	-------	-------	-------	-------	527	3,322	-------	11,657
New Jersey	169,775	1	-------	+2,281	-------	-------	-------	-------	-------	89,762	-------	82,295
New York	25,208	−1	1,882	+17	-------	-------	-------	5,311	-------	-------	19,913	-------
Pennsylvania:												
East	193,867	146	-------	+2,102	-------	-------	-------	-------	-------	119,119	-------	76,996
West	16,756	1	4,560	+112	4,438	122	-------	10,675	941	693	-------	-------
West Virginia	2,587	-------	3,391	+17	1,454	61	-------	733	356	-------	-------	-------
Total	[1] 462,531	133	11,359	+5,115	5,892	183	-------	16,719	1,824	226,241	19,913	197,007
District 2:												
Illinois	239,968	32	72,846	+346	23,445	117	-------	216,605	-------	179	-------	-------
Indiana	164,487	3	2,538	+34	1,266	633	-------	162,496	129	-------	-------	-------
Kansas	129,245	38	108,009	+329	79,715	2,384	-------	47,498	15	-------	-------	-------
Kentucky, Tennessee	54,441	3	12,023	−328	4,465	227	7,319	-------	24	42,081	-------	-------
Michigan	50,150	83	12,948	+182	10,975	1,825	-------	29,204	-------	-------	8,411	-------
Minnesota, Wisconsin	42,596	16	-------	−450	-------	-------	-------	7,772	-------	-------	34,390	-------
Missouri, Nebraska	25,503	-------	10,844	+22	-------	-------	-------	25,525	-------	-------	-------	-------
North Dakota	17,086	7	[2] 24,415	−54	16,132	508	-------	-------	399	-------	-------	-------
Ohio:												
East	21,796	-------	} 9,940	−213 {	4,941	753	-------	16,114	-------	-------	-------	-------
West	140,207	18			-------	26	-------	126,139	-------	-------	13,835	-------
Oklahoma	154,526	63	227,067	+467	112,449	2,978	-------	39,629	-------	-------	-------	-------
Total	1,040,005	263	480,630	+335	253,388	9,451	7,319	670,982	567	42,260	56,636	-------
District 3:												
Alabama	4,222	−1	7,432	−106	-------	-------	1,035	-------	165	2,915	-------	-------
Arkansas	28,202	−2	22,407	−17	20,952	1,171	-------	5,771	289	-------	-------	-------
Louisiana	356,743	−383	744,332	−393	227,076	4,109	64,959	47,547	370	11,234	-------	672
Mississippi	62,113	−1	56,310	+12	9,914	2,107	-------	50,103	-------	-------	-------	-------
New Mexico	12,438	6	125,328	−24	11,151	1,269	-------	-------	-------	-------	-------	-------
Texas	960,895	129	1,117,781	+930	677,520	8,446	24,523	128,036	179	123,250	-------	-------
Total	1,424,613	−252	2,073,590	+402	946,613	17,102	90,517	231,457	1,003	137,399	-------	672

District 4:												
Colorado	13,427	41	33,150	−55	------	1,291	------	11,823	43	------	256	------
Montana	36,432	−1	33,286	+181	11,047	913	------	18,291	------	------	6,361	------
Utah	36,081	−2	24,369	+2	7,396	2,335	------	25,098	1,252	------	------	------
Wyoming	39,466	58	138,471	−55	37,072	669	------	1,105	623	------	------	------
Total	125,406	96	229,276	+73	55,515	5,208	------	56,317	1,918	------	6,617	------
District 5:												
California	436,658	−16	360,189	+3,049	313,004	8,015	31,304	20,446	376	14,849	------	51,697
Other States [3]	93,381	−103	25,198	+399	6,730	------	------	------	------	7,643	63,391	15,913
Total	530,039	−119	385,387	+3,448	319,734	8,015	31,304	20,446	376	22,492	63,391	67,610
Total United States	3,582,594	121	3,180,242	+9,373	1,581,142	39,959	129,140	995,921	5,688	428,392	[4] 146,557	265,289
Daily average	9,815	------	8,713	+26	4,332	109	354	2,728	16	1,174	401	727

[1] Includes 288,576,000 barrels in Delaware River Valley.
[2] Includes 12,000 barrels from South Dakota.
[3] Alaska, Arizona, Hawaii, Nevada, Oregon, and Washington.
[4] Excludes crude oil imported for direct fuel use by pipelines.

Table 17.—Transportation of petroleum products by pipelines in the United States, 1967 by months

(Thousand barrels)

Item	January	February	March	April	May	June	July	August	September	October	November	December	Total
Turned into lines:													
Gasoline:													
Motor	89,394	85,579	95,193	95,897	102,951	106,484	105,318	105,813	101,416	101,556	99,039	101,353	1,189,993
Aviation	688	706	867	704	964	786	975	809	820	711	773	585	9,388
Total	90,082	86,285	96,060	96,601	103,915	107,270	106,293	106,622	102,236	102,267	99,812	101,938	1,199,381
Jet fuel:													
Naphtha type	1,586	1,769	2,100	1,800	2,073	1,797	2,207	2,058	2,201	2,377	1,778	1,945	23,691
Kerosine type	7,467	5,856	7,055	6,843	6,943	7,664	8,344	9,351	8,659	8,589	9,595	9,044	95,410
Total	9,053	7,625	9,155	8,643	9,016	9,461	10,551	11,409	10,860	10,966	11,373	10,989	119,101
Kerosine	7,682	5,672	4,668	3,473	3,417	4,244	4,300	4,244	4,279	5,696	7,001	7,888	62,564
Distillate fuel oil	51,852	42,715	42,572	34,763	35,691	36,215	38,514	37,828	38,213	40,796	46,595	54,392	500,146
Natural gas liquids	19,159	15,338	17,886	14,929	17,013	17,319	17,614	17,792	17,744	19,155	20,948	23,381	218,278
Delivered from lines:													
Gasoline:													
Motor	89,350	82,269	95,691	93,973	104,553	106,945	105,493	108,101	100,168	101,705	102,529	100,083	1,190,860
Aviation	688	684	744	773	839	863	764	962	854	730	723	618	9,242
Total	90,038	82,953	96,435	94,746	105,392	107,808	106,257	109,063	101,022	102,435	103,252	100,701	1,200,102
Jet fuel:													
Naphtha type	1,504	1,735	2,097	1,890	2,040	1,894	2,151	2,176	2,033	2,403	1,928	1,758	23,609
Kerosine type	6,868	5,980	6,747	6,576	6,698	7,452	8,294	8,927	8,564	8,418	9,445	9,357	93,326
Total	8,372	7,715	8,844	8,466	8,738	9,346	10,445	11,103	10,597	10,821	11,373	11,115	116,935
Kerosine	8,188	5,827	5,208	3,487	3,315	3,403	4,121	4,174	4,208	5,173	6,644	7,568	61,316
Distillate fuel oil	51,596	46,220	45,731	34,874	35,663	33,650	37,123	35,075	37,217	40,184	45,465	54,787	497,585
Natural gas liquids	19,159	15,777	18,212	14,983	16,227	18,028	17,410	18,129	16,390	19,106	20,419	23,201	217,041

Shortage (or overage): [1]													
Gasoline:													
Motor	(182)	(45)	(190)	(87)	(111)	13	(81)	(46)	(67)	40	(157)	(125)	(1,038)
Aviation	9	12	9	9	5	19	14	22	13	10	12	13	147
Total	(173)	(33)	(181)	(78)	(106)	32	(67)	(24)	(54)	50	(145)	(112)	(891)
Jet fuel:													
Naphtha type	(2)	(3)	(4)	(4)	1	(2)	(3)	(6)	29	(28)	1	(1)	(22)
Kerosine type	100	91	87	65	96	94	86	110	115	115	65	108	1,132
Total	98	88	83	61	97	92	83	104	144	87	66	107	1,110
Kerosine	130	129	119	75	97	102	76	56	129	111	148	124	1,296
Distillate fuel oil	57	(88)	(18)	4	(26)	19	3	62	(68)	(97)	(36)	17	(171)
Natural gas liquids	79	22	66	12	16	2	17	74	184	89	71	132	764
Stocks in lines and working tanks at end of month:													
Gasoline:													
Motor	34,728	38,083	37,775	39,786	38,295	37,821	37,727	35,485	36,800	36,611	33,278	34,673	34,673
Aviation	346	356	470	392	512	416	613	438	391	362	400	354	354
Total	35,074	38,439	38,245	40,178	38,807	38,237	38,340	35,923	37,191	36,973	33,678	35,027	35,027
Jet fuel:													
Naphtha type	795	832	839	753	785	690	749	637	776	778	627	815	815
Kerosine type	1,734	1,519	1,740	1,942	2,091	2,209	2,173	2,487	2,467	2,523	2,608	2,187	2,187
Total	2,529	2,351	2,579	2,695	2,876	2,899	2,922	3,124	3,243	3,301	3,235	3,002	3,002
Kerosine	2,882	2,598	1,939	1,850	1,855	2,594	2,697	2,711	2,653	3,065	3,274	3,470	3,470
Distillate fuel oil	23,094	19,677	16,536	16,421	16,475	19,021	20,409	23,100	24,164	24,873	26,039	25,627	25,627
Natural gas liquids	6,670	6,209	5,817	5,751	6,521	5,810	5,997	5,586	6,756	6,716	7,174	7,222	7,222

[1] Figures in parentheses represent overage.

Table 18.—Transportation of petroleum products by pipeline between PAD districts in the United States, by months

(Thousand barrels)

Item	1967 January	February	March	April	May	June	July	August	September	October	November	December	Total	1966 total
From District 1 to District 2:														
Gasoline:														
Motor	2,338	2,031	2,331	2,506	2,617	2,507	2,464	2,498	2,404	2,260	2,286	2,243	28,485	28,141
Aviation	16	4	9	17	9	23	18	12	23	3	6	16	156	154
Total	2,354	2,035	2,340	2,523	2,626	2,530	2,482	2,510	2,427	2,263	2,292	2,259	28,641	28,295
Jet fuel (kerosine-type)	69	44	34	32	28	42	28	29	29	66	57	101	559	156
Kerosine	94	94	58	28	1	90	1	30	16	104	60	143	719	1,007
Distillate fuel oil	590	560	510	408	396	538	443	554	451	522	545	733	6,250	5,666
From District 2 to District 1:														
Gasoline (motor)	424	312	408	301	282	403	443	380	420	320	466	381	4,540	4,657
Distillate fuel oil	------	21	14	------	11	------	14	------	41	13	15	16	145	208
Natural gas liquids	547	475	422	173	322	536	596	662	506	660	420	265	5,584	4,747
From District 2 to District 3:														
Gasoline:														
Motor	1,288	1,199	1,282	1,244	1,452	1,607	1,688	1,678	1,450	1,737	1,502	1,534	17,661	16,717
Aviation	4	11	9	------	11	18	19	10	------	18	8	17	125	75
Total	1,292	1,210	1,291	1,244	1,463	1,625	1,707	1,688	1,450	1,755	1,510	1,551	17,786	16,792
Jet fuel:														
Naphtha-type	54	109	196	73	90	85	112	108	149	100	91	60	1,227	1,031
Kerosine-type	------	------	------	------	------	2	------	------	------	------	------	------	2	8
Total	54	109	196	73	90	87	112	108	149	100	91	60	1,229	1,039
Distillate fuel oil	625	486	379	348	337	293	327	226	372	470	453	527	4,843	3,895
Natural gas liquids	5	------	------	------	------	------	------	5	------	------	------	------	10	51
From District 3 to District 1:														
Gasoline:														
Motor	17,958	15,430	19,163	19,150	21,592	21,643	20,529	22,401	20,427	21,697	22,365	19,949	242,304	200,847
Aviation	114	54	69	162	68	123	123	112	111	66	77	135	1,214	1,402
Total	18,072	15,484	19,232	19,312	21,660	21,766	20,652	22,513	20,538	21,763	22,442	20,084	243,518	202 249

Jet fuel:														
Naphtha-type	120	161	166	154	157	175	105	145	89	172	173	129	1,746	1,494
Kerosine-type	1,727	1,198	1,406	1,452	1,525	1,881	2,008	2,413	2,370	2,398	2,372	2,488	23,238	10,575
Total	1,847	1,359	1,572	1,606	1,682	2,056	2,113	2,558	2,459	2,570	2,545	2,617	24,984	12,069
Kerosine	2,298	1,938	1,226	843	662	780	1,138	1,538	1,206	1,405	1,815	2,450	17,299	22,959
Distillate fuel oil	13,455	13,009	12,267	9,020	9,772	10,134	12,430	9,754	10,820	11,406	12,826	15,790	140,683	108,225
Natural gas liquids	1,098	979	649	241	368	528	618	1,010	907	696	969	949	9,012	7,953
From District 3 to District 2:														
Gasoline:														
Motor	2,377	2,966	3,161	3,244	3,600	3,409	3,120	3,534	3,200	3,349	3,396	2,857	38,213	36,359
Aviation	68	176	197	87	132	130	277	188	197	151	166	149	1,918	1,945
Total	2,445	3,142	3,358	3,331	3,732	3,539	3,397	3,722	3,397	3,500	3,562	3,006	40,131	38,304
Jet fuel (kerosine-type)	------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	123	123	66
Kerosine	290	218	88	112	109	11	80	100	216	204	133	448	2,009	1,443
Distillate fuel oil	1,535	1,654	993	714	365	397	869	1,112	921	923	1,170	1,090	11,743	10,000
Natural gas liquids	5,226	3,236	3,451	2,797	2,962	2,729	2,496	2,217	3,507	4,202	4,466	5,864	43,153	41,181
From District 3 to District 4:														
Gasoline:														
Motor	257	199	259	250	291	328	352	378	322	334	295	271	3,536	3,560
Aviation	25	21	25	25	21	24	28	26	21	20	20	17	273	373
Total	282	220	284	275	312	352	380	404	343	354	315	288	3,809	3,933
Kerosine	266	237	251	247	253	237	258	274	296	322	316	320	3,277	2,854
Distillate fuel oil	37	32	37	38	43	43	44	44	43	43	40	41	485	471
Natural gas liquids	167	102	79	50	59	42	43	65	72	44	81	123	927	961
From District 3 to District 5:														
Gasoline (motor)	826	769	876	902	953	672	675	928	777	835	841	802	9,856	10,044
Jet fuel:														
Naphtha-type	293	307	307	365	357	354	269	300	338	289	268	291	3,738	3,101
Kerosine-type	158	104	135	125	189	157	228	220	172	189	195	195	2,067	174
Total	451	411	442	490	546	511	497	520	510	478	463	486	5,805	3,275
Kerosine	------	-------	-------	5	-------	5	-------	-------	5	6	6	5	32	840
Distillate fuel oil	217	187	204	128	266	231	268	202	189	211	218	234	2,555	2,570
From District 4 to District 2:														
Gasoline (motor)	207	181	220	267	282	308	391	409	319	245	247	248	3,824	3,847
Jet fuel (naphtha-type)	42	42	47	78	18	30	-------	-------	-------	-------	-------	-------	257	-------
Kerosine	3	2	3	-------	1	-------	2	-------	-------	-------	-------	1	12	18
Distillate fuel oil	125	88	152	93	160	146	132	85	145	169	143	136	1,574	1,562

Table 18.—Transportation of petroleum products by pipeline between PAD districts in the United States, by months—Continued

(Thousand barrels)

Item	1967													1966 total
	January	February	March	April	May	June	July	August	September	October	November	December	Total	
From District 4 to District 5:														
Gasoline:														
Motor	896	694	765	961	945	1,020	1,064	916	967	829	734	886	10,677	9,260
Aviation	------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	15
Total	896	694	765	961	945	1,020	1,064	916	967	829	734	886	10,677	9,275
Jet fuel:														
Naphtha-type	75	82	125	136	36	42	102	206	96	143	96	105	1,244	971
Kerosine-type	------	-------	20	18	15	43	84	36	61	57	69	60	463	--------
Total	75	82	145	154	51	85	186	242	157	200	165	165	1,707	971
Kerosine	------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	28	28	--------
Distillate fuel oil	600	502	409	377	318	353	244	274	356	427	537	481	4,878	4,956

Table 19.—Pipeline tariff rates for crude petroleum and petroleum products, January 1

(Cents per barrel)

Origin	Destination	1966	1967	1968
Crude oil:				
West Texas	Houston, Tex	$0.16	$0.16	$0.145–$0.16
Do	East Chicago,	$0.29–0.31	0.29–0.31	0.29– 0.31
Do	Wood River, Ill	0.27–0.28	0.27–0.28	0.27– 0.28
Oklahoma	Chicago, Ill	.22	.22	.22
Do	Wood River, Ill	.19	.19	.19
Eastern Wyoming	Chicago, Ill	.33	.33	0.32– 0.33
Do	Wood River, Ill	.30	.30	0.29– 0.30
Refined products:				
Houston, Tex	Atlanta, Ga	$0.249–0.287	.249	0.219– 0.277
Do	New York, N.Y	.348	.348	.305
Tulsa, Okla	Minneapolis, Minn	.52	.52	.52
Salt Lake City, Utah	Spokane, Wash	.55	.49	.48
Philadelphia, Pa	Rochester, N.Y	.24	.24	.24

Source: Interstate Commerce Commission.

Table 20.—Petroleum oils, crude and refined, shipped from gulf and west coasts to east coast ports and from the gulf coast to west coast ports, in 1967 by months

(Thousand barrels)

Item	January	February	March	April	May	June	July	August	September	October	November	December	Total
Gulf coast to east coast:													
Crude oil	16,114	16,145	16,978	12,968	15,946	17,684	20,955	24,319	21,742	20,025	20,750	20,479	224,105
Unfinished oils	1,417	1,291	1,458	1,742	1,814	1,174	2,795	2,159	1,145	1,983	2,141	2,035	21,154
Gasoline:													
Motor	13,833	11,030	13,414	12,322	11,477	11,868	14,816	15,577	13,921	13,572	12,974	13,809	158,613
Aviation	596	622	687	492	654	379	598	431	610	634	610	435	6,748
Total	14,429	11,652	14,101	12,814	12,131	12,247	14,531	16,008	14,351	14,206	13,584	14,244	165,361
Special naphthas	307	330	287	409	387	323	586	343	250	262	367	376	4,227
Kerosine	1,952	1,816	1,688	1,543	1,082	876	1,161	1,430	1,185	1,837	1,963	2,110	18,643
Distillate fuel oil	14,317	12,406	13,295	11,046	9,089	7,100	8,808	9,526	10,879	13,200	11,371	14,333	135,370
Residual fuel oil	1,908	2,593	2,113	2,871	1,978	2,366	2,180	2,666	2,533	3,563	2,708	2,982	30,461
Jet fuel:													
Naphtha type	1,498	1,010	1,726	1,879	1,652	1,627	1,472	2,418	1,668	1,842	1,710	1,328	19,830
Kerosine type	2,113	2,208	2,845	2,162	2,126	1,872	1,473	883	1,910	1,826	1,435	2,155	23,008
Total	3,611	3,218	4,571	4,041	3,778	3,499	2,945	3,301	3,578	3,668	3,145	3,483	42,838
Lubricating oil	640	553	989	792	818	1,127	844	731	613	795	807	684	9,393
Wax	13	8	14	11	5	6	3	22	-------	13	21	11	127
Asphalt and road oil	542	330	297	489	635	466	396	316	488	585	513	217	5,274
Liquefied gases	278	151	75	-------	2	20	42	74	183	266	431	215	1,737
Petrochemical feedstocks	154	207	228	131	262	218	180	221	150	219	217	229	2,416
Other products	195	211	267	187	255	185	307	101	95	185	87	60	2,135
Total	55,877	50,911	56,361	49,044	48,182	47,291	56,616	61,217	57,372	60,807	58,105	61,458	663,241

West coast to east coast:													
Crude oil	------	-------	-------	-------	-------	-------	346	174	181	-------	-------	106	807
Distillate fuel oil	102	63	-------	-------	-------	-------	151	-------	-------	-------	-------	-------	316
Residual fuel oil	------	-------	-------	-------	-------	-------	117	-------	-------	-------	-------	-------	117
Kerosine type jet fuel	13	-------	13	-------	-------	-------	-------	-------	-------	-------	-------	-------	26
Lubricating oil	67	60	70	59	63	72	33	45	60	90	55	77	751
Total	182	123	83	59	63	72	647	219	241	90	55	183	2,017
Gulf coast to west coast:													
Gasoline:													
Motor	338	-------	1,005	754	1,065	411	328	580	211	1,066	331	87	6,176
Aviation	65	175	161	260	145	460	269	84	136	158	140	66	2,119
Total	403	175	1,166	1,014	1,210	871	597	664	347	1,224	471	153	8,295
Special naphthas	15	-------	31	9	24	-------	37	15	-------	26	-------	-------	157
Kerosine	39	-------	-------	-------	-------	-------	-------	-------	-------	60	-------	-------	99
Distillate fuel oil	187	120	98	52	5	172	111	48	43	16	216	48	1,116
Jet fuel:													
Naphtha type	577	423	750	811	380	640	635	419	1,105	842	690	853	8,125
Kerosine type	673	470	49	363	-------	738	198	100	279	409	352	640	4,271
Total	1,250	893	799	1,174	380	1,378	833	519	1,384	1,251	1,042	1,493	12,396
Lubricating oil	96	22	202	185	72	128	208	177	150	155	167	-------	1,562
Petrochemical feedstocks	21	73	38	18	90	-------	16	32	-------	26	32	-------	346
Other products	------	20	-------	-------	11	8	-------	-------	-------	7	-------	-------	46
Total	2,011	1,303	2,334	2,452	1,792	2,557	1,802	1,455	1,924	2,765	1,928	1,694	24,017

Table 21.—Barge movements via the Mississippi river of crude oil and products from PAD District III to PAD Districts I and II in 1967 by months

(Thousand barrels)

Movements from District III to—	January	February	March	April	May	June	July	August	September	October	November	December	Total
District I:													
Gasoline:													
Motor gasoline	918	803	1,049	951	906	940	1,021	966	687	740	874	1,501	11,356
Aviation gasoline	19	38	26	37	23	23	26	31	24	18	11	33	309
Total	937	841	1,075	988	929	963	1,047	997	711	758	885	1,534	11,665
Special naphthas	7	10	26	7	31	19	8	34	4	17	20	28	211
Kerosine	48	68	23	5	-------	3	7	7	21	63	43	72	360
Distillate fuel oil	88	149	121	67	116	101	94	118	86	149	71	172	1,332
Residual fuel oil	38	44	33	87	14	7	11	18	-------	29	14	52	347
Jet fuel:													
Naphtha-type jet fuel	------	34	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	34
Kerosine-type jet fuel	35	84	44	36	57	46	100	54	39	61	32	108	696
Total	35	118	44	36	57	46	100	54	39	61	32	108	730
Lubricating oil	145	88	183	141	191	188	131	159	170	160	129	133	1,818
Wax	4	-------	-------	25	-------	4	2	-------	-------	-------	5	-------	40
Asphalt and road oil	------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Liquefied gases	------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Petrochemical feedstocks	7	-------	-------	9	46	35	10	17	2	32	28	33	219
Other products	39	23	19	5	103	-------	16	8	10	9	2	-------	234
Total	1,348	1,341	1,524	1,370	1,487	1,366	1,426	1,412	1,043	1,278	1,229	2,132	16,956

District II:													
Crude oil	2,765	2,667	3,154	3,031	2,662	2,412	2,381	2,492	3,059	3,235	3,383	3,099	34,340
Unfinished oils	14	9	6	124	118	4	-------	4	-------	13	86	8	386
Gasoline:													
Motor gasoline	1,741	1,632	1,588	2,583	1,810	2,376	2,094	2,550	2,282	2,129	2,158	2,533	25,476
Aviation gasoline	69	52	75	71	62	91	87	72	69	95	54	61	858
Total	1,810	1,684	1,663	2,654	1,872	2,467	2,181	2,622	2,351	2,224	2,212	2,594	26,334
Special naphthas	240	194	163	192	174	191	131	229	174	214	219	249	2,370
Kerosine	228	273	174	71	89	92	178	113	134	263	196	267	2,078
Distillate fuel oil	970	766	831	998	510	413	777	410	419	407	443	465	7,409
Residual fuel oil	828	664	1,118	745	418	580	515	364	410	536	555	691	7,424
Jet fuel:													
Naphtha-type jet fuel	------	25	-------	9	68	59	-------	8	59	9	-------	-------	237
Kerosine-type jet fuel	258	368	236	374	423	540	540	731	260	652	384	385	5,151
Total	258	393	236	383	491	599	540	739	319	661	384	385	5,388
Lubricating oil	242	148	226	224	122	232	164	228	131	216	288	88	2,309
Wax	------	-------	-------	-------	-------	-------	-------	-------	4	-------	-------	-------	4
Asphalt and road oil	203	214	152	272	331	291	319	261	281	369	251	91	3,035
Liquefied gases	167	56	112	168	120	112	111	168	-------	112	111	-------	1,237
Petrochemical feedstocks	288	211	181	169	150	174	142	180	176	164	142	136	2,113
Other products	98	69	79	60	55	65	77	31	38	25	29	34	660
Total	8,111	7,348	8,095	9,091	7,112	7,632	7,516	7,841	7,496	8,439	8,299	8,107	95,087

Table 22.—Tanker rates from U.S. Gulf to destinations north of Cape Hatteras

Year	Vessels under 25,000 DWT [1]					
	Clean products (cents per gallon)			Dirty products (dollars per barrel)		
	Gasoline	Kerosine	No. 2 fuel oil	30 gravity crude oil	No. 5 fuel oil	Bunker C fuel oil
1960	0.77	0.84	0.89	0.30	0.32	0.33
1961	.89	.98	1.03	.41	.43	.46
1962	.80	.88	.93	.38	.40	.43
1963	.92	1.01	1.06	.45	.47	.50
1964	.86	.95	1.00	.43	.46	.48
1965	.83	.91	.96	.50	.53	.56
1966	.93	1.03	1.08	.52	.55	.58
1967	1.46	1.60	1.69	.80	.85	.90
	Vessels over 25,000 DWT [1]					
1960	0.64	0.70	0.74	0.27	0.29	0.31
1961	.73	.81	.85	.36	.38	.40
1962	.77	.84	.89	.33	.35	.40
1963	.85	.93	.98	.37	.39	.41
1964	.76	.84	.88	.38	.40	.43
1965	.67	.74	.78	.40	.43	.45
1966	.93	1.02	1.07	.41	.43	.46
1967	1.35	1.49	1.57	.68	.72	.77

[1] Deadweight ton.
Source: Platt's Oil Price Handbook.

Table 23.—Stocks of crude petroleum, natural gas liquids, and refined products in the United States at yearend

(Thousand barrels)

	1963	1964	1965	1966	1967
Crude petroleum:					
At refineries	61,487	63,908	59,386	62,720	72,093
Pipeline and tank farm	157,544	149,415	144,740	153,930	158,797
Producers	18,330	16,734	16,163	21,741	18,080
Total	237,361	230,057	220,289	238,391	248,970
Natural gas liquids	33,747	35,679	35,867	40,423	65,742
Refined products	564,451	573,499	580,188	595,651	623,702
Grand total	835,559	839,235	836,344	874,465	938,414

Table 24.—Stocks of crude petroleum in the United States by State of origin, by month in 1967

(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	188	454	350	423	138	107	158	255	443	579	486	209	298
Alaska	335	925	513	340	732	769	470	351	494	539	488	900	2,222
Arizona	------	------	------	------	------	------	8	70	190	171	174	144	155
Arkansas	887	1,013	1,057	1,022	1,152	1,053	1,098	1,013	940	1,135	1,168	1,034	929
California	23,658	24,910	26,134	27,729	28,533	28,481	28,487	29,419	28,607	28,653	28,473	29,147	30,518
Colorado	3,428	3,329	3,162	3,564	4,200	3,698	3,304	3,382	3,316	3,065	3,327	3,309	3,010
Florida	263	219	161	296	125	177	312	353	190	142	245	185	256
Illinois	6,878	7,489	7,449	7,793	7,630	7,581	8,127	6,200	7,277	7,081	6,621	6,754	6,495
Indiana	378	406	347	393	495	485	474	597	287	431	365	305	324
Kansas	5,742	6,370	6,634	5,962	6,717	7,237	6,943	6,132	5,875	6,067	5,970	6,749	6,463
Kentucky	1,514	1,653	1,453	1,342	1,439	1,609	1,222	1,355	1,242	1,532	1,503	1,314	1,306
Louisiana	26,749	30,206	29,569	28,151	27,081	26,694	28,074	30,505	32,651	29,981	28,074	28,397	26,554
Michigan	787	714	739	729	731	747	798	971	1,074	827	952	811	772
Mississippi	2,776	3,015	2,350	2,166	2,859	2,685	2,195	1,991	2,168	2,403	2,140	2,168	2,319
Missouri	------	------	------	------	------	1	1	1	------	1	1	1	1
Montana	3,703	4,188	3,939	3,846	3,960	4,235	4,185	3,755	4,134	3,785	3,651	4,046	4,049
Nebraska	1,401	1,228	1,576	991	908	1,367	1,287	1,108	1,275	1,139	989	1,104	1,267
Nevada	------	------	------	2	------	------	1	1	1	------	------	------	------
New Mexico	8,699	8,800	9,132	10,206	9,653	9,237	8,820	9,205	9,831	9,852	10,439	10,100	9,656
New York	30	30	30	30	30	30	30	30	30	30	30	30	30
North Dakota	1,670	1,636	1,525	1,486	1,802	2,398	2,373	2,133	1,968	2,002	1,882	1,629	1,466
Ohio	955	1,009	1,034	953	925	796	890	853	888	875	849	760	788
Oklahoma	17,796	17,852	17,953	17,226	19,165	19,133	17,972	17,552	17,093	17,380	15,872	16,781	16,271
Pennsylvania	1,015	1,051	1,124	1,192	1,258	1,392	1,403	1,558	1,770	1,765	1,789	1,806	1,679
Texas	99,212	100,900	101,565	103,611	105,308	103,364	101,425	102,120	107,206	105,544	106,350	104,194	96,760
Utah	2,096	2,315	2,220	2,187	2,386	2,229	2,245	2,136	2,133	1,998	1,959	1,956	2,066
West Virginia	985	949	998	1,003	985	1,016	990	1,047	1,096	971	1,084	1,056	1,116
Wyoming	15,022	15,307	16,699	18,554	20,267	21,421	20,448	18,369	16,601	15,054	16,202	17,005	17,196
Total domestic crude	226,167	235,968	237,713	241,197	248,479	247,942	243,740	242,462	248,780	243,002	241,083	241,894	233,966
Foreign crude located in districts:													
1–4	8,352	9,311	9,627	10,945	11,959	13,185	10,316	8,348	7,484	7,399	8,881	7,956	10,384
5	3,872	5,367	5,048	5,964	6,317	7,718	7,559	5,432	5,302	6,885	5,150	4,335	4,620
Total foreign crude	12,224	14,678	14,675	16,909	18,276	20,903	17,875	13,780	12,786	14,284	14,031	12,291	15,004
Total crude stocks	**238,391**	**250,646**	**252,388**	**258,106**	**266,755**	**268,845**	**261,615**	**256,242**	**261,566**	**257,286**	**255,114**	**254,185**	**248,970**
Pennsylvania grade (included above)	2,501	2,492	2,606	2,679	2,736	2,866	2,940	3,111	3,387	3,261	3,359	3,328	3,246

Table 25.—Stocks of crude petroleum in the United States by location, by month in 1967

(Thousand barrels)

State	Jan. 1	Jan. 31	Feb. 28	Mar. 31	Apr. 30	May 31	June 30	July 31	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
Alabama	270	185	248	285	235	181	234	187	267	305	287	250	229
Alaska	335	656	513	340	357	769	470	351	494	539	488	823	820
Arizona	448	449	449	449	447	446	454	412	544	447	481	448	474
Arkansas	1,426	1,557	1,599	1,548	1,681	1,578	1,627	1,537	1,463	1,661	1,694	1,569	1,463
California, Nevada, Oregon, Washington	27,642	30,419	31,452	33,659	35,138	36,304	35,718	34,622	33,665	35,301	33,672	33,656	36,354
Colorado	1,488	1,380	1,471	1,473	1,619	1,666	1,489	1,327	1,361	1,177	1,401	1,489	1,384
Florida, Georgia, South Carolina, Virginia	486	1,003	694	807	1,058	1,349	982	682	1,054	803	1,055	879	768
Hawaii	490	742	287	531	734	398	879	738	884	700	481	562	675
Illinois	13,365	14,018	14,321	14,532	15,208	15,936	15,036	14,717	14,846	14,620	14,433	14,083	13,449
Indiana	4,322	4,397	4,077	4,208	4,325	4,530	4,533	4,283	3,822	4,324	4,317	3,967	3,604
Iowa, Missouri	7,351	7,264	7,146	6,961	6,891	7,513	7,118	6,917	6,832	6,700	6,237	6,462	6,407
Kansas	9,202	9,282	9,138	9,077	10,436	10,328	10,203	9,505	9,200	9,636	8,930	9,773	9,445
Kentucky, Tennessee	3,609	3,720	3,687	3,656	3,968	3,647	3,403	3,090	3,147	3,497	3,627	3,823	3,452
Louisiana	18,300	20,049	20,025	18,726	17,120	17,069	18,147	17,940	19,155	18,552	18,257	16,729	16,157
Maryland	243	281	281	215	245	206	217	288	260	326	269	230	158
Massachusetts, Delaware, Rhode Island	716	741	786	670	679	718	871	852	994	1,175	1,525	1,073	1,191
Michigan	1,658	1,605	1,681	1,684	1,714	1,926	1,903	1,794	1,844	1,718	1,732	1,624	1,558
Minnesota, Wisconsin	2,272	2,243	2,106	2,011	2,498	2,188	2,297	2,196	2,215	2,159	2,261	1,771	1,648
Mississippi	2,520	2,576	2,321	2,454	2,239	2,590	2,686	2,470	3,062	2,600	2,524	2,620	2,539
Montana	2,050	2,140	2,333	2,412	2,774	2,710	2,961	2,509	2,035	2,054	2,319	2,555	2,414
Nebraska	1,558	1,725	1,887	1,801	1,835	1,841	1,786	1,747	1,728	1,751	1,707	1,838	1,794
New Jersey	4,585	5,098	4,470	5,544	5,097	5,903	5,628	5,485	6,664	6,223	5,883	6,172	6,866
New Mexico	3,776	4,031	3,975	3,884	3,778	3,600	3,390	3,329	3,627	4,108	4,007	3,966	3,814
New York	436	507	466	443	360	460	384	524	453	451	451	373	409
North Dakota	1,371	1,292	1,279	1,238	1,345	2,051	1,847	1,576	1,375	1,358	1,333	1,348	1,249
Ohio	7,765	7,363	7,641	7,643	7,970	8,106	8,240	6,612	7,745	7,012	6,506	7,111	6,926
Oklahoma	17,521	16,936	17,274	17,422	19,940	19,887	18,721	17,589	17,675	16,849	16,813	17,970	17,640
Pennsylvania	8,889	9,956	10,168	10,299	10,372	10,875	10,781	11,127	11,262	10,322	9,437	9,842	11,717
Texas	84,991	89,157	89,817	92,098	93,175	90,145	86,829	90,346	93,412	91,593	92,910	90,235	83,072
Utah	981	1,017	1,148	1,195	1,366	1,197	1,098	1,062	1,135	984	930	988	984
West Virginia	749	704	733	769	733	640	685	716	775	698	755	718	702
Wyoming	7,576	8,153	8,915	10,072	11,418	12,088	10,998	9,712	8,571	7,643	8,392	9,238	9,608
Total	238,391	250,646	252,388	258,106	266,755	268,845	261,615	256,242	261,566	257,286	255,114	254,185	248,970

Table 26.—Stocks of crude petroleum in the United States by classification and location, by month in 1967

(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	206	119	170	202	176	110	162	124	134	160	161	118	100
Alaska	44	68	77	72	33	99	57	34	67	83	79	69	87
Arkansas	337	403	444	432	387	386	398	356	346	362	341	327	320
California, Oregon, Washington	13,316	14,213	15,273	17,514	17,481	19,237	18,965	17,419	15,683	17,664	15,944	15,365	16,536
Colorado	347	284	305	325	382	416	410	268	252	284	295	362	292
Florida, Georgia, South Carolina Virginia	412	784	540	704	1,023	1,174	870	628	864	682	1,009	719	608
Hawaii	490	742	287	531	734	398	879	738	884	700	481	562	675
Illinois	2,786	3,107	3,030	3,086	3,774	3,677	3,508	3,427	3,202	3,158	3,370	3,248	3,132
Indiana	1,162	1,228	1,258	1,279	1,108	1,264	1,411	1,382	1,155	1,300	1,415	1,399	1,196
Kansas	1,392	1,516	1,481	1,423	1,960	1,943	1,839	1,543	1,346	1,161	1,239	1,736	1,721
Kentucky, Tennessee	1,702	1,513	1,578	1,590	1,779	1,394	1,272	1,147	1,122	1,348	1,437	1,709	1,374
Louisiana	4,785	5,402	5,507	5,520	5,624	5,551	5,764	5,906	5,972	5,924	5,476	4,953	4,392
Maryland	243	281	281	215	245	206	217	288	260	326	269	230	158
Massachusetts, Delaware, Rhode Island	716	741	786	670	679	718	871	852	994	1,175	1,525	1,073	1,191
Michigan	676	717	767	818	896	980	974	916	863	880	912	775	858
Minnesota, Wisconsin	1,486	1,446	1,411	1,354	1,559	1,369	1,550	1,450	1,257	1,382	1,433	1,227	1,036
Mississippi	716	734	540	612	574	608	655	620	1,202	704	803	676	728
Missouri	267	331	278	287	265	266	261	256	251	296	288	300	279
Montana	546	561	612	625	793	750	809	606	584	599	779	833	727
Nebraska	24	27	26	35	17	27	17	20	35	36	36	36	34
New Jersey	4,585	5,098	4,470	5,544	5,097	5,903	5,628	5,485	6,664	6,223	5,883	6,172	6,866
New Mexico	207	245	251	242	251	211	192	169	156	204	220	227	183
New York	251	271	236	235	193	256	237	317	251	312	351	249	268
North Dakota	311	283	258	170	199	644	597	372	252	266	280	288	257
Ohio	2,024	1,898	2,190	2,356	2,076	2,228	2,263	2,084	2,129	1,938	1,812	2,141	1,811
Oklahoma	1,352	1,573	1,509	1,548	1,698	1,517	1,689	1,684	1,650	1,532	1,527	1,752	1,819
Pennsylvania	7,328	8,242	8,378	8,548	8,473	8,837	8,761	9,008	8,924	8,068	7,249	7,689	9,542
Texas	14,075	16,448	15,992	16,601	15,511	14,520	15,031	15,894	16,375	14,918	16,648	16,067	15,005
Utah	367	384	400	483	554	483	451	407	424	376	394	448	369
West Virginia	104	74	73	78	72	75	78	72	88	80	74	64	121
Wyoming	463	397	397	513	701	667	588	568	465	460	467	502	408
Total	62,720	69,130	68,805	73,612	74,314	75,914	76,404	74,085	73,846	72,601	72,197	71,316	72,098

Table 26.—Stocks of crude petroleum in the United States by classification and location, by month in 1967—Continued

(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
Pipeline and tank-farm stocks:													
Alabama	49	51	63	68	40	57	57	47	45	44	34	48	58
Alaska	286	583	430	264	320	666	409	312	423	452	405	750	730
Arkansas	998	1,063	1,055	1,027	1,205	1,103	1,140	1,092	1,028	1,204	1,258	1,147	1,048
California, Arizona	12,925	14,176	14,677	14,979	16,678	15,398	16,158	16,440	17,314	16,160	16,199	16,037	18,334
Colorado	1,024	979	1,049	1,031	1,112	1,125	954	934	984	768	981	1,002	951
Florida	51	200	131	80	12	152	89	24	184	115	40	153	153
Illinois	10,172	10,520	10,907	11,062	11,041	11,893	11,171	10,921	11,299	11,112	10,706	10,488	9,962
Indiana	3,126	3,135	2,785	2,895	3,183	3,232	3,088	2,867	2,633	2,990	2,868	2,534	2,374
Iowa, Missouri	7,084	6,933	6,868	6,674	6,626	7,246	6,856	6,660	6,581	6,403	5,948	6,161	6,127
Kansas	7,376	7,332	7,238	7,251	8,061	7,963	7,977	7,565	7,473	8,086	7,311	7,654	7,338
Kentucky, Tennessee	1,842	2,142	2,044	2,001	2,124	2,188	2,066	1,878	1,960	2,084	2,125	2,049	2,013
Louisiana	10,990	11,990	11,970	10,698	8,885	8,896	9,857	9,446	10,492	9,893	10,214	9,227	9,341
Michigan	784	790	816	768	715	843	826	775	878	735	717	746	613
Minnesota, Wisconsin	786	797	695	657	939	819	747	746	958	777	828	544	612
Mississippi	1,489	1,512	1,437	1,522	1,314	1,655	1,712	1,525	1,544	1,568	1,393	1,627	1,494
Montana	1,166	1,234	1,385	1,441	1,615	1,613	1,805	1,563	1,123	1,109	1,178	1,337	1,264
Nebraska	1,441	1,605	1,768	1,673	1,717	1,719	1,674	1,632	1,598	1,620	1,576	1,707	1,657
New Mexico	2,423	2,649	2,595	2,513	2,405	2,267	2,096	2,048	2,191	2,561	2,479	2,257	2,108
New York	155	206	200	178	137	174	117	177	172	109	70	94	111
North Dakota	907	846	846	897	968	1,071	1,061	1,011	956	916	879	895	828
Ohio	5,666	5,390	5,376	5,212	5,819	5,803	5,902	4,453	5,541	4,999	4,619	4,895	5,040
Oklahoma	14,943	14,164	14,566	14,750	17,078	17,218	15,906	14,764	14,901	14,129	14,152	15,084	14,707
Pennsylvania	1,420	1,573	1,649	1,610	1,758	1,924	1,906	2,005	2,224	2,140	2,074	2,039	2,061
Texas	59,197	62,165	64,213	68,943	70,931	69,021	65,301	67,675	70,263	69,576	69,217	66,976	60,226
Utah	545	570	680	638	742	651	577	586	656	543	475	479	550
West Virginia	480	465	495	526	496	400	442	479	527	453	516	489	416
Wyoming	6,605	7,207	7,987	9,039	10,197	10,878	9,873	8,601	7,582	6,653	7,432	8,246	8,681
Total	153,930	160,277	163,925	168,397	176,118	175,975	169,767	166,226	171,530	167,199	165,694	164,665	158,797
Lease stocks	21,741	21,239	19,658	16,097	16,323	16,956	15,444	15,981	16,190	17,486	17,223	18,204	18,080
Total stocks: 1967	238,391	250,646	252,388	258,106	266,755	268,845	261,615	256,242	261,566	257,286	255,114	254,185	248,970
1966	220,289	220,302	223,422	233,224	245,232	250,418	253,388	246,877	245,347	238,198	236,092	241,692	238,391

Table 27.—Stocks of refined petroleum products in the United States at end of month

(Thousand barrels)

Product	January	February	March	April	May	June	July	August	September	October	November	December
1966:												
Gasoline:												
Motor	194,984	203,088	205,033	198,980	195,555	178,661	176,344	169,844	172,351	177,791	180,187	186,393
Aviation	8,495	9,099	9,168	8,965	8,066	7,208	6,956	7,184	7,325	7,410	7,054	7,784
Total	203,479	212,187	214,201	207,945	203,621	185,869	183,300	177,028	179,676	185,201	187,241	194,177
Special naphthas	6,379	6,303	6,008	5,706	5,686	5,468	5,496	5,510	5,439	5,445	5,460	5,583
Kerosine	20,209	17,866	18,676	19,565	21,259	23,542	27,092	30,253	30,428	30,434	27,915	25,004
Distillate fuel oil	130,041	104,042	92,761	91,004	102,513	117,654	142,467	161,065	177,363	186,576	175,805	154,096
Residual fuel oil	53,627	47,634	46,751	46,231	49,456	51,703	56,862	59,570	61,640	63,951	63,538	61,196
Jet fuel:												
Naphtha-type	8,423	8,292	8,562	7,913	7,528	7,491	7,652	7,726	7,486	7,456	6,806	7,235
Kerosine-type	10,515	10,888	11,521	10,821	12,075	12,307	15,374	15,970	15,139	13,597	14,037	12,139
Total	18,938	19,180	20,083	18,734	19,603	19,798	23,026	23,696	22,625	21,053	20,843	19,374
Lubricants	13,818	14,095	13,631	13,089	13,101	12,546	12,507	12,599	12,371	12,241	r 12,507	12,682
Wax	905	907	856	846	815	814	870	857	854	858	865	861
Coke	7,752	7,732	7,919	7,849	7,813	7,759	7,910	7,781	7,528	7,418	7,294	7,297
Asphalt	19,454	22,387	24,467	26,794	26,515	23,586	20,890	16,860	15,260	13,282	14,405	17,309
Road oil	731	877	1,221	1,480	1,449	1,201	1,166	951	847	746	689	919
Liquefied refinery gases [1]	2,761	2,602	2,364	2,354	2,927	3,051	3,625	3,803	3,787	4,008	3,694	3,336
Petrochemical feedstocks	3,602	3,968	3,946	2,928	2,780	2,795	2,888	2,992	2,569	2,619	2,790	2,476
Miscellaneous	1,764	2,034	1,949	1,772	2,015	1,904	2,077	2,086	2,002	2,219	2,244	2,128
Unfinished oils	86,086	84,628	88,517	90,838	95,610	97,833	96,014	91,762	92,377	92,601	90,837	89,213
Total	569,546	546,442	543,350	537,135	555,163	555,528	586,190	596,818	614,766	628,652	r 616,127	595,651

See footnotes at end of table.

Table 27.—Stocks of refined petroleum products in the United States at end of month—Continued

(Thousand barrels)

Product	January	February	March	April	May	June	July	August	September	October	November	December
1967:												
Gasoline:												
Motor	204,198	212,869	208,458	206,835	199,054	190,237	186,969	176,382	182,891	182,597	184,131	199,790
Aviation	8,238	8,318	7,694	7,868	7,887	7,523	7,311	7,325	7,628	7,556	7,545	7,925
Total	212,436	221,187	216,152	214,703	206,941	197,760	194,280	183,707	190,519	190,153	191,676	207,715
Special naphthas	5,680	5,636	5,445	5,618	5,418	5,327	5,618	5,579	5,674	5,587	5,616	5,742
Kerosine	21,498	18,265	17,199	18,670	19,426	21,612	23,718	25,066	25,513	26,373	25,858	25,008
Distillate fuel oil	131,278	104,676	87,049	92,797	96,358	113,048	132,633	154,502	176,644	186,674	172,822	157,078
Residual fuel oil	59,108	56,602	52,899	58,612	59,838	61,239	62,714	63,737	65,530	64,956	61,416	62,496
Jet fuel:												
Naphtha-type	7,252	7,716	7,754	7,510	7,219	7,916	8,038	8,290	7,408	8,186	8,316	9,023
Kerosine-type	12,189	12,945	12,664	12,723	13,230	13,389	12,980	13,294	13,657	13,631	13,725	13,174
Total	19,441	20,661	20,418	20,233	20,449	21,305	21,018	21,584	21,065	21,817	22,041	22,197
Lubricants	13,144	13,743	13,421	13,536	13,628	13,429	13,853	13,806	13,573	13,997	13,822	14,774
Wax	870	877	876	883	941	941	1,005	1,002	959	977	952	1,045
Coke	7,445	7,372	7,266	7,100	6,860	6,933	7,253	7,039	7,066	7,001	6,684	6,821
Asphalt	20,351	23,036	25,405	26,809	27,073	25,022	23,709	19,034	16,760	15,645	17,166	19,939
Road oil	1,115	1,188	1,475	1,857	1,786	1,760	1,589	1,283	1,101	868	769	804
Liquefied refinery gases [1]	3,061	3,014	3,058	3,367	4,224	4,371	4,317	4,409	4,768	5,379	5,153	4,925
Petrochemical feedstocks	2,655	2,741	2,805	3,077	3,291	3,392	3,252	3,262	3,289	3,066	3,103	3,254
Miscellaneous	1,929	1,941	1,883	2,087	1,845	1,966	1,986	1,935	2,002	2,040	1,652	1,703
Unfinished oils	89,617	90,822	95,435	97,604	100,887	96,501	97,342	96,061	91,023	94,274	93,554	90,201
Total	589,628	571,761	550,786	566,953	568,965	574,606	594,287	602,006	625,486	638,807	622,284	623,702

r Revised.
[1] Includes L.R.G. used for petrochemical feedstocks.

Table 28.—Value of crude petroleum at wells in the United States, by States

State	1966		1967	
	Total value at wells (thousands)	Average value per barrel	Total value at wells (thousands)	Average value per barrel
Alabama	$20,878	$2.60	$19,500	$2.65
Alaska	44,007	3.06	91,164	3.13
Arizona	370	2.80	8,188	2.80
Arkansas	63,372	2.66	56,902	2.70
California	812,834	2.35	829,133	2.31
Colorado	97,462	2.91	99,003	2.92
Illinois	184,983	3.00	179,792	3.04
Indiana	31,850	3.00	30,041	2.98
Kansas	306,027	2.95	297,600	3.00
Kentucky	51,488	2.85	45,052	2.90
Louisiana:				
Gulf coast	1,936,430	3.12	2,254,162	3.13
Northern	160,699	2.96	165,661	3.01
Total	2,097,129	3.11	2,419,823	3.12
Michigan	40,913	2.87	39,455	2.89
Mississippi	146,353	2.65	155,726	2.72
Montana	86,273	2.44	87,543	2.50
Nebraska	37,673	2.72	36,775	2.75
New Mexico:				
Southeastern	320,854	2.84	338,408	2.94
Northwestern	31,247	2.75	29,932	2.70
Total	352,101	2.84	368,340	2.92
New York	7,925	4.57	9,026	4.58
North Dakota	69,170	2.55	65,818	2.60
Ohio	32,700	3.00	31,427	3.17
Oklahoma	654,281	2.91	676,095	2.93
Pennsylvania	19,300	4.45	19,701	4.49
South Dakota	479	2.00	502	2.38
Texas: [1]				
Gulf Coast	632,368	3.22	705,718	3.27
East Texas Field	137,579	3.05	158,860	3.06
West Texas	1,420,820	2.88	1,525,226	2.92
Panhandle	103,147	2.95	103,288	2.97
Rest of State	847,473	2.95	882,473	2.97
Total	3,141,387	2.97	3,375,565	3.01
Utah	63,760	2.64	63,221	2.63
West Virginia	14,623	3.98	14,244	4.00
Wyoming	344,243	2.56	351,685	2.58
Other States [2]	4,842	2.19	4,406	2.28
Total United States	8,726,423	2.88	9,375,727	2.92

[1] Texas Railroad Commission Divisions.
[2] Florida, Missouri, Nevada, Tennesse, and Virginia.

Table 29.—Posted price per barrel of petroleum at wells in the United States in 1967 by grade, with data change

Date	Pennsylvania grade: Bradford and Allegheny districts	Pennsylvania grade: In southwest Pennsylvania	Corning grade	Western Kentucky	Indiana-Illinois	Coldwater, Mich.	Oklahoma-Kansas: 34°–34.9°	Oklahoma-Kansas: 36°–36.9°
January 1	4.63	4.08	3.02	3.10	3.10	2.90	2.92	3.00
August 1	----	----	3.07	3.15	3.15	2.95	2.91	2.99

Date	Panhandle, Texas (Carson, Gray, Hutchinson, and Wheeler Counties) 35°–35.9°	West Texas 30°–30.9° (sweet)	Lea, County, N. Mex. 30°–30.9° (sour)	South Texas Mirando 24°–24.9°	East Texas	Conroe Texas	Texas: 30°–30.9°	Texas: 20°–20.9°	Louisiana 30°–30.9°
January 1	2.92	2.86	2.80	3.05	3.15	3.35	3.10	2.90	3.10
July 10	2.97	----	----	----	----	----	----	----	----
July 18	----	2.91	----	----	----	----	----	----	----
August 8	----	----	----	3.15	----	----	----	----	----

Date	Caddo-Pine Island, La. 36°–36.9°	Magnolia-Smackover, Limestone, Ark. 31°–31.9°	Elk Basin Wyo. (including Montana) 30°–30.9°	California: Coalinga 32°–32.9°	California: Kettleman Hills 37°–37.9°	California: Midway Sunset 19°–19.9°	California: Wilmington 24°–24.9°
January 1	2.97	2.62	2.68	2.96	3.21	2.23	2.58
February 1	----	2.67	----	----	----	----	----
August 1	----	2.72	----	----	----	----	----
August 8	3.05	----	----	----	----	----	----

Source: Platt's Oil Price Handbook.

Table 30.—Wholesale price index, crude petroleum

(1957–59 = 100)

Year	Average	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1958	101.2	101.5	101.5	101.5	101.5	101.4	101.4	100.9	100.9	100.9	100.9	100.9	100.9
1959	97.8	99.1	97.9	97.9	98.0	98.0	98.0	98.0	98.0	97.2	97.2	97.2	97.2
1960	97.2	97.2	97.2	97.2	97.2	97.2	97.2	97.2	97.2	97.2	97.2	97.2	97.2
1961	97.5	97.2	97.2	97.2	97.5	97.5	97.5	97.5	97.5	97.5	97.8	97.8	97.8
1962	97.7	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.8	97.7	97.7	97.7
1963	97.3	97.7	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.2	97.2	97.2
1964	96.9	97.2	97.2	97.2	97.2	97.2	96.8	96.8	96.7	96.7	96.7	96.7	96.7
1965	96.8	96.7	96.7	96.7	96.7	96.7	96.7	96.7	96.7	96.7	96.7	96.7	96.9
1966	97.5	96.9	97.0	97.0	97.0	97.2	97.4	97.5	97.7	97.7	98.1	98.1	98.1
1967	98.6	98.2	98.3	98.3	98.3	98.3	98.3	98.4	99.0	99.0	99.0	99.0	99.0

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

Table 31.—Average monthly price of petroleum products in the United States, 1966–1967

Monthly average and grade	Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average for year
Gasoline 92 octane (cents per gallon):														
At refineries in Oklahoma	1966	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25	12.25
	1967	12.25	12.37	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.52	12.38
Tank wagon prices to dealers at 55 cities on first of month	1966	15.55	15.78	15.53	15.57	15.65	15.91	15.94	15.91	16.11	16.02	15.93	16.02	15.83
	1967	16.05	15.98	16.46	16.44	16.33	16.21	16.48	16.36	16.59	16.30	16.31	16.25	16.31
At service station (including all taxes)	1966	31.53	31.80	31.45	31.64	31.73	32.25	32.27	32.33	32.61	32.44	32.38	32.50	32.08
	1967	32.58	32.53	33.23	33.22	33.03	32.97	33.42	33.31	33.68	33.33	33.33	33.24	33.16
Kerosine (cents per gallon):														
No. 1 range at Chicago district	1966	10.50	10.58	10.36	10.13	10.07	10.00	10.00	10.00	10.00	10.00	10.00	10.09	10.14
	1967	10.21	10.25	10.24	10.02	10.00	10.00	10.00	10.39	10.53	10.54	10.57	10.71	10.29
No. 1 fuel oil at Oklahoma	1966	10.63	10.63	10.63	10.48	10.38	10.38	10.38	10.38	10.38	10.38	10.38	10.38	10.45
	1967	10.55	10.81	10.81	10.81	10.81	10.81	10.81	10.81	10.81	10.81	10.81	10.81	10.79
Kerosine (or No. 1 fuel oil) at New York Harbor	1966	11.20	11.20	11.20	10.83	10.80	10.80	10.80	10.88	11.00	11.00	11.29	11.35	11.03
	1967	11.44	11.60	11.60	11.60	11.51	11.51	11.78	11.80	11.80	11.80	11.80	11.80	11.67
Kerosine (or No. 1 fuel oil) at Tampa	1966	11.36	11.54	12.05	12.05	12.05	12.05	12.05	11.39	11.27	10.83	10.70	10.65	11.50
	1967	10.97	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.10	11.50	11.50	10.18
Distillate and diesel fuel oil (cents per gallon):														
No 2 fuel oil at refineries, Oklahoma	1966	9.63	9.63	9.63	9.48	9.38	9.38	9.38	9.38	9.38	9.38	9.38	9.38	9.45
	1967	9.55	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.79
No 2 fuel oil at New York Harbor	1966	10.20	10.20	10.20	9.74	9.70	9.70	9.70	9.74	10.00	10.00	10.29	10.35	9.99
	1967	10.44	10.60	10.60	10.60	10.51	10.78	10.80	10.80	10.80	10.80	10.80	10.80	10.67
Diesel oil, shore plants, New York	1966	10.50	10.50	10.55	10.18	10.15	10.15	10.15	10.22	10.35	10.35	10.35	10.58	10.34
	1967	10.78	10.90	10.90	10.90	10.81	10.81	11.08	11.10	11.10	11.10	11.10	11.10	10.97
Diesel oil for ships (dollars per barrel):														
New York	1966	4.31	4.31	4.31	4.20	4.18	4.18	4.18	4.21	4.28	4.28	4.28	4.36	4.26
	1967	4.40	4.47	4.47	4.47	4.47	4.47	4.60	4.61	4.61	4.61	4.63	4.58	4.53
New Orleans	1966	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
	1967	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.31	4.39	4.27
San Pedro	1966	5.09	5.09	5.09	4.75	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.44	4.63
	1967	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.55	4.59	4.59	4.59	4.59	4.50

Residual fuel oil (dollars per barrel):														
No. 6 fuel at refineries, Oklahoma	[1] 1966	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
No. 5 fuel oil at New York Harbor	1966	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.78	2.76
	1967	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
Bunker "C" for ships:														
New York	1966	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
	1967	2.25	2.25	2.25	2.25	2.25	2.25	2.30	2.33	2.35	2.38	2.36	2.32	2.29
New Orleans	1966	2.19	2.19	2.19	2.19	2.19	2.19	2.19	2.19	2.19	2.19	2.19	2.19	2.19
	1967	2.19	2.19	2.19	2.19	2.19	2.19	2.24	2.27	2.27	2.27	2.29	2.26	2.23
San Pedro	1966	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
	1967	2.20	2.20	2.20	2.20	2.20	1.99	1.93	1.93	1.93	1.93	1.93	1.93	2.05
Lubricating oil (cents per gallon):														
Oklahoma:														
200 viscosity, No. 3 color neutral	[1] 1966	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50
150–160 viscosity at 210° bright stock, 10–25 pour test	[1] 1966	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50
Pennsylvania:														
200 viscosity, No. 3 color, neutral 420–425 flash, 25 pour test	[1] 1966	28.00	28.00	28.00	28.00	28.00	28.00	29.74	30.00	30.00	30.00	30.00	30.00	28.98
600 steam refined cylinder stock filterable	[1] 1966	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.50	22.04
South Texas: 500 viscosity, No. 2½–3½ color, neutral	[1] 1966	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	1966	8.13	8.13	8.13	8.13	8.13	8.14	8.25	8.25	8.25	8.58	8.75	8.75	8.30
	1967	9.21	9.25	9.25	9.25	9.25	9.10	8.75	8.75	8.75	8.75	8.75	8.75	8.98
Oklahoma	1966	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.08	5.48	5.50	5.52	5.13
	1967	5.94	6.00	6.00	6.00	6.00	5.87	5.75	5.75	5.75	5.75	5.75	5.73	5.86
Baton Rouge	1966	5.25	5.25	5.25	5.46	5.50	5.50	5.50	5.50	5.57	5.75	5.75	5.77	5.50
	1967	6.19	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.24
Wax (cents per pound): Pennsylvania 124° to 126°, white crude scale	[1] 1966	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13

[1] No change in price during 1967.

Source: Platt's Oil Price Handbook.

Table 32.—Salient statistics of the major refined petroleum products in the United States

(Thousand barrels)

	1964	1965	1966	1967 p
Gasoline production:				
At refineries	1,649,400	1,693,741	1,783,700	1,838,522
At gas processing plants	11,901	10,660	8,938	7,364
Total	1,661,301	1,704,401	1,792,638	1,845,886
Stocks end of year	193,633	183,058	194,177	207,715
Imports	10,482	10,052	15,648	15,215
Exports	6,209	4,827	3,786	4,889
Domestic demand	1,657,906	1,720,201	1,793,381	1,842,674
Motor gasoline production:				
At refineries	1,598,186	1,645,172	1,742,456	1,801,448
At gas processing plants	11,901	10,660	8,938	7,364
Total	1,610,087	1,655,832	1,751,394	1,808,812
Stocks end of year	185,766	174,717	186,393	199,790
Imports	10,482	10,052	15,648	15,215
Exports	683	629	434	841
Domestic demand	1,611,348	1,676,304	1,754,932	1,809,789
Aviation gasoline production	51,214	48,569	41,244	37,074
Stocks end of year	7,867	8,341	7,784	7,925
Exports	5,526	4,198	3,352	4,048
Domestic demand	46,558	43,897	38,449	32,885
Special naphthas production:				
At refineries	25,878	28,734	29,634	26,912
At gas processing plants	266	123	116	51
Total	26,144	28,857	29,750	26,963
Stocks end of year	5,879	6,209	5,583	5,742
Imports	4,144	2,864	1,895	375
Exports	1,830	1,564	2,010	1,975
Domestic demand	27,551	29,827	30,261	25,204
Kerosine (including range oil) production:				
At refineries	93,474	93,149	100,849	99,061
At gas processing plants	1,493	1,306	1,226	1,144
Total	94,967	94,455	102,075	100,205
Stocks end of year	27,325	24,080	25,004	25,008
Imports	4	100	219	33
Exports	170	219	254	156
Domestic demand	92,738	97,581	101,116	100,078
Distillate fuel oil production:				
At refineries	742,046	765,071	784,717	804,429
At gas processing plants	393	359	1,132	366
Total	742,439	765,430	785,849	804,795
Crude used directly as distillate	755	773	752	730
Stocks end of year	155,846	155,407	154,096	157,078
Imports	11,785	13,002	13,845	18,492
Exports	5,386	3,830	4,377	4,287
Domestic demand	750,424	775,814	797,380	816,748
Residual fuel oil production	266,825	268,567	263,961	275,956
Crude used directly as residual	3,720	3,950	3,551	3,671
Stocks end of year	40,403	56,214	61,196	62,496
Imports	295,771	345,187	376,795	395,754
Exports	18,870	14,882	12,895	21,955
Domestic demand	554,581	587,011	626,430	652,126
Jet fuel production:				
At refineries	182,131	191,055	215,446	273,185
At gas processing plants	409	113	50	38
Total	182,540	191,168	215,496	273,223
Stocks end of year	18,744	18,699	19,374	22,197
Imports	23,243	29,426	31,338	32,391
Exports	170	1,007	1,773	2,021
Domestic demand	204,253	219,632	244,386	300,770

See footnotes at end of table.

Table 32.—Salient statistics of the major refined petroleum products in the United States —Continued

(Thousand barrels)

	1964	1965	1966	1967 p
Naphtha type production:				
At refineries	NA	82,416	89,473	109,650
At gas processing plants	NA	113	50	38
Total	NA	82,529	89,523	109,688
Stocks end of year	NA	8,338	7,235	9,023
Imports	NA	15,948	12,574	5,450
Exports	NA	694	1,565	1,802
Domestic demand	NA	97,813	101,635	111,548
Kerosine type jet fuel production	NA	108,639	125,973	163,535
Stocks end of year	NA	10,361	12,139	13,174
Imports	NA	13,478	18,764	26,941
Exports	NA	313	208	219
Domestic demand	NA	121,819	142,751	189,222
Lubricant production	63,668	62,925	65,407	64,870
Stocks end of year	14,062	13,304	12,682	14,774
Imports	37	29	32	40
Exports:				
Grease	397	385	376	357
Oil	17,779	16,207	16,736	18,209
Total	18,176	16,592	17,112	18,566
Domestic demand	45,788	47,120	48,949	44,252
Wax [1] production	5,352	5,456	5,772	5,719
Stocks end of year	908	890	861	1,045
Imports	----------	11	5	20
Exports	1,734	1,654	1,888	1,688
Domestic demand	3,596	3,831	3,918	3,867
Coke [1] production:				
Marketable coke	34,872	36,318	38,508	42,944
Catalyst coke	49,453	49,722	49,546	47,989
Total	84,325	86,040	88,054	90,933
Stocks end of year	6,795	7,389	7,297	6,821
Exports	13,618	11,819	14,466	16,279
Domestic demand	70,395	73,627	73,680	75,130
Asphalt [1] production	114,879	123,604	129,579	127,767
Stocks end of year	14,231	16,178	17,309	19,939
Imports (including natural)	5,912	6,302	6,104	6,447
Exports	759	362	482	421
Domestic demand	120,155	127,597	134,070	131,163
Road oil production	6,371	6,565	7,247	6,978
Stocks end of year	579	584	919	804
Domestic demand	6,545	6,560	6,912	7,093
Still gas for fuel production	131,257	135,295	135,459	140,034
Liquefied gases (including ethane) for fuel and chemical use:				
LRG production:				
For fuel use	59,244	56,125	60,090	67,589
For chemical use	47,268	50,711	46,128	43,928
Total	106,512	106,836	106,218	111,517
Stocks of LRG end of year:				
For fuel use	3,074	2,816	3,130	4,741
For chemical use	618	849	206	184
Total	3,692	3,665	3,336	4,925
LPG for fuel and chemical use:				
Delivered from gas processing plants	189,619	200,218	215,081	233,900
Imports	4,128	7,553	10,489	9,885
Exports	5,358	7,521	8,181	9,279
Domestic demand:				
LRG for fuel use	59,516	56,383	59,776	65,978
LRG for chemical use	47,190	50,480	46,771	43,950
LPG for fuel and chemical use	188,389	200,250	217,389	234,506
Total	295,095	307,113	323,936	344,434

See footnotes at end of table.

Table 32.—Salient statistics of the major refined petroleum products in the United States —Continued

(Thousand barrels)

	1964	1965	1966	1967 p
Petrochemical feedstocks production	57,578	57,851	74,453	87,428
Stocks end of year	2,569	4,093	2,476	3,254
Imports:				
Naphtha–400°	---------	130	436	280
Other	---------	370	---------	---------
Total	---------	500	436	280
Exports:				
Other	---------	1,952	2,710	2,995
Domestic demand:				
Still gas	7,698	8,926	10,068	9,532
Naphtha–400°	24,583	23,521	39,854	50,349
Other	25,318	22,428	23,874	24,054
Total	57,599	54,875	73,796	83,935
Miscellaneous production:				
At refineries	13,583	13,994	16,474	14,919
At gas processing plants	3,194	2,913	1,956	1,554
Total	16,777	16,907	18,430	16,473
Stocks end of year	1,819	1,809	2,128	1,703
Exports	236	962	989	903
Domestic demand	16,353	15,955	17,122	15,995
Unfinished oils (net):				
Input (plus) Output (minus)	27,322	32,111	34,632	34,237
Stocks end of year	87,014	88,609	89,213	90,201
Imports	32,587	33,706	35,236	35,225
Shortage or (overage)	79,335	80,241	89,535	106,592

p Preliminary. NA Not available.

[1] Conversion factors: 280 pounds of wax to the barrel; 5 barrels of coke to the short ton; 5.5 barrels of asphalt to the short ton.

Table 33.—Input and output of petroleum products at refineries in the United States

(Thousand barrels)

	1963	1964 [1]	1965	1966	1967 [p]
Input:					
Crude petroleum:					
Domestic	2,758,168	2,785,895	2,847,821	3,000,789	3,174,004
Foreign	412,484	437,434	453,021	446,404	408,590
Total crude petroleum	3,170,652	3,223,329	3,300,842	3,447,193	3,582,594
Unfinished oils rerun (net)	31,934	27,322	32,111	34,632	34,237
Total crude and unfinished oils rerun	3,202,586	3,250,651	3,332,953	3,481,825	3,616,831
Natural gas liquids	190,143	213,264	225,676	235,580	244,720
Benzol	80	29	13	30	87
Output:					
Gasoline:					
Motor gasoline	NA	1,598,186	1,645,172	1,742,456	1,801,448
Aviation gasoline		51,214	48,569	41,244	37,074
Total gasoline [2]	1,581,209	1,649,400	1,693,741	1,783,700	1,838,522
Special naphthas [2]	22,687	25,878	[1] 28,734	29,634	26,912
Kerosine [2]	164,805	93,474	93,149	100,849	99,061
Distillate fuel oil [2]	764,597	742,046	765,071	784,717	804,429
Residual fuel oil	275,910	266,825	268,567	263,961	275,956
Jet fuel:					
Naphtha type	NA	NA	82,416	89,473	109,650
Kerosine type			108,639	125,973	163,535
Total jet fuel [2]	98,745	182,131	191,055	215,446	273,185
Lubricants	63,086	63,668	62,925	65,407	64,870
Wax [3]	5,126	5,352	5,456	5,772	5,719
Coke [3]	80,688	84,325	86,040	88,054	90,933
Asphalt [3]	111,948	114,879	123,604	129,579	127,767
Road oil	6,792	6,371	6,565	7,247	6,978
Still gas for fuel	129,598	131,257	135,295	135,459	140,034
Liquefied refinery gas (incl. ethane):					
For fuel use	56,394	59,244	56,125	60,090	67,590
For chemical use	38,963	47,268	50,711	46,128	43,927
Total liquefied refinery gas	95,357	106,512	106,836	106,218	111,517
Petrochemical feedstocks:					
Still gas	7,834	7,698	8,926	10,068	9,500
Naphtha-400	21,984	24,657	24,511	38,446	50,573
Other	22,575	25,223	24,414	25,939	27,355
Total petrochemical feedstocks	52,393	57,578	57,851	74,453	87,428
Miscellaneous products [2]	13,578	13,583	13,994	16,474	14,919
Shortage (or overage) [4]	−73,710	−79,335	−80,241	−89,535	−106,592

p Preliminary. NA Not available.

[1] New basis, comparable to 1965 data.

[2] Production at natural gasoline plants shown as direct transfers and omitted from the input and output at the 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.

[4] Includes losses or gains in volume during processing.

Table 34.—Percentage yields of refined petroleum products from crude oil in the United States [1]

Product	1963	1964 [2]	1965	1966	1967 [p]
Finished products:					
Gasoline	44.1	44.1	44.0	44.4	44.0
Special naphthas	(3)	.8	.9	.9	.8
Kerosine	5.1	2.9	2.8	2.9	2.7
Distillate fuel oil	23.9	22.8	22.9	22.5	22.2
Residual fuel oil	8.6	8.2	8.1	7.6	7.7
Jet fuel	3.1	5.6	5.7	6.2	7.5
Lubricating oil	2.0	2.0	1.9	1.8	1.8
Wax	.1	.2	.2	.2	.2
Coke	2.6	2.6	2.5	2.5	2.5
Asphalt	3.5	3.5	3.7	3.8	3.5
Road oil	.2	.2	.2	.2	.2
Still gas	4.0	4.0	4.1	3.9	3.9
Liquefied gases	1.8	3.3	3.2	3.0	3.1
Petrochemical feedstocks	2.8	1.8	1.7	2.1	2.4
Other finished products	.4	.4	.5	.5	.4
Shortage	−2.2	−2.4	−2.4	−2.5	−2.9
Total	100.0	100.0	100.0	100.0	100.0

p Preliminary.
[1] Other unfinished oils added to crude in computing yields.
[2] New basis, comparable to 1965 data.
[3] Included with gasoline.

Table 35.—Input and output at refineries in the United States, by months

(Thousand barrels)

	January	February	March	April	May	June	July	August	September	October	November	December	Total
1966:													
Input:													
Crude petroleum:													
Domestic	251,325	227,527	247,109	237,265	251,691	247,917	259,783	258,902	253,711	257,350	245,183	263,026	3,000,789
Foreign	39,293	34,104	38,163	34,444	38,429	37,648	39,986	39,003	36,361	38,031	35,705	35,237	446,404
Total crude petroleum	290,618	261,631	285,272	271,709	290,120	285,565	299,769	297,905	290,072	295,381	280,888	298,263	3,447,193
Unfinished oils rerun (net)	5,716	3,364	−410	482	−1,646	375	4,723	8,214	2,719	2,022	4,200	4,873	34,632
Total crude and unfinished oils rerun	296,334	264,995	284,862	272,191	288,474	285,940	304,492	306,119	292,791	297,403	285,088	303,136	3,481,825
Natural gas liquids	20,724	17,925	18,835	18,594	18,592	18,487	19,554	19,605	19,461	20,743	21,024	22,036	235,580
Benzol	1	1	-------	-------	1	2	4	-------	5	5	5	6	30
Output:													
Gasoline:													
Motor gasoline	147,996	129,822	142,267	136,281	143,593	142,917	151,683	152,893	147,133	151,285	145,053	151,533	1,742,456
Aviation gasoline	3,700	3,291	3,348	3,029	3,274	3,179	3,542	3,581	3,513	3,575	3,472	3,740	41,244
Total gasoline [1]	151,696	133,113	145,615	139,310	146,867	146,096	155,225	156,474	150,646	154,860	148,525	155,273	1,783,700
Special naphthas [1]	2,655	2,340	2,490	2,250	2,659	2,502	2,397	2,553	2,588	2,581	2,345	2,274	29,634
Kerosine [1]	10,128	9,604	9,418	6,910	7,375	7,107	8,024	8,928	7,603	7,709	8,090	9,953	100,849
Distillate fuel oil [1]	70,042	62,696	64,577	60,282	63,739	61,979	67,201	69,074	65,765	66,460	63,087	69,815	784,717
Residual fuel oil	26,305	22,185	23,792	20,501	20,521	19,565	21,621	20,896	20,372	21,197	21,741	25,265	263,961
Jet fuel:													
Naphtha type	6,407	5,336	6,561	6,952	7,074	7,440	7,512	8,207	8,006	8,981	8,104	8,893	89,473
Kerosine type	10,364	10,318	11,311	10,694	11,396	11,143	10,257	8,129	9,695	10,483	11,538	10,645	125,973
Total jet fuel	16,771	15,654	17,872	17,646	18,470	18,583	17,769	16,336	17,701	19,464	19,642	19,538	215,446
Lubricants:													
Bright stock	590	480	496	465	489	381	519	551	537	570	459	624	6,161
Neutral	2,339	2,030	2,204	2,265	2,363	2,101	2,514	2,452	2,339	2,352	2,120	2,354	27,433
Other grades	2,696	2,612	2,662	2,569	2,783	2,651	2,765	2,762	2,547	2,923	2,635	2,208	31,813
Total lubricants	5,625	5,122	5,362	5,299	5,635	5,133	5,798	5,765	5,423	5,845	5,214	5,186	65,407
Wax:													
Microcrystalline	78	88	94	79	85	100	95	99	88	81	82	78	1,037
Fully refined	260	244	295	280	264	298	273	270	210	268	304	290	3,251
Other	161	112	124	141	140	100	131	103	172	113	93	94	1,484
Total wax [2]	494	439	513	500	489	498	499	472	470	457	479	462	5,772

See footnotes at end of table.

Table 35.—Input and output at refineries in the United States, by months—Continued

(Thousand barrels)

	January	February	March	April	May	June	July	August	September	October	November	December	Total
1966—Continued													
Output—Continued													
Coke [2]	7,788	6,761	7,388	6,906	7,240	7,097	7,351	7,651	7,027	7,391	7,589	7,865	88,054
Asphalt [2]	6,580	6,027	7,956	10,253	11,430	13,795	14,057	14,817	14,194	12,946	10,026	7,498	129,579
Road oil	210	199	486	554	573	874	1,369	1,257	771	424	172	358	7,247
Still gas for fuel	11,179	10,453	10,060	11,143	11,412	11,577	12,296	11,990	11,609	11,022	11,111	11,607	135,459
Liquefied gases (including ethane):													
LRG for fuel use	5,357	4,927	5,282	4,874	5,349	4,865	5,075	5,035	4,614	4,775	4,829	5,108	60,090
LRG for chemical use	4,261	3,922	3,648	4,197	4,444	3,430	3,854	4,113	3,522	3,499	3,574	3,664	46,128
Total liquefied gases	9,618	8,849	8,930	9,071	9,793	8,295	8,929	9,148	8,136	8,274	8,403	8,772	106,218
Petrochemical feedstocks:													
Still gas	742	648	927	941	774	813	739	894	864	951	824	951	10,068
Naphtha-400 degrees	2,439	2,474	2,626	2,664	2,708	3,351	3,736	3,883	3,247	3,743	3,856	3,719	38,446
Other	1,860	1,793	2,070	2,240	2,271	2,212	2,345	2,335	1,966	2,141	2,225	2,481	25,939
Total petrochemical feedstocks	5,041	4,915	5,623	5,845	5,753	6,376	6,820	7,112	6,077	6,835	6,905	7,151	74,453
Miscellaneous products [1]	1,153	1,311	1,231	1,305	1,446	1,466	1,473	1,563	1,288	1,442	1,439	1,357	16,474
Processing gain	−8,226	−6,747	−7,616	−6,990	−6,335	−6,514	−6,779	−8,312	−7,413	−8,756	−8,651	−7,196	−89,535
1967: p													
Input:													
Crude petroleum:													
Domestic	255,130	239,192	260,742	246,025	259,873	257,899	275,874	277,278	272,054	278,822	267,711	283,404	3,174,004
Foreign	38,642	29,185	35,319	36,840	37,220	36,682	34,154	32,465	29,903	32,114	31,369	34,697	408,590
Total crude petroleum	293,772	268,377	296,061	282,865	297,093	294,581	310,028	309,743	301,957	310,936	299,080	318,101	3,582,594
Unfinished oils rerun (net)	3,734	1,468	−1,275	1,061	−63	8,009	1,547	3,624	7,705	−608	3,156	5,879	34,237
Total crude and unfinished oils rerun	297,506	269,845	294,786	283,926	297,030	302,590	311,575	313,367	309,662	310,328	302,236	323,980	3,616,831
Natural gas liquids	21,787	18,798	19,731	18,212	18,767	19,418	19,910	20,159	19,853	22,565	22,962	22,558	244,720
Benzol	8	7	7	6	7	7	11	6	6	7	8	7	87
Output:													
Gasoline:													
Motor gasoline	150,258	132,804	142,734	139,099	147,763	151,990	155,446	156,344	155,001	155,636	151,870	162,503	1,801,448
Aviation gasoline	3,273	3,103	2,901	3,016	3,503	2,818	3,082	3,332	3,277	3,149	2,901	2,719	37,074
Total gasoline [1]	153,531	135,907	145,635	142,115	151,266	154,808	158,528	159,676	158,278	158,785	154,771	165,222	1,838,522
Special naphthas [1]	2,249	2,160	2,152	2,398	2,197	2,210	2,274	2,389	2,252	2,294	2,241	2,096	26,912
Kerosine [1]	9,992	9,058	8,380	7,042	6,788	6,391	7,513	7,381	7,541	8,495	9,976	10,504	99,061

Distillate fuel oil [1]	68,584	61,854	70,099	62,964	62,723	64,861	67,612	68,227	69,087	69,170	65,492	73,756	804,429
Residual fuel oil	25,390	23,184	24,184	22,782	21,566	21,584	21,459	21,141	20,892	21,734	24,504	27,536	275,956
Jet fuel:													
Naphtha type	7,748	7,670	8,391	8,792	8,359	9,573	9,446	9,685	10,021	10,278	10,346	9,341	109,650
Kerosine type	11,621	12,294	13,084	13,134	14,330	13,860	14,263	14,164	13,492	14,804	13,815	14,674	163,535
Total jet fuel [1]	19,369	19,964	21,475	21,926	22,689	23,433	23,709	23,849	23,513	25,082	24,161	24,015	273,185
Lubricants:													
Bright stock	491	554	520	537	571	539	602	564	530	475	502	719	6,604
Neutral	2,357	2,248	2,696	2,468	2,502	2,244	2,466	2,429	2,315	2,314	2,482	2,537	29,058
Other grades	2,629	2,246	2,243	2,414	2,632	2,568	2,357	2,465	2,311	2,714	2,276	2,353	29,208
Total lubricants	5,477	5,048	5,459	5,419	5,705	5,351	5,425	5,458	5,156	5,503	5,260	5,609	64,870
Wax:													
Microcrystalline	99	105	75	118	105	80	94	93	88	99	104	97	1,157
Fully refined	278	210	236	274	225	231	241	226	217	257	238	281	2,914
Other	93	128	164	131	168	149	143	157	127	174	108	106	1,648
Total wax [2]	470	443	475	523	498	460	478	476	432	530	450	484	5,719
Coke [2]	7,684	6,704	7,615	7,099	7,727	7,675	8,024	7,699	7,644	7,613	7,417	8,032	90,933
Asphalt [2]	6,943	5,737	8,124	8,982	11,872	12,773	14,321	14,858	13,721	13,418	10,084	6,934	127,767
Road oil	297	241	457	560	565	942	1,210	1,159	651	471	236	189	6,978
Still gas for fuel	11,241	10,004	10,941	10,551	12,485	12,646	12,550	12,547	12,192	12,249	11,307	11,321	140,034
Liquefied gases (including ethane):													
LRG for fuel use	5,541	5,123	5,806	5,536	6,222	5,665	5,644	5,643	5,838	5,498	5,330	5,744	67,590
LRG for chemical use	3,867	3,265	3,969	4,049	3,766	3,785	3,474	3,235	3,653	3,392	3,455	4,017	43,927
Total liquefied gases	9,408	8,388	9,775	9,585	9,988	9,450	9,118	8,878	9,491	8,890	8,785	9,761	111,517
Petrochemical feedstocks:													
Still gas	896	690	804	705	659	643	751	843	819	931	868	891	9,500
Naphtha–400°	4,331	3,553	4,362	3,968	4,012	4,286	3,580	3,981	3,975	4,638	4,816	5,071	50,573
Other	2,208	2,104	2,400	2,141	2,378	2,234	2,372	2,381	2,495	2,237	2,254	2,151	27,355
Total petrochemical feedstocks	7,435	6,347	7,566	6,814	7,049	7,163	6,703	7,205	7,289	7,806	7,938	8,113	87,428
Miscellaneous products [1]	1,320	1,213	1,247	1,385	1,222	1,367	1,263	1,138	1,231	1,305	1,023	1,205	14,919
Processing gain	−10,089	−7,602	−9,060	−8,001	−8,536	−9,099	−8,691	−8,549	−9,849	−10,445	−8,439	−8,232	−106,592

p Preliminary.
[1] Production at natural gas processing plants shown as direct transfers and omitted from the input and output at refineries.
[2] 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 36.—Input and output at refineries

(Thousand

	PAD district 1			PAD district 2				
	East Coast	Appalachian No. 1	Total	Appalachian No. 2	Ind., Ill., etc.	Minn., Wisc., etc.	Okla., Kans., etc.	Total
1966:								
Input:								
Crude petroleum:								
Domestic	172,175	27,984	200,159	28,513	615,951	27,648	298,627	970,739
Foreign	244,818	14,504	259,322	------	15,936	31,560	-------	47,496
Total crude petroleum	416,993	42,488	459,481	28,513	631,887	59,208	298,627	1,018,235
Unfinished oils rerun (net)	51,158	611	51,769	1,587	−2,930	−34	−77	−1,454
Total crude and unfinished oils rerun	468,151	43,099	511,250	30,100	628,957	59,174	298,550	1,016,781
Natural gas liquids	5,698	89	5,787	462	20,627	2,437	18,466	41,992
Benzol	-------	------	-------	------	24	------	-------	24
Output:								
Gasoline:								
Motor gasoline	211,530	16,571	228,101	15,354	336,523	30,810	173,680	556,367
Aviation gasoline	2,300	19	2,319	------	4,605	------	1,165	5,770
Total gasoline [1]	213,830	16,590	230,420	15,354	341,128	30,810	174,845	562,137
Special naphthas [1]	1,300	437	1,737	177	3,628	------	2,431	6,236
Kerosine [1]	11,749	1,255	13,004	643	18,021	2,317	3,365	24,346
Distillate fuel oil [1]	122,456	10,587	133,043	5,837	128,908	14,467	72,129	221,341
Residual fuel oil	35,132	4,314	39,446	2,262	42,571	5,616	3,941	54,390
Jet fuel:								
Naphtha type	2,805	736	3,541	22	9,064	2,037	6,965	18,088
Kerosine type	9,057	259	9,316	715	20,436	------	7,737	28,888
Total jet fuel [1]	11,862	995	12,857	737	29,500	2,037	14,702	46,976
Lubricants:								
Bright stock	695	1,270	1,965	8	944	------	562	1,514
Neutral	2,952	1,674	4,626	176	5,040	------	3,092	8,308
Other grades	3,314	621	3,935	222	156	------	1,484	1,862
Total lubricants	6,961	3,565	10,526	406	6,140	------	5,138	11,684
Wax:								
Microcrystalline	251	222	473	------	24	------	200	224
Fully refined	1,338	71	1,409	53	218	------	244	515
Other	468	175	643	16	122	------	77	215
Total wax [2]	2,057	468	2,525	69	364	------	521	954
Coke [2]	13,652	217	13,869	289	18,562	2,710	8,010	29,571
Asphalt [2]	27,750	1,359	29,109	3,299	26,756	2,278	12,328	44,661
Road oil	13	793	806	------	1,519	215	1,835	3,569
Still gas for fuel	17,364	1,641	19,005	1,426	29,019	1,538	11,742	43,725
Liquefied gases (including ethane):								
LRG for fuel use	10,771	760	11,531	454	10,365	1,190	7,673	19,682
LRG for chemical use	3,528	------	3,528	------	1,839	------	340	2,179
Total liquefied gases	14,299	760	15,059	454	12,204	1,190	8,013	21,861
Petrochemical feedstocks:								
Still gas	1,846	------	1,846	------	1,410	------	-------	1,410
Naphtha-400°	2,298	------	2,298	------	3,542	------	1,528	5,070
Other	707	256	963	------	2,529	------	71	2,600
Total petrochemical feedstocks	4,851	256	5,107	------	7,481	------	1,599	9,080
Miscellaneous products [1]	1,658	171	1,829	16	1,052	106	2,387	3,561
Processing gain	−11,085	−220	−11,305	−407	−17,245	−1,673	−5,970	−25,295

See footnotes at end of table.

in the United States, by districts

barrels)

PAD district 3						PAD district 4	PAD district 5	United States Total
Texas Inland	Texas Gulf	La. Gulf	Ark., La., Inland etc.	N. Mex.	Total	Other Rocky Mountain	West Coast	
124,001	797,618	356,737	46,817	12,267	1,337,440	118,642	373,809	3,000,789
----------	----------	432	----------	----------	432	4,858	134,296	446,404
124,001	797,618	357,169	46,817	12,267	1,337,872	123,500	508,105	3,447,193
887	−15,407	−9,274	598	35	−23,161	487	6,991	34,632
124,888	782,211	347,895	47,415	12,302	1,314,711	123,987	515,096	3,481,825
23,386	103,591	22,730	7,159	1,077	157,943	4,757	25,101	235,580
----------	----------	----------	----------	----------	----------	6	----------	30
77,455	399,459	158,004	24,240	7,620	666,778	62,836	228,374	1,742,456
3,519	9,504	10,807	----------	----------	23,830	802	8,523	41,244
80,974	408,963	168,811	24,240	7,620	690,608	63,638	236,897	1,783,700
1,009	16,520	521	748	----------	18,798	559	2,304	29,634
1,546	44,344	12,678	1,738	173	60,479	2,542	478	100,849
20,923	203,001	91,531	11,597	2,175	329,227	28,354	72,752	784,717
4,867	35,815	11,652	1,800	347	54,481	10,687	104,957	263,961
10,179	20,540	11,211	1,410	1,199	44,539	3,924	19,381	89,473
7,412	23,486	23,307	107	----------	54,312	1,313	32,144	125,973
17,591	44,026	34,518	1,517	1,199	98,851	5,237	51,525	215,446
----------	1,562	701	----------	----------	2,263	43	376	6,161
----------	6,531	5,901	132	----------	12,564	247	1,688	27,433
156	19,221	1,117	2,059	----------	22,553	187	3,276	31,813
156	27,314	7,719	2,191	----------	37,380	477	5,340	65,407
66	182	84	----------	----------	332	8	----------	1,037
----------	525	389	----------	----------	914	96	317	3,251
----------	412	23	----------	----------	435	10	181	1,484
66	1,119	496	----------	----------	1,681	114	498	5,772
2,198	17,376	8,919	1,970	183	30,646	3,007	10,961	88,054
5,849	7,983	8,445	5,981	883	29,141	7,840	18,828	129,579
----------	29	----------	----------	----------	29	1,553	1,290	7,247
5,456	26,956	10,326	2,172	517	45,427	4,654	22,648	135,459
3,141	8,306	7,622	793	242	20,104	1,632	7,141	60,090
143	28,178	7,295	203	----------	35,819	----------	4,602	46,128
3,284	36,484	14,917	996	242	55,923	1,632	11,743	106,218
----------	5,890	----------	----------	----------	5,890	----------	922	10,068
1,374	24,006	820	42	----------	26,242	----------	4,836	38,446
2,584	7,103	11,285	244	188	21,404	328	644	25,939
3,958	36,999	12,105	286	188	53,536	328	6,402	74,453
1,020	5,222	909	8	----------	7,159	195	3,730	16,474
−623	−26,349	−12,922	−670	−148	−40,712	−2,067	−10,156	−89,535

Table 36.—Input and output at refineries in

(Thousand

	PAD district 1			PAD district 2				
	East Coast	Appalachian No. 1	Total	Appalachian No. 2	Ind., Ill., etc.	Minn., Wisc., etc.	Okla., Kans., etc.	Total
1967:[p]								
Input:								
Crude petroleum:								
Domestic	223,522	24,734	248,256	21,796	627,106	24,916	309,274	983,092
Foreign	194,458	19,817	214,275	------	22,147	34,766	-------	56,913
Total crude petroleum	417,980	44,551	462,531	21,796	649,253	59,682	309,274	1,040,005
Unfinished oils rerun (net)	55,649	1,459	57,108	551	−1,225	−57	−171	−902
Total crude and unfinished oils rerun	473,629	46,010	519,639	22,347	648,028	59,625	309,103	1,039,103
Natural gas liquids	4,851	123	4,974	128	21,534	2,579	19,978	44,219
Benzol	-------	------	-------	------	56	------	13	69
Output:								
Gasoline:								
Motor gasoline	214,918	17,409	232,327	11,825	345,566	30,721	179,419	567,531
Aviation gasoline	1,879	27	1,906	------	3,796	------	1,247	5,043
Total gasoline	216,797	17,436	234,233	11,825	349,362	30,721	180,666	572,574
Special naphthas [1]	1,067	386	1,453	342	3,462	------	2,316	6,120
Kerosine [1]	12,184	1,087	13,271	748	18,166	2,289	4,954	26,157
Distillate fuel oil [1]	123,238	11,137	134,375	4,698	134,567	15,107	73,002	227,374
Residual fuel oil	36,272	4,669	40,941	1,788	44,222	5,435	4,750	56,195
Jet fuel:								
Naphtha-type	5,425	1,435	6,860	32	8,649	1,763	8,720	19,164
Kerosine-type	11,033	391	11,424	20	24,133	------	9,090	33,243
Total jet fuel [1]	16,458	1,826	18,284	52	32,782	1,763	17,810	52,407
Lubricants:								
Bright stock	454	1,233	1,687	------	637	------	1,030	1,667
Neutral	2,499	1,839	4,338	279	4,245	------	3,232	7,756
Other grades	3,543	769	4,312	------	1,398	------	1,209	2,607
Total lubricants	6,496	3,841	10,337	279	6,280	------	5,471	12,030
Wax:								
Microcrystalline	268	219	487	------	22	------	254	276
Fully refined	1,075	67	1,142	41	254	------	221	516
Other	586	163	749	18	133	------	88	239
Total wax [2]	1,929	449	2,378	59	409	------	563	1,031
Coke [2]	14,376	139	14,515	92	18,617	2,659	7,765	29,133
Asphalt [2]	26,595	1,705	28,300	1,810	28,134	2,452	12,714	45,110
Road oil	-------	709	709	------	1,896	111	1,278	3,285
Still gas for fuel	17,512	1,771	19,283	1,075	29,098	1,842	11,526	43,541
Liquefied gases (including ethane):								
LRG for fuel use	10,819	654	11,473	331	11,039	1,267	8,890	21,527
LRG for chemical use	3,947	------	3,947	------	2,254	------	431	2,685
Total liquefied gases	14,766	654	15,420	331	13,293	1,267	9,321	24,212
Petrochemical feedstocks:								
Still gas	1,635	------	1,635	------	1,396	------	-------	1,396
Naphtha–400°	2,642	11	2,653	------	4,106	------	2,047	6,153
Other	733	319	1,052	------	2,365	------	407	2,772
Total petrochemical feedstocks	5,010	330	5,340	------	7,867	------	2,454	10,321
Miscellaneous products [1]	1,617	181	1,798	6	1,019	111	1,802	2,938
Processing gain	−15,837	−187	−16,024	−630	−19,556	−1,553	−7,298	−29,037

[p] Preliminary.
[1] Production at gas processing plants shown as direct transfers and omitted from the input and output at refineries.
[2] 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 3						PAD district 4	PAD district 5	United States total
Texas Inland	Texas Gulf	La. Gulf	Ark., La., Inland, etc.	N. Mex.	Total	Other Rocky Mountain	West Coast	
127,650	833,245	401,460	49,201	12,438	1,423,994	118,895	399,767	3,174,004
----------	----------	619	----------	----------	619	6,511	130,272	408,590
127,650	833,245	402,079	49,201	12,438	1,424,613	125,406	530,039	3,582,594
−374	−24,911	−7,113	422	59	−31,917	−360	10,308	34,237
127,276	808,334	394,966	49,623	12,497	1,392,696	125,046	540,347	3,616,831
23,738	107,804	28,032	5,581	1,129	166,284	4,792	24,451	244,720
15	----------	----------	----------	----------	15	3	----------	87
80,820	401,830	188,269	24,004	7,554	702,477	63,192	235,921	1,801,448
3,500	9,307	9,098	----------	----------	21,905	791	7,429	37,074
84,320	411,137	197,367	24,004	7,554	724,382	63,983	243,350	1,838,522
1,083	13,471	589	769	6	15,918	613	2,808	26,912
1,585	37,015	16,433	1,797	161	56,991	1,987	655	99,061
21,052	214,853	92,901	11,538	2,210	342,554	28,000	72,126	804,429
4,440	40,052	14,773	1,770	423	61,458	10,832	106,530	275,956
9,659	27,620	13,441	1,564	1,390	53,674	4,279	25,673	109,650
7,808	33,276	34,937	313	----------	76,334	2,539	39,995	163,535
17,467	60,896	48,378	1,877	1,390	130,008	6,818	65,668	273,185
----------	1,955	721	----------	----------	2,676	33	541	6,604
----------	8,647	5,851	494	----------	14,992	280	1,692	29,058
156	17,306	1,093	1,502	----------	20,057	64	2,168	29,208
156	27,908	7,665	1,996	----------	37,725	377	4,401	64,870
76	216	91	----------	----------	383	11	----------	1,157
----------	564	335	----------	----------	899	66	291	2,914
----------	374	82	----------	----------	456	22	182	1,648
76	1,154	508	----------	----------	1,738	99	473	5,719
2,253	16,735	9,365	2,007	190	30,550	3,066	13,669	90,933
5,846	8,197	8,548	6,017	794	29,402	7,337	17,618	127,767
53	42	----------	----------	----------	95	1,437	1,452	6,978
4,549	27,362	11,250	2,112	498	45,771	4,504	26,935	140,034
3,394	11,475	7,223	1,466	282	23,840	2,249	8,501	67,590
454	23,730	8,322	230	----------	32,736	----------	4,559	43,927
3,848	35,205	15,545	1,696	282	56,576	2,249	13,060	111,517
----------	5,799	----------	----------	----------	5,799	----------	670	9,500
1,429	32,814	1,600	611	19	36,473	----------	5,294	50,573
2,511	9,285	10,249	285	140	22,470	336	725	27,355
3,940	47,898	11,849	896	159	64,742	336	6,689	87,428
1,138	3,881	1,131	10	----------	6,160	522	3,501	14,919
−777	−29.668	−13,304	−1,285	−41	−45,075	−2,319	−14,137	−106,592

Table 37.—Salient statistics of motor and aviation gasoline in the United States, by months

(Thousand barrels)

	January	February	March	April	May	June	July	August	September	October	November	December	Total
1966:													
Production:													
Gasoline produced at refineries:													
Motor gasoline	147,996	129,822	142,267	136,281	143,593	142,917	151,683	152,893	147,133	151,285	145,053	151,533	1,742,456
Aviation gasoline	3,700	3,291	3,348	3,029	3,274	3,179	3,542	3,581	3,513	3,575	3,472	3,740	41,244
Motor gasoline produced at natural-gas processing plants	766	725	701	820	837	744	771	720	641	668	767	778	8,938
Total gasoline production	152,462	133,838	146,316	140,130	147,704	146,840	155,996	157,194	151,287	155,528	149,292	156,051	1,792,638
Daily average	4,918	4,780	4,720	4,671	4,765	4,895	5,032	5,071	5,043	5,017	4,976	5,034	4,911
Stocks, end of period:													
Motor gasoline	194,984	203,088	205,033	198,980	195,555	178,661	176,344	169,844	172,351	177,791	180,187	186,393	186,393
Aviation gasoline	8,495	9,099	9,168	8,965	8,066	7,208	6,956	7,184	7,325	7,410	7,054	7,784	7,784
Total stocks	203,479	212,187	214,201	207,945	203,621	185,869	183,300	177,028	179,676	185,201	187,241	194,177	194,177
Imports: Motor gasoline	713	1,026	1,365	1,103	1,790	1,251	1,464	1,483	1,715	1,270	1,123	1,345	15,648
Exports:													
Motor gasoline	104	29	17	21	12	42	14	16	51	103	14	11	434
Aviation gasoline	122	225	160	102	330	410	182	394	525	309	334	259	3,352
Total exports	226	254	177	123	342	452	196	410	576	412	348	270	3,786
Domestic demand:													
Motor gasoline	129,104	123,440	142,371	144,236	149,633	161,764	156,221	161,580	146,931	147,680	144,533	147,439	1,754,932
Aviation gasoline	3,424	2,462	3,119	3,130	3,843	3,627	3,612	2,959	2,847	3,181	3,494	2,751	38,449
Total domestic demand	132,528	125,902	145,490	147,366	153,476	165,391	159,833	164,539	149,778	150,861	148,027	150,190	1,793,381

1967: p													
Production:													
Gasoline produced at refineries:													
Motor gasoline	150,258	132,804	142,734	139,099	147,763	151,990	155,446	156,344	155,001	155,636	151,870	162,503	1,801,448
Aviation gasoline	3,273	3,103	2,901	3,016	3,503	2,818	3,082	3,332	3,277	3,149	2,901	2,719	37,074
Motor gasoline produced at natural-gas processing plants	810	539	604	564	561	666	655	604	554	605	577	625	7,364
Total gasoline production	154,341	136,446	146,239	142,679	151,827	155,474	159,183	160,280	158,832	159,390	155,348	165,847	1,845,886
Daily average	4,979	4,873	4,717	4,756	4,898	4,756	5,135	5,170	5,294	5,142	5,178	5,350	5,057
Stocks, end of period:													
Motor gasoline	204,198	212,869	208,458	206,835	199,054	190,237	186,969	176,382	182,891	182,597	184,131	199,790	199,790
Aviation gasoline	8,238	8,318	7,694	7,868	7,887	7,523	7,311	7,325	7,628	7,556	7,545	7,925	7,925
Total stocks	212,436	221,187	216,152	214,703	206,941	197,760	194,280	183,707	190,519	190,153	191,676	207,715	207,715
Imports: Motor gasoline	1,472	1,623	1,202	1,891	1,818	1,063	771	823	1,244	1,129	1,101	1,078	15,215
Exports:													
Motor gasoline	25	22	10	11	22	8	135	299	270	15	16	8	841
Aviation gasoline	258	382	301	338	285	182	571	332	436	279	369	315	4,048
Total exports	283	404	311	349	307	190	706	631	706	294	385	323	4,889
Domestic demand:													
Motor gasoline	134,710	126,273	148,941	143,166	157,901	162,528	160,005	168,059	150,020	157,649	151,998	148,539	1,809,789
Aviation gasoline	2,561	2,641	3,224	2,504	3,199	3,000	2,723	2,986	2,538	2,942	2,543	2,024	32,885
Total domestic demand	137,271	128,914	152,165	145,670	161,100	165,528	162,728	171,045	152,558	160,591	154,541	150,563	1,842,674

p Preliminary.

Table 38.—Production of gasoline at refineries and natural gas processing plants in the United States in 1967 p, by districts and months

(Thousand barrels)

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Motor gasoline at refineries:													
East Coast	19,037	16,687	18,057	16,377	17,905	16,731	17,832	18,100	18,740	18,563	17,924	18,965	214,918
Appalachian No. 1	1,421	1,357	1,553	1,276	1,404	1,503	1,449	1,395	1,494	1,501	1,528	1,528	17,409
Appalachian No. 2	950	807	938	935	1,100	1,001	1,064	1,049	982	921	1,049	1,029	11,825
Indiana, Illinois, Kentucky, etc.	29,577	26,201	27,216	26,525	27,847	27,785	29,975	29,617	29,282	29,580	29,615	32,346	345,566
Minnesota, Wisconsin, etc.	2,782	2,455	2,690	1,975	1,907	2,460	2,732	2,720	2,639	2,663	2,793	2,905	30,721
Oklahoma, Kansas, etc.	15,714	13,718	14,953	13,477	14,702	15,509	15,690	15,211	14,905	15,267	14,580	15,693	179,419
Texas Inland	6,942	5,908	6,344	6,628	7,020	6,579	6,497	6,955	6,900	7,005	7,050	6,992	80,820
Texas Gulf Coast	31,935	28,901	32,207	32,347	32,571	34,287	34,854	35,523	34,973	35,478	33,265	35,489	401,830
Louisiana Gulf Coast	14,026	12,576	14,606	14,966	15,666	16,194	16,486	15,965	17,092	16,411	16,152	18,129	188,269
Arkansas, Louisiana Inland, etc.	2,039	2,000	2,146	1,940	1,985	1,850	1,960	2,097	1,878	1,949	2,018	2,142	24,004
New Mexico	647	612	676	640	617	657	627	635	563	569	666	645	7,554
Rocky Mountain	5,546	4,991	5,097	4,512	5,201	5,373	5,550	5,444	5,533	4,985	5,219	5,741	63,192
West Coast	19,642	16,591	16,251	17,501	19,838	22,061	20,730	21,633	20,020	20,744	20,011	20,899	235,921
Total	150,258	132,804	142,734	139,099	147,763	151,990	155,446	156,344	155,001	155,636	151,870	162,503	1,801,448
Aviation gasoline at refineries:													
East Coast	183	172	255	186	189	173	121	203	64	181	79	73	1,879
Appalachian No. 1	-------	5	-------	-------	4	7	-------	-------	4	7	-------	-------	27
Appalachian No. 2	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Indiana, Illinois, Kentucky, etc.	330	362	449	290	291	299	367	338	270	320	243	237	3,796
Minnesota, Wisconsin, etc.	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Oklahoma, Kansas, etc.	68	87	81	164	106	69	129	107	111	93	109	123	1,247
Texas Inland	255	175	375	264	252	255	313	355	346	287	263	360	3,500

Texas Gulf Coast	921	864	574	713	603	695	698	784	1,016	806	747	886	9,307
Louisiana Gulf Coast	825	912	671	681	1,253	718	959	706	636	678	682	377	9,098
Arkansas, Louisiana Inland, etc	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	--------
New Mexico	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	--------
Rocky Mountain	46	62	65	66	54	61	77	88	79	71	55	67	791
West Coast	645	464	431	652	751	541	418	751	751	706	723	596	7,429
Total	3,273	3,103	2,901	3,016	3,503	2,818	3,082	3,332	3,277	3,149	2,901	2,719	37,074
Motor gasoline produced at natural-gas processing plants:													
East Coast	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	--------
Appalachian No. 1	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	--------
Appalachian No. 2	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	--------
Indiana, Illinois, Kentucky, etc	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	--------
Minnesota, Wisconsin, etc	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	--------
Oklahoma, Kansas, etc	26	4	1	-------	1	1	3	3	4	3	3	1	50
Texas Inland	182	143	163	147	168	162	165	149	124	155	86	76	1,720
Texas Gulf Coast	34	28	31	26	31	24	31	28	25	29	30	27	344
Louisiana Gulf Coast	196	165	172	172	171	212	218	205	154	200	169	242	2,276
Arkansas Louisiana, Inland, etc	372	199	237	219	190	267	238	219	247	218	289	279	2,974
New Mexico	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	--------
Rocky Mountain	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	--------
West Coast	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	--------
Total	810	539	604	564	561	666	655	604	554	605	577	625	7,364
Grand total:													
1967	154,341	136,446	146,239	142,679	151,827	155,474	159,183	160,280	158,832	159,390	155,348	165,847	1,845,886
1966	152,462	133,838	146,316	140,130	147,704	146,840	155,996	157,194	151,287	155,528	149,292	156,051	1,792,638

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Table 39.—Consumption, production, and distribution of motor gasoline in 1967 [1] by PAD districts

(Million barrels)

	PAD districts					
	I	II	III	IV	V	Total
Consumption [2]	621.5	635.8	232.3	58.6	260.3	1,808.5
Supply:						
Production [3]	232.3	567.6	709.8	63.2	235.9	1,808.8
Imports	9.5	-------	-------	-------	5.7	15.2
Received from other districts:						
From 1	------	28.9	.1	-------	-------	-------
From 2	8.4	-------	18.3	.2	-------	-------
From 3	412.9	64.8	-------	3.5	16.0	-------
From 4	-----	3.4	-------	-------	15.5	-------
From 5	-----	-------	-------	4.1	-------	-------
Total receipts	421.3	97.1	18.4	7.8	31.5	-------
Total supply	663.1	664.7	728.2	71.0	273.1	1,824.0
Stock change	+4.8	−.9	+8.7	−.7	+1.5	+13.4
Shipped to other districts	29.0	26.9	497.2	18.9	4.1	-------
Exports	-----	-------	.7	-------	.1	.8
Domestic demand	629.3	638.7	221.6	52.8	267.4	1,809.8
Difference between consumption and demand	−7.8	−2.9	+10.7	+5.8	−7.1	−1.3

[1] Apparent distribution of motor gasoline by districts is based on pipeline, tidewater, and river shipments compiled by the Bureau of Mines, an estimate of annual interdistrict railroad shipments was computed from the 1963 data compiled by the Bureau of Transport Economics, Interstate Commerce Commission, and records compiled by the San Francisco office of the Bureau of Mines. An estimate of shipments moving from PAD district 2 by way of the Great Lakes and the Ohio River to PAD district 1 was computed from 1964 data compiled by the U.S. Army Corps of Engineers.

[2] Compiled from data supplied by the American Petroleum Institute.

[3] Includes motor gasoline produced at natural-gas processing plants.

Table 40.—Production (refinery output) and consumption of gasoline (excluding naphtha) in the United States, by States

(Thousand barrels)

	1965		1966		1967 p	
	Production	Consumption [1]	Production	Consumption [1]	Production	Consumption [1]
Alabama	(2)	29,613	(2)	31,138	(2)	32,179
Alaska	---------	1,898	---------	1,967	---------	2,020
Arizona	---------	15,356	---------	16,202	---------	16,720
Arkansas	13,572	18,423	13,067	19,057	13,128	19,796
California	[3] 232,072	177,909	[3] 236,897	185,251	[3] 243,350	189,963
Colorado	6,302	19,570	6,533	20,363	6,821	21,702
Connecticut	---------	23,061	---------	24,062	---------	24,844
Delaware	(4)	5,503	(4)	5,518	(4)	5,752
District of Columbia	---------	5,433	---------	5,518	---------	5,467
Florida	---------	55,342	---------	58,625	---------	61,803
Georgia	(5)	40,104	(5)	42,268	(5)	44,621
Hawaii	(3)	4,713	(3)	4,792	(3)	4,820
Idaho	---------	7,747	---------	7,986	---------	8,340
Illinois	118,032	87,796	129,538	91,999	129,482	94,642
Indiana	81,841	49,376	85,371	51,471	85,879	52,622
Iowa	---------	31,237	---------	33,092	---------	34,292
Kansas	68,158	26,754	73,915	27,198	77,683	27,699
Kentucky	18,401	26,601	[6] 19,592	27,777	[6] 22,641	29,295
Louisiana	172,849	28,615	[2] 179,984	29,899	[2] 208,243	31,277
Maine	---------	9,232	---------	9,540	---------	9,768
Maryland	(5)	27,537	(5)	29,363	(5)	30,745
Massachusetts	[4] 22,174	40,358	[4] 23,651	41,540	[4] 22,337	42,639
Michigan	25,486	79,494	27,782	83,649	25,664	85,379
Minnesota	15,362	36,227	17,210	38,103	17,578	38,910
Mississippi	(-)	18,976	(2)	20,255	(4)	21,192
Missouri	[7] 13,131	46,579	[7] 15,225	48,230	[7] 14,532	49,594
Montana	15,603	9,349	17,014	9,350	18,757	9,458
Nebraska	(7)	16,873	(7)	17,629	(7)	18,190
Nevada	---------	5,813	---------	6,089	---------	6,184
New Hampshire	---------	5,873	---------	6,298	---------	6,621
New Jersey	74,003	56,452	82,070	57,963	81,670	59,139
New Mexico	7,069	11,214	7,620	11,507	7,554	11,589
New York	12,849	122,829	10,431	127,346	10,881	133,159
Norrh Carolina	---------	44,119	---------	46,290	---------	48,818
North Dakota	[8] 12,982	8,458	[8] 13,600	8,419	[8] 13,143	8,401
Ohio	92,765	88,453	94,199	92,140	97,521	94,649
Oklahoma	78,712	30,176	85,705	31,723	88,451	32,227
Oregon	---------	20,044	---------	20,975	---------	21,668
Pennsylvania	101,585	87,167	106,447	89,436	110,613	85,525
Rhode Island	(4)	6,677	(4)	6,886	(4)	7,099
South Carolina	(5)	21,481	(5)	22,846	(5)	23,890
South Dakota	---------	9,437	---------	9,362	---------	9,481
Tennessee	(6)	33,741	(6)	35,955	(6)	37,845
Texas	465,567	127,904	489,937	137,446	495,457	139,126
Utah	19,174	10,744	20,493	11,159	20,429	11,717
Vermont	---------	3,803	---------	4,048	---------	4,336
Virginia	[5] 6,887	38,105	[5] 7,220	40,063	[5] 8,044	42,102
Washington	(3)	29,351	(3)	30,105	(3)	31,821
West Virginia	642	12,968	601	13,658	688	14,171
Wisconsin	(8)	37,002	(8)	38,556	(8)	39,532
Wyoming	18,523	4,850	19,598	4,997	17,976	5,106
Total	1,693,741	1,756,337	1,783,700	1,835,109	1,838,522	1,887,935

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[1] American Petroleum Institute.
[2] Alabama and Mississippi included with Louisiana.
[3] Washington and Hawaii included with California.
[4] Delaware and Rhode Island with Massachusetts.
[5] Maryland, South Carolina, and Georgia included with Virginia.
[6] Tennessee included with Kentucky.
[7] Nebraska included with Missouri.
[8] Wisconsin included with North Dakota.

Table 41.—Stocks of gasoline in the United States in 1967, by districts and months

(Thousand barrels)

	Jan. 31	Feb. 28	Mar. 31	Apr. 30	May 31	June 30	July 31	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
Motor gasoline:												
East Coast	49,355	49,331	48,802	48,793	47,150	43,195	43,110	42,877	45,067	46,855	48,761	52,224
Appalachian No. 1	5,586	5,871	5,846	5,366	5,316	4,848	5,078	4,877	4,975	4,621	4,794	5,601
Appalachian No. 2	3,338	3,376	3,422	3,829	3,665	3,296	3,330	2,972	2,822	2,888	2,902	3,109
Indiana, Illinois, Kentucky, etc	36,760	40,166	39,019	39,169	35,676	31,710	31,141	28,999	29,864	28,301	28,264	32,191
Minnesota, Wisconsin, North Dakota and South Dakota	6,589	6,667	7,254	7,010	6,720	6,514	6,591	6,351	6,215	5,747	6,261	6,781
Oklahoma, Kansas, etc	20,662	22,455	22,715	21,672	19,714	19,080	18,303	16,539	16,647	16,609	15,724	16,697
Texas Inland	9,449	9,655	9,396	9,492	8,903	7,973	7,026	5,949	6,465	6,486	6,983	7,875
Texas Gulf	22,722	23,101	22,183	20,926	21,562	22,334	23,637	21,755	22,253	23,249	22,698	25,296
Louisiana Gulf Coast	11,892	13,089	12,765	13,302	13,300	14,208	14,852	14,438	15,510	14,647	14,018	14,769
Arkansas, Louisiana Inland, etc	8,835	9,199	9,290	9,476	8,753	8,630	7,261	7,158	7,433	8,878	8,366	8,572
New Mexico	778	839	794	714	714	632	652	641	685	687	800	886
Rocky Mountain	7,240	8,296	8,746	8,190	7,987	7,126	5,947	4,612	4,552	4,313	4,676	5,578
West Coast	20,992	20,824	18,226	18,896	19,594	20,691	20,041	19,214	20,403	19,316	19,884	20,211
Total	204,198	212,869	208,458	206,835	199,054	190,237	186,969	176,382	182,891	182,597	184,131	199,790
Aviation gasoline:												
East Coast	1,343	1,190	1,115	1,263	1,252	1,343	1,134	1,037	1,031	1,111	1,177	1,192
Appalachian No. 1	113	122	110	107	98	85	100	95	101	84	58	84
Appalachian No. 2	29	33	30	28	26	25	26	22	19	20	21	15
Indiana, Illinois, Kentucky, etc	1,227	1,268	1,403	1,409	1,290	1,245	1,336	1,253	1,129	988	942	1,077
Minnesota, Wisconsin, North Dakota and South Dakota	141	128	95	102	98	107	126	91	139	217	205	191
Oklahoma, Kansas, etc	307	332	387	403	401	324	301	384	282	261	318	326

Texas Inland	587	462	492	525	530	518	493	448	510	504	498	632
Texas Gulf	1,688	1,711	1,456	1,256	1,313	1,236	1,236	1,347	1,470	1,648	1,470	1,642
Louisiana Gulf Coast	1,405	1,747	1,407	1,435	1,533	1,284	1,262	1,426	1,519	1,322	1,412	1,271
Arkansas, Louisiana Inland, etc	1	-------	61	1	1	20	27	1	27	1	26	1
New Mexico	28	35	24	30	27	7	13	12	4	11	12	20
Rocky Mountain	130	143	166	150	148	139	149	130	143	143	123	145
West Coast	1,239	1,147	948	1,159	1,170	1,190	1,108	1,079	1,254	1,246	1,283	1,329
Total	8,238	8,318	7,694	7,868	7,887	7,523	7,311	7,325	7,628	7,556	7,545	7,925
Total motor and aviation stocks: [1]												
East Coast	50,698	50,521	49,917	50,056	48,402	44,538	44,244	43,914	46,098	47,966	49,938	53,416
Appalachian No. 1	5,699	5,903	5,956	5,473	5,414	4,933	5,178	4,972	5,076	4,705	4,852	5,685
Appalachian No. 2	3,367	3,409	3,452	3,857	3,691	3,321	3,356	2,994	2,841	2,908	2,923	3,124
Indiana, Illinois, Kentucky, etc	37,987	41,434	40,422	40,578	36,966	32,955	32,477	30,252	30,993	29,289	29,206	33,268
Minnesota, Wisconsin, North Dakota and South Dakota	6,730	6,795	7,349	7,112	6,818	6,621	6,717	6,442	6,354	5,964	6,466	6,972
Oklahoma, Kansas, etc	20,969	22,877	23,102	22,075	20,115	19,404	18,604	16,923	16,929	16,870	16,042	17,023
Texas Inland	10,036	10,117	9,888	10,017	9,433	8,491	7,519	6,397	6,975	6,990	7,481	8,507
Texas Gulf	24,410	24,812	23,639	22,182	22,875	23,570	24,873	23,102	23,723	24,897	24,168	26,938
Louisiana Gulf Coast	13,297	14,836	14,172	14,737	14,833	15,492	16,114	15,864	17,029	15,969	15,430	16,040
Arkansas, Louisiana Inland, etc	8,836	9,199	9,351	9,477	8,754	8,650	7,288	7,159	7,460	8,879	8,392	8,573
New Mexico	806	874	818	744	741	639	665	653	689	698	812	906
Rocky Mountain	7,370	8,439	8,912	8,340	8,135	7,265	6,096	4,742	4,695	4,456	4,799	5,723
West Coast	22,231	21,971	19,174	20,055	20,764	21,881	21,149	20,293	21,657	20,562	21,167	21,540
Total:												
1967	212,436	221,187	216,152	214,703	206,941	197,760	194,280	183,707	190,519	190,153	191,676	207,715
1966	203,479	212,187	214,201	207,945	203,621	185,869	183,300	177,028	179,676	185,201	187,241	194,177

[1] Includes stocks of gasoline at refineries, bulk terminals and pipelines.

Table 42.—Shipments of aviation fuels

(Thousand barrels)

Product and use	Shipments to PAD districts: I	II	III	IV	V	United States total
1966:						
Aviation gasoline:						
For commercial use:						
Airlines	3,770	3,217	1,037	383	1,167	9,574
Factory	76	60	92	-------	20	248
General aviation	2,066	2,289	1,464	349	1,616	7,784
Total	5,912	5,566	2,593	732	2,803	17,606
For military use	3,415	2,213	6,500	506	5,849	18,483
Jet fuel:						
For commercial use:						
Airlines	48,830	25,436	9,997	4,023	36,921	125,207
Factory	1,143	523	127	-------	663	2,456
General aviation	1,246	897	1,355	70	567	4,135
Total	51,219	26,856	11,479	4,093	38,151	131,798
For military use: [1]						
JP-4	20,611	19,038	13,895	1,801	29,730	85,075
JP-5	1,491	321	7,450	-------	4,907	14,169
Other	131	192	99	1	613	1,036
Total	22,233	19,551	21,444	1,802	35,250	100,280
1967:						
Aviation gasoline:						
For commercial use:						
Airlines	2,509	2,286	602	254	267	5,918
Factory	81	48	64	2	19	214
General aviation	1,993	2,337	1,550	361	2,733	8,974
Total	4,583	4,671	2,216	617	3,019	15,106
For military use	5,593	3,005	4,636	488	6,015	19,737
Jet fuel:						
For commercial use:						
Airlines	64,196	34,403	12,821	4,897	51,508	167,825
Factory	1,172	479	180	-------	697	2,528
General aviation	1,703	1,692	465	81	1,548	5,489
Total	67,071	36,574	13,466	4,978	53,753	175,842
For military use: [2]						
JP-4	30,867	20,889	20,586	3,759	36,959	113,060
JP-5	5,260	191	3,128	-------	7,343	15,922
Other	104	75	165	-------	591	935
Total	36,231	21,155	23,879	3,759	44,893	129,917

[1] Does not include 8,028,000 barrels imported directly by the military in PAD district 1, and 1,926,000 barrels in PAD district 5.

[2] None was imported directly by the military in PAD district 1; does not include 783,000 barrels imported directly by the military in PAD district 5.

Definitions of terms used in this table.

1. Aviation gasoline—Any fuel in the gasoline boiling range for use in a piston-type aviation engine.
2. Jet fuel—Any fuel for use in an aviation turbine engine.
3. 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 nonschedule carriers, air taxi, etc.
4. Factory—Direct sales to airframe and engine manufacturers.
5. General aviation—Primarily sales to distributors and airport dealers.
6. Military—Sales to Defense Fuel Supply Center and to other military agencies of the Government.

Table 43.—Salient statistics of kerosine in the United States, by months and refinery districts

(Thousand barrels unless otherwise stated)

Month and district	1966							1967 p						
	Production at refineries	Yield (percent)	Production at gas processing plants	Imports	Exports	Stocks (end of period)	Domestic demand	Production at refineries	Yield (percent)	Production at gas processing plants	Imports	Exports	Stocks (end of period)	Domestic demand
Month:														
January	10,128	3.4	124	27	28	20,209	14,122	9,992	3.4	89	------	13	21,498	13,574
February	9,604	3.6	147	------	15	17,866	12,079	9,058	3.4	125	------	19	18,265	12,397
March	9,418	3.3	80	------	29	18,676	8,659	8,380	2.8	137	------	10	17,199	9,573
April	6,910	2.6	109	------	22	19,565	6,108	7,042	2.5	111	33	13	18,670	5,702
May	7,375	2.5	70	130	30	21,259	5,851	6,788	2.3	160	------	21	19,426	6,171
June	7,107	2.5	78	------	27	23,542	4,875	6,391	2.1	76	------	7	21,612	4,274
July	8,024	2.6	102	------	14	27,092	4,562	7,513	2.4	65	------	11	23,718	5,461
August	8,928	2.9	115	------	9	30,253	5,873	7,381	2.4	79	------	11	25,066	6,101
September	7,603	2.6	61	------	29	30,428	7,460	7,541	2.4	59	------	12	25,513	7,141
October	7,709	2.6	108	62	19	30,434	7,854	8,495	2.7	71	------	2	26,373	7,704
November	8,090	2.8	67	------	16	27,915	10,660	9,976	3.3	82	------	29	25,858	10,544
December	9,953	3.3	165	------	16	25,004	13,013	10,504	3.2	90	------	8	25,008	11,436
Total	100,849	2.9	1,226	219	254	25,004	101,116	99,061	2.7	1,144	33	156	25,008	100,078
District:														
East Coast	11,749	2.5	------	219	99	10,441		12,184	2.6	------	33	47	10,126	
Appalachian No. 1	1,255	2.9	------			640		1,087	2.4	------			629	
Appalachian No. 2	643	2.1	------			265		748	3.4	------			302	
Indiana, Illinois, Kentucky, etc.	18,021	2.8	------			4,733		18,166	2.8	------			4,745	
Minnesota, Wisconsin, etc.	2,317	3.9	------	------	24	1,013		2,289	3.9	------	------	10	865	
Oklahoma, Kansas, etc.	3,365	1.2	------			1,129		4,954	1.6	------			1,125	
Texas Inland	1,546	1.2	263			333	NA	1,585	1.2	203			336	NA
Texas Gulf Coast	44,344	5.7	59			2,834		37,015	4.6	59			3,014	
Louisiana Gulf Coast	12,678	3.6	392	------	59	1,899		16,433	4.1	406	------	57	2,222	
Arkansas, Louisiana Inland, etc.	1,738	3.6	482			933		1,797	3.6	438			969	
New Mexico	173	1.4	30			64		161	1.3	38			61	
Rocky Mountain	2,542	2.0	------	------	------	477		1,987	1.6	------	------	------	464	
West Coast	478	0.1	------	------	72	243		655	0.1	------	------	42	150	
Total	100,849	2.9	1,226	219	254	25,004	101,116	99,061	2.7	1,144	33	156	25,008	100,078

p Preliminary. NA Not available.

Table 44.—Salient statistics of distillate fuel oil in the United States, by months and refinery districts

(Thousand barrels unless otherwise stated)

Month and district	1966								1967 p							
	Production at refineries	Yield (percent)	Production at gas processing plants	Crude used directly as distillate [1]	Imports	Exports	Stocks (end of period)	Domestic demand	Production at refineries	Yield (percent)	Production at gas processing plants	Crude used directly as distillate [1]	Imports	Exports	Stocks (end of period)	Domestic demand
Month:																
January	70,042	23.6	25	62	1,054	437	130,041	96,112	68,584	23.0	54	63	1,148	121	131,278	92,546
February	62,696	23.7	91	60	564	1,015	104,042	88,395	61,854	22.9	38	57	895	318	104,676	89,128
March	64,577	22.7	102	66	750	290	92,761	76,486	70,099	23.8	42	66	2,696	306	87,049	90,224
April	60,282	22.1	93	62	1,424	288	91,004	63,330	62,964	22.2	35	58	1,378	422	92,797	58,265
May	63,739	22.1	93	59	1,194	348	102,513	53,228	62,723	21.1	24	61	1,302	103	96,358	60,446
June	61,979	21.7	102	64	1,784	285	117,654	48,503	64,861	21.4	27	60	1,327	337	113,048	49,248
July	67,201	22.1	99	63	1,062	178	142,467	43,434	67,612	21.7	24	63	893	427	132,633	48,580
August	69,074	22.6	110	65	1,019	339	161,065	51,331	68,227	21.8	24	64	1,054	221	154,502	47,279
September	65,765	22.5	92	62	1,128	354	177,363	50,395	69,087	22.3	18	60	1,155	435	176,644	47,743
October	66,460	22.3	96	60	1,372	189	186,576	58,586	69,170	22.3	29	61	1,681	643	186,674	60,268
November	63,087	22.1	117	65	909	285	175,805	74,664	65,492	21.7	26	60	1,435	518	172,822	80,347
December	69,815	23.0	112	64	1,585	369	154,096	92,916	73,756	22.8	25	57	3,528	436	157,078	92,674
Total	784,717	22.5	1,132	752	13,845	4,377	154,096	797,380	804,429	22.2	366	730	18,492	4,287	157,078	816,748
District:																
East Coast	122,456	26.2	-----	-----	12,548	90	60,220		123,238	26.0	-----	-----	16,851	37	64,191	
Appalachian No. 1	10,587	24.5	-----				3,614		11,137	24.2	-----				3,171	
Appalachian No. 2	5,837	19.4	-----				1,479		4,698	21.0	-----				2,055	
Indiana, Illinois, Kentucky, etc	128,908	20.5	-----	480	107	190	21,909		134,567	20.7	-----	451	224	276	22,145	
Minnesota, Wisconsin, etc	14,467	24.5	-----				7,369		15,107	25.3	-----				8,229	
Oklahoma, Kansas, etc	72,129	24.1	-----				13,206		73,002	23.6	-----				12,972	
Texas Inland	20,923	16.8	195				2,328	NA	21,052	16.6	179				2,179	NA
Texas Gulf Coast	203,001	25.9	22				17,035		214,853	26.6	25				18,341	
Louisiana Gulf Coast	91,531	26.3	29	200	967	2,579	7,509		92,901	23.6	36	206	891	2,198	6,225	
Arkansas, Louisiana-Inland, etc	11,597	24.5	886				2,676		11,538	23.3	126				2,347	
New Mexico	2,175	17.7	-----				258		2,210	17.7	-----				224	
Rocky Mountain	28,354	22.9	-----	72	-----	18	3,174		28,000	22.4	-----	73	-----	5	2,602	
West Coast	72,752	14.1	-----	-----	223	1,500	13,319		72,126	13.3	-----	-----	526	1,771	12,397	
Total	784,717	22.5	1,132	752	13,845	4,377	154,096	797,380	804,429	22.2	366	730	18,492	4,287	157,078	816,748

p Preliminary. NA Not available.
[1] Figures represent crude oil used as fuel on pipelines, which is considered part of the demand for distillate.

Table 45.—Salient statistics of residual fuel oil in the United States, by months and refinery districts

(Thousand barrels unless otherwise stated)

Month and district	1966							1967 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
Month:														
January	26,305	8.9	266	37,807	1,085	53,627	65,880	25,390	8.5	256	44,340	1,594	59,108	70,480
February	22,185	8.4	288	37,269	1,075	47,634	64,660	23,184	8.6	231	38,274	1,384	56,602	62,811
March	23,792	8.2	309	42,763	1,852	46,751	65,895	24,184	8.2	260	41,129	1,607	52,899	67,669
April	20,501	7.5	292	28,650	842	46,231	49,121	22,782	8.0	350	36,542	1,281	58,612	52,680
May	20,521	7.1	321	26,722	1,123	49,456	43,216	21,566	7.3	233	30,839	1,659	59,838	49,753
June	19,565	6.8	305	27,849	1,074	51,703	44,398	21,584	7.1	295	26,587	1,560	61,239	45,505
July	21,621	7.1	292	27,137	888	56,862	43,003	21,459	6.9	373	23,128	1,956	62,714	41,529
August	20,896	6.8	316	27,615	887	59,570	45,232	21,141	6.8	329	26,472	2,556	63,737	44,363
September	20,372	7.0	248	24,802	1,438	61,640	41,914	20,892	6.7	322	24,208	2,835	65,530	40,794
October	21,197	7.1	272	28,912	785	63,951	47,285	21,734	7.0	359	35,406	1,857	64,956	56,216
November	21,741	7.6	286	31,205	700	63,538	52,945	24,504	8.1	335	30,885	2,463	61,416	56,801
December	25,265	8.3	356	36,064	1,146	61,196	62,881	27,536	8.5	328	37,944	1,203	62,496	63,525
Total	263,961	7.6	3,551	376,795	12,895	61,196	626,430	275,956	7.7	3,671	395,754	21,955	62,496	652,126
District:														
East Coast	35,132	7.5	------	357,907	34	14,659		36,272	7.7	------	383,107	319	15,546	
Appalachian No. 1	4,314	10.0				496		4,669	10.1				468	
Appalachian No. 2	2,262	7.6				107		1,788	8.0				132	
Indiana, Illinois, Kentucky, etc.	42,571	6.8	585	860	158	6,160		44,222	6.9	564	587	503	6,574	
Minnesota, Wisconsin, etc.	5,616	9.5				835		5,435	9.1				1,038	
Oklahoma, Kansas, etc.	3,941	1.4				1,177		4,750	1.5				1,062	
Texas Inland	4,867	3.9				2,247	NA	4,440	3.5				2,185	NA
Texas Gulf Coast	35,815	4.6				6,053		40,052	5.0				4,898	
Louisiana Gulf Coast	11,652	3.4	1,813	11,708	3,072	1,494		14,773	3.7	1,768	7,443	4,925	1,728	
Arkansas, Louisiana Inland, etc.	1,800	3.8				135		1,770	3.6				78	
New Mexico	347	2.8				18		423	3.4				35	
Rocky Mountain	10,687	8.6	253	55	5	804		10,832	8.6	243	60	2	812	
West Coast	104,957	20.4	900	6,265	9,626	27,011		106,530	19.8	1,096	4,557	16,206	27,940	
Total	263,961	7.6	3,551	376,795	12,895	61,196	626,430	275,956	7.7	3,671	395,754	21,955	62,496	652,126

p Preliminary. NA Not available.

[1] Represents crude oil used as fuel on leases and for general industrial purposes.

Table 46.—Salient statistics of jet fuel in the United States, by months and districts

(Thousand barrels)

Month and district	1966														
	Production			Imports			Exports			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
By months:															
January	6,417	10,364	16,781	1,186	1,098	2,284	114	37	151	8,423	10,515	18,938	7,404	11,271	18,675
February	5,336	10,318	15,654	1,059	1,286	2,345	154	7	161	8,292	10,888	19,180	6,372	11,224	17,596
March	6,561	11,311	17,872	1,628	1,469	3,097	128	14	142	8,562	11,521	20,083	7,791	12,133	19,924
April	6,952	10,694	17,646	1,203	1,440	2,643	92	66	158	7,913	10,821	18,734	8,712	12,768	21,480
May	7,074	11,396	18,470	1,491	1,330	2,821	50	22	72	7,528	12,075	19,603	8,900	11,450	20,350
June	7,440	11,143	18,583	732	1,729	2,461	148	2	150	7,491	12,307	19,798	8,061	12,638	20,699
July	7,512	10,257	17,769	1,536	1,822	3,358	157	------	157	7,652	15,374	23,026	8,730	9,012	17,742
August	8,218	8,129	16,347	2,019	1,978	3,997	167	38	205	7,726	15,970	23,696	9,996	9,473	19,469
September	8,021	9,695	17,716	848	1,565	2,413	148	------	148	7,486	15,139	22,625	8,961	12,091	21,052
October	8,981	10,483	19,464	339	1,662	2,001	166	------	166	7,456	13,597	21,053	9,184	13,687	22,871
November	8,104	11,538	19,642	254	1,562	1,816	120	------	120	6,806	14,037	20,843	8,888	12,660	21,548
December	8,907	10,645	19,552	279	1,823	2,102	121	22	143	7,235	12,139	19,374	8,636	14,344	22,980
Total	89,523	125,973	215,496	12,574	18,764	31,338	1,565	208	1,773	7,235	12,139	19,374	101,635	142,751	244,386
By districts:															
East Coast	2,805	9,057	11,862	8,326	12,810	21,136				382	2,423	2,805			
Appalachian No. 1	736	259	995							30	93	123			
Appalachian No. 2	22	715	737							79	126	205			
Indiana, Illinois, Kentucky, etc	9,064	20,436	29,500							443	2,397	2,840			
Minnesota, Wisconsin, North and South Dakota	2,037	-------	2,037	------	459	459				192	335	527			
Oklahoma, Kansas, Missouri, etc	6,965	7,737	14,702				21	26	47	753	643	1,396	NA	NA	NA
Texas Inland	10,179	7,412	17,591							518	692	1,210			
Texas Gulf	20,540	23,486	44,026							1,555	1,513	3,068			
Louisiana Gulf Coast	11,211	23,307	34,518	------	194	194				934	494	1,428			
Arkansas, Louisiana Inland, etc	1,460	107	1,567							304	17	321			
New Mexico	1,199	-------	1,199							132	9	141			
Rocky Mountain	3,924	1,313	5,237	------	------	------				508	120	628			
West Coast	19,381	32,144	51,525	4,248	5,301	9,549	1,544	182	1,726	1,405	3,277	4,682			
Total	89,523	125,973	215,496	12,574	18,764	31,338	1,565	208	1,773	7,235	12,139	19,374	101,635	142,751	244,386

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By months:															
January	7,748	11,621	19,369	237	1,983	2,220	215	------	215	7,252	12,189	19,441	7,753	13,554	21,307
February	7,670	12,294	19,964	177	1,512	1,689	159	10	169	7,716	12,945	20,661	7,224	13,040	20,264
March	8,391	13,084	21,475	682	1,662	2,344	215	1	216	7,754	12,664	20,418	8,820	15,026	23,846
April	8,792	13,134	21,926	622	1,683	2,305	90	------	90	7,510	12,723	20,233	9,568	14,758	24,326
May	8,378	14,330	22,708	159	2,113	2,272	133	------	133	7,219	13,230	20,449	8,695	15,936	24,631
June	9,573	13,860	23,433	767	2,374	3,141	160	------	160	7,916	13,389	21,305	9,483	16,075	25,558
July	9,446	14,263	23,709	959	2,600	3,559	241	122	363	8,038	12,980	21,018	10,042	17,150	27,192
August	9,685	14,164	23,849	417	2,739	3,156	120	------	120	8,290	13,294	21,584	9,730	16,589	26,319
September	10,021	13,492	23,513	262	1,786	2,048	125	------	125	7,408	13,657	21,065	11,040	14,915	25,955
October	10,297	14,804	25,101	499	3,625	4,124	43	86	129	8,186	13,631	21,817	9,975	18,369	28,344
November	10,346	13,815	24,161	289	2,268	2,557	149	------	149	8,316	13,725	22,041	10,356	15,989	26,345
December	9,341	14,674	24,015	380	2,596	2,976	152	------	152	9,023	13,174	22,197	8,862	17,821	26,683
Total	109,688	163,535	273,223	5,450	26,941	32,391	1,802	219	2,021	9,023	13,174	22,197	111,548	189,222	300,770
By districts:															
East Coast	5,425	11,033	16,458	1,500	17,240	18,740				689	2,423	3,112			
Appalachian No. 1	1,435	391	1,826							84	249	333			
Appalachian No. 2	32	20	52							46	138	184			
Indiana, Illinois, Kentucky, etc	8,649	24,133	32,782							722	2,430	3,152			
Minnesota, Wisconsin, North and South Dakota	1,763	-------	1,763	------	538	538				146	382	528			
Oklahoma, Kansas, Missouri, etc	8,720	9,090	17,810				148	203	351	891	805	1,696	NA	NA	NA
Texas Inland	9,659	7,808	17,467							600	662	1,262			
Texas Gulf	27,620	33,276	60,896							2,245	1,210	3,455			
Louisiana Gulf Coast	13,441	34,937	48,378							908	997	1,905			
Arkansas, Louisiana Inland, etc	1,602	313	1,915	------	247	247				499	352	851			
New Mexico	1,390	-------	1,390							213	39	252			
Rocky Mountain	4,279	2,539	6,818	------	------	------				302	159	461			
West Coast	25,673	39,995	65,668	3,950	8,916	12,866	1,654	16	1,670	1,678	3,328	5,006			
Total	109,688	163,535	273,223	5,450	26,941	32,391	1,802	219	2,021	9,023	13,174	22,197	111,548	189,222	300,770

p Preliminary. NA Not available.

[1] Includes naphtha-type jet fuel produced at natural gas liquid plants: Arkansas, Louisiana Inland, etc.; 1966—50; 1967—38.

Table 47.—Salient statistics of lubricants in the United States, by months and districts

(Thousand barrels unless otherwise stated)

Month and district	1966											
	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	
By months:												
January	590	2,339	2,696	5,625	1.9	2	1,055	1,793	3,733	8,292	13,818	4,058
February	480	2,030	2,612	5,122	1.9	2	1,257	1,935	3,961	8,199	14,095	3,590
March	496	2,204	2,662	5,362	1.9	3	1,242	1,895	3,721	8,015	13,631	4,587
April	465	2,265	2,569	5,299	2.0	3	1,436	1,750	3,508	7,831	13,089	4,408
May	489	2,363	2,783	5,635	1.9	3	1,227	1,743	3,461	7,897	13,101	4,399
June	381	2,101	2,651	5,133	1.8	3	1,463	1,456	3,189	7,901	12,546	4,228
July	519	2,514	2,765	5,798	1.9	3	1,707	1,363	3,262	7,882	12,507	4,133
August	551	2,452	2,762	5,765	1.9	2	1,337	1,243	3,369	7,987	12,599	4,338
September	537	2,339	2,547	5,423	1.9	3	1,686	1,314	3,370	7,687	12,371	3,968
October	570	2,352	2,923	5,845	2.0	3	1,712	1,334	3,323	7,584	12,241	4,266
November	459	2,120	2,635	5,214	1.8	3	1,467	1,299	3,260	7,948	12,507	3,484
December	624	2,354	2,208	5,186	1.7	2	1,523	1,364	3,387	7,931	12,682	3,490
Total	6,161	27,433	31,813	65,407	1.8	32	17,112	1,364	3,387	7,931	12,682	48,949
By districts:												
East Coast	695	2,952	3,314	6,961	1.5	24		148	607	2,426	3,181	
Appalachian No. 1	1,270	1,674	621	3,565	8.3			259	245	319	823	
Appalachian No. 2	8	176	222	406	1.4			-----	36	46	82	
Indiana, Illinois, Kentucky, etc	944	5,040	156	6,140	1.0			120	541	828	1,489	
Minnesota, Wisconsin, etc	-----	------	------	------	---	4		-----	-----	44	44	
Oklahoma, Kansas, etc	562	3,092	1,484	5,138	1.7			111	422	203	736	
Texas Inland	-----	------	156	156	.2		16,333	-----	-----	33	33	NA
Texas Gulf Coast	1,562	6,531	19,221	27,314	3.5			273	898	2,424	3,595	
Louisiana Gulf Coast	701	5,901	1,117	7,719	2.2	2		33	375	254	662	
Arkansas, Louisiana Inland, etc	-----	132	2,059	2,191	4.6			-----	18	404	422	
New Mexico	-----	------	------	------	---			-----	-----	4	4	
Rocky Mountain	43	247	187	477	.3	---		14	65	43	122	
West Coast	376	1,688	3,276	5,340	1.0	2	779	406	180	903	1,489	
Total	6,161	27,433	31,813	65,407	1.8	32	17,112	1,364	3,387	7,931	12,682	48,949

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By months:												
January	491	2,357	2,629	5,477	1.8	3	1,204	1,503	3,616	8,025	13,144	3,814
February	554	2,248	2,246	5,048	1.9	1	1,438	1,647	3,957	8,139	13,743	3,012
March	520	2,696	2,243	5,459	1.9	2	1,900	1,448	3,817	8,156	13,421	3,883
April	537	2,468	2,414	5,419	1.9	3	1,722	1,566	4,088	7,882	13,536	3,585
May	571	2,502	2,632	5,705	1.9	3	1,776	1,519	4,159	7,950	13,628	3,840
June	539	2,244	2,568	5,351	1.8	4	1,412	1,544	3,960	7,925	13,429	4,142
July	602	2,466	2,357	5,425	1.7	4	1,565	1,698	4,186	7,969	13,853	3,440
August	564	2,429	2,465	5,458	1.8	4	1,497	1,574	4,065	8,167	13,806	4,012
September	530	2,315	2,311	5,156	1.7	4	1,450	1,595	4,237	7,741	13,573	3,943
October	475	2,314	2,714	5,503	1.8	3	1,599	1,614	4,200	8,183	13,997	3,483
November	502	2,482	2,276	5,260	1.7	5	1,812	1,663	4,250	7,909	13,822	3,628
December	719	2,537	2,353	5,609	1.7	4	1,191	1,886	4,811	8,077	14,774	3,470
Total	6,604	29,058	29,208	64,870	1.8	40	18,566	1,886	4,811	8,077	14,774	44,252
By districts:												
East Coast	454	2,499	3,543	6,496	1.3	23		143	685	2,404	3,232	
Appalachian No. 1	1,233	1,839	769	3,841	8.4			215	294	292	801	
Appalachina No. 2	-----	279	------	279	1.3			-----	54	54	108	
Indiana, Illinois, Kentucky, etc	637	4,245	1,398	6,280	1.0	14		112	656	853	1,621	
Minnesota, Wisconsin, etc	-----	------	------	------	---			-----	-----	43	43	
Oklahoma, Kansas, etc	1,030	3,232	1,209	5,471	1.8		17,940	160	604	181	945	
Texas Inland	-----	------	156	156	.1			-----	-----	42	42	NA
Texas Gulf Coast	1,955	8,647	17,306	27,908	3.4			506	1,393	2,685	4,584	
Louisiana Gulf Coast	721	5,851	1,093	7,665	2.0	1		84	714	333	1,131	
Arkansas, Louisiana Inland	-----	494	1,502	1,996	4.1			-----	48	363	411	
New Mexico	-----	------	------	------	---			-----	-----	5	5	
Rocky Mountain	33	280	64	377	.3	----		11	63	41	115	
West Coast	541	1,692	2,168	4,401	.8	2	626	655	300	781	1,736	
Total	6,604	29,058	29,208	64,870	1.8	40	18,566	1,886	4,811	8,077	14,774	44,252

NA Not available. p Preliminary.

Table 48.—Salient statistics of liquefied gases and ethane in the United States, by months and districts

(Thousand barrels unless otherwise stated)

Month and district	1966 Refinery production	1966 Yield (percent)	1966 Transfers from gasoline plants	1966 Imports	1966 Exports	1966 Stocks, end of period	1966 Domestic demand	1967 p Refinery production	1967 p Yield (percent)	1967 p Transfers from gasoline plants	1967 p Imports	1967 p Exports	1967 p Stocks, end of period	1967 p Domestic demand
By months:														
January	9,618	3.2	24,038	1,013	801	2,761	34,772	9,408	3.2	25,363	1,130	680	3,061	35,496
February	8,849	3.4	21,100	950	542	2,602	30,516	8,388	3.1	21,962	1,340	811	3,014	30,926
March	8,930	3.2	17,923	949	837	2,364	27,203	9,775	3.3	20,068	907	722	3,058	29,984
April	9,071	3.3	14,861	727	694	2,354	23,975	9,585	3.4	14,902	637	736	3,367	24,079
May	9,793	3.4	13,765	594	639	2,927	22,940	9,988	3.3	15,216	651	693	4,224	24,305
June	8,295	2.9	13,344	720	655	3,051	21,580	9,450	3.2	14,529	548	784	4,371	23,596
July	8,929	3.0	13,247	659	593	3,625	21,668	9,118	2.9	15,232	460	620	4,317	24,244
August	9,148	3.0	14,267	846	602	3,803	23,481	8,878	2.8	16,564	600	976	4,409	24,974
September	8,136	2.8	15,792	831	660	3,787	24,115	9,491	3.1	16,793	637	771	4,768	25,791
October	8,274	2.8	18,829	935	679	4,008	27,138	8,890	2.9	20,870	873	898	5,379	29,124
November	8,403	3.0	22,157	1,108	760	3,694	31,222	8,785	2.9	26,003	1,057	801	5,153	35,270
December	8,772	2.9	25,758	1,157	719	3,336	35,326	9,761	3.0	26,398	1,045	787	4,925	36,645
Total	106,218	3.0	215,081	10,489	8,181	3,336	323,936	111,517	3.1	233,900	9,885	9,279	4,925	344,434
By districts:														
East Coast	14,299	3.0	NA	71		478		14,766	3.1	NA	189		1,136	
Appalachian No. 1	760	1.8				5		654	1.4				8	
Appalachian No. 2	454	1.5				2		331	1.4				3	
Indiana, Illinois, Kentucky, etc.	12,204	1.9				509		13,293	2.0				674	
Minnesota, Wisconsin, North and South Dakota	1,190	2.0	NA	5,678		22		1,267	2.2	NA	5,591		23	
Oklahoma, Kansas, etc.	8,013	2.7			7,262	278	NA	9,321	3.0			8,330	422	NA
Texas Inland	3,284	2.7				108		3,848	3.1				142	
Texas Gulf Coast	36,484	4.6				626		35,205	4.3				1,042	
Louisiana Gulf Coast	14,917	4.3	NA	------		268		15,545	3.9	NA	18		428	
Arkansas, Louisiana Inland, etc.	996	2.1				12		1,696	3.4				20	
New Mexico	242	1.9				5		282	2.3				3	
Rocky Mountain	1,632	1.3	NA	916		20		2,249	1.8	NA	819		31	
West Coast	11,743	2.3	NA	3,824	919	1,003		13,060	2.4	NA	3,268	949	993	
Total	106,218	3.0	215,081	10,489	8,181	3,336	323,936	111,517	3.1	233,900	9,885	9,279	4,925	344,434

p Preliminary. NA Not available.

Table 49.—Statistical summary of petroleum asphalt and road oil

(Thousand short tons)[1]

	1963	1964	1965	1966	1967 p
Petroleum asphalt:					
Production	20,354	20,887	22,473	23,560	23,230
Imports (including natural)	1,130	1,075	1,145	1,110	1,172
Exports	128	139	66	87	77
Stocks (end of period)	2,610	2,588	2,941	3,147	3,625
Apparent domestic consumption	21,337	21,845	23,199	24,377	23,847
Petroleum asphalt shipments:					
Paving	16,947	17,367	18,441	19,648	18,867
Roofing	3,821	4,217	4,031	3,992	3,967
All other	1,879	2,462	2,555	2,798	2,969
Total	22,647	24,046	25,027	26,438	25,803
Road oil:					
Production	1,235	1,158	1,194	1,318	1,269
Stocks (end of period)	137	105	106	167	146
Apparent domestic consumption	1,257	1,190	1,193	1,257	1,290
Road oil shipments	1,099	1,208	1,132	1,045	1,033

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 districts

(Thousand short tons)[1]

Month and district	1966 Production	1966 Imports (including natural)	1966 Exports	1966 Stocks (end of period)	1966 Domestic demand	1967 p Production	1967 p Imports (including natural)	1967 p Exports	1967 p Stocks (end of period)	1967 p Domestic demand
Month:										
January	1,196	70	6	3,537	664	1,262	156	7	3,700	858
February	1,096	68	3	4,070	628	1,043	16	6	4,188	565
March	1,447	52	10	4,449	1,110	1,477	43	12	4,619	1,077
April	1,864	38	5	4,872	1,474	1,633	45	7	4,874	1,416
May	2,078	81	9	4,820	2,202	2,159	62	6	4,922	2,167
June	2,508	93	8	4,288	3,125	2,322	131	4	4,549	2,822
July	2,555	154	12	3,798	3,187	2,604	133	9	4,311	2,966
August	2,695	136	7	3,065	3,557	2,701	149	5	3,460	3,696
September	2,581	136	7	2,775	3,000	2,495	140	6	3,047	3,042
October	2,354	172	7	2,415	2,879	2,440	98	7	2,844	2,734
November	1,823	66	8	2,619	1,677	1,833	148	5	3,120	1,700
December	1,363	44	5	3,147	874	1,261	51	3	3,625	804
Total	23,560	1,110	87	3,147	24,377	23,230	1,172	77	3,625	23,847
District:										
East Coast	5,045	988		845		4,836	969		963	
Appalachian No. 1	247			48		310			55	
Appalachian No. 2	600			82		329			93	
Illinois, Indiana, Kentucky, etc	4,865	27		581		5,115	28		649	
Minnesota, Wisconsin, North Dakota	414			40		446			55	
Oklahoma, Kansas, etc	2,242		47	308		2,312		42	402	
Texas Inland	1,063			92	NA	1,063			137	NA
Texas Gulf Coast	1,452			140		1,490			185	
Louisiana Gulf Coast	1,535	95		222		1,554	175		159	
Arkansas, Louisiana Inland, etc	1,088			155		1,094			189	
New Mexico	161			40		144			41	
Rocky Mountain	1,425	--------		242		1,334	--------		269	
West Coast	3,423	--------	40	352		3,203	--------	35	428	
Total	23,560	1,110	87	3,147	24,377	23,230	1,172	77	3,625	23,847

p Preliminary. NA Not available.
[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 refinery districts

(Short tons)[1]

Month and district	1966			1967 p		
	Production	Stocks (end of period)	Domestic demand	Production	Stocks (end of period)	Domestic demand
Month:						
January	38,182	132,909	11,455	54,000	202,727	18,364
February	36,182	159,454	9,637	43,818	216,000	30,545
March	88,364	222,000	25,818	83,091	268,182	30,909
April	100,727	269,101	53,626	101,818	337,636	32,364
May	104,181	263,455	109,827	102,727	324,727	115,636
June	158,909	218,364	204,000	171,273	320,000	176,000
July	248,909	212,010	255,263	220,000	288,909	251,091
August	228,545	173,073	267,482	210,727	233,273	266,363
September	140,182	154,000	159,255	118,364	200,182	151,455
October	77,091	135,636	95,455	85,636	157,818	128,000
November	31,273	125,273	41,636	42,909	139,818	60,909
December	65,091	167,091	23,273	34,364	146,182	28,000
Total	1,317,636	167,091	1,256,727	1,268,727	146,182	1,289,636
District:						
East Coast	2,363	-------		-------	-------	
Appalachian No. 1	144,182	15,273		128,909	-------	
Appalachian No. 2	-------	-------		-------	-------	
Indiana, Illinois, Kentucky, etc	276,182	7,454		344,727	19,818	
Minnesota, Wisconsin, North Dakota	39,091	-------		20,182	-------	
Oklahoma, Kansas, etc	333,636	35,273	NA	232,364	47,636	NA
Texas Inland	-------	-------		9,636	-------	
Texas Gulf Coast	5,273	364		7,636	364	
Louisiana Gulf Coast	-------	-------		-------	-------	
Arkansas, Louisiana Inland, etc	-------	-------		-------	-------	
New Mexico	-------	-------		-------	-------	
Rocky Mountain	282,364	16,182		261,273	21,818	
West Coast	234,545	92,545		264,000	56,546	
Total	1,317,636	167,091	1,256,727	1,268,727	146,182	1,289,636

p Preliminary. NA Not available.
[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)

Month and district	1966							1967 p						
	Production at refineries	Yield (percent)	Production at gas processing plants	Imports	Exports	Stocks (end of period)	Domestic demand	Production at refineries	Yield (percent)	Production at gas processing plants	Imports	Exports	Stocks (end of period)	Domestic demand
Month:														
January	2,655	0.9	28	330	111	6,379	2,732	2,249	0.8	6	1	171	5,680	1,988
February	2,340	.9	6	2	157	6,303	2,267	2,160	.8	5	2	179	5,636	2,032
March	2,490	.9	7	278	189	6,008	2,881	2,152	.7	5	146	151	5,445	2,343
April	2,250	.8	5	2	137	5,706	2,422	2,398	.8	3	1	168	5,618	2,061
May	2,659	.9	5	318	151	5,686	2,851	2,197	.7	5	2	167	5,418	2,237
June	2,502	.9	5	149	267	5,468	2,607	2,210	.7	4	3	158	5,327	2,150
July	2,397	.8	5	154	175	5,496	2,353	2,274	.7	3	1	110	5,618	1,877
August	2,553	.8	27	141	139	5,510	2,568	2,389	.8	4	2	169	5,579	2,265
September	2,588	.9	10	137	183	5,439	2,623	2,252	.7	6	2	146	5,674	2,019
October	2,581	.9	6	3	137	5,445	2,447	2,294	.7	4	148	197	5,587	2,336
November	2,345	.8	5	241	201	5,460	2,375	2,241	.7	3	64	124	5,616	2,155
December	2,274	.8	7	140	163	5,583	2,135	2,096	.6	3	3	235	5,742	1,741
Total	29,634	.9	116	1,895	2,010	5,583	30,261	26,912	.8	51	375	1,975	5,742	25,204
District:														
East Coast	1,300	.3	------	1,875	588	1,248		1,067	.3	------	356	575	1,401	
Appalachian No. 1	437	1.1	------			77		386	.8	------			86	
Appalachian No. 2	177	.6	------			26		342	1.5	------			20	
Indiana, Illinois, Kentucky, etc	3,628	.6	------	20	428	924		3,462	.6	------	19	286	989	
Minnesota, Wisconsin, etc	------	------	------			93		------	------	------			89	
Oklahoma, Kansas, etc	2,431	.8	------			303		2,316	.8	------			275	
Texas Inland	1,009	.8	51			126	NA	1,083	.9	43			179	NA
Texas Gulf Coast	16,520	2.1	------			1,665		13,471	1.6	------			1,639	
Louisiana Gulf Coast	521	.2	2	------	915	92		589	.2	2	------	992	107	
Arkansas, Louisiana Inland, etc	748	1.6	63			106		769	1.5	6			162	
New Mexico	------	------	------			1		6	------	------			1	
Rocky Mountain	559	.5	------	------	------	53		613	.5	------	------	------	45	
West Coast	2,304	.4	------	------	79	869		2,808	.5	------	------	122	749	
Total	29,634	.9	116	1,895	2,010	5,583	30,261	26,912	.8	51	375	1,975	5,742	25,204

p Preliminary.

Table 53.—Salient statistics on wax in the United States, by types, months, and districts

(Thousand barrels) [1]

Month and district	1966										
	Production				Imports (all types)	Exports (all types)	Stocks, end of period				Domestic demand (all types)
	Micro-crystal-line	Fully refined	Other	Total			Micro-crystal-line	Fully refined	Other	Total	
By months:											
January	73	260	161	494	----	132	188	396	321	905	347
February	83	244	112	439	----	135	196	391	320	907	302
March	94	295	124	513	----	161	202	390	264	856	403
April	79	280	141	500	----	154	201	382	263	846	356
May	85	264	140	489	----	157	207	361	247	815	363
June	100	298	100	498	1	158	203	372	239	814	342
July	95	273	131	499	1	157	209	403	258	870	287
August	99	270	103	472	1	168	221	395	241	857	318
September	88	210	172	470	----	196	219	372	263	854	277
October	81	263	113	457	----	155	217	347	294	858	298
November	82	304	93	479	1	138	217	352	296	865	335
December	78	290	94	462	1	177	207	397	257	861	290
Total	1,037	3,251	1,484	5,772	5	1,888	207	397	257	861	3,918
By districts:											
East Coast	251	1,338	468	2,057	5		48	117	38	203	
Appalachian No. 1	222	71	175	468			39	36	16	91	
Appalachian No. 2	-----	53	16	69			----	8	---	8	
Indiana, Illinois, Kentucky, etc	24	218	122	364	----		1	37	99	137	
Minnesota, Wisconsin, etc	-----	-----	-----	-----			---	---	---	---	
Oklahoma, Kansas, etc	200	244	77	521		1,742	44	22	5	71	
Texas Inland	66	-----	-----	66			35	---	---	35	NA
Texas Gulf Coast	182	525	412	1,119			20	39	87	146	
Louisiana Gulf Coast	84	389	23	496	----		14	46	2	62	
Arkansas, Louisiana Inland, etc	-----	-----	-----	-----			---	---	---	---	
New Mexico	-----	-----	-----	-----			---	---	---	---	
Rocky Mountain	8	96	10	114	----		6	20	10	36	
West Coast	-----	317	181	498	----	146	---	72	---	72	
Total	1,037	3,251	1,484	5,772	5	1,888	207	397	257	861	3,918

See footnotes at end of table.

Table 53.—Salient statistics on wax in the United States, by types, months, and districts—Continued

(Thousand barrels) [1]

Month and district	1967 p										
	Production				Imports (all types)	Exports (all types)	Stocks, end of period				Domestic demand (all types)
	Micro-crystal-line	Fully refined	Other	Total			Micro-crystal-line	Fully refined	Other	Total	
By months:											
January	99	278	93	470	1	146	205	394	271	870	316
February	105	210	128	443	----	145	208	396	273	877	291
March	75	236	164	475	6	153	183	371	322	876	329
April	118	274	131	523	----	175	167	421	295	883	341
May	105	225	168	498	----	131	182	439	320	941	309
June	80	231	149	460	----	138	190	440	311	941	322
July	94	241	143	478	6	128	201	465	339	1,005	292
August	93	226	157	476	----	135	194	435	373	1,002	344
September	88	217	127	432	1	130	187	442	330	959	346
October	99	257	174	530	----	168	181	453	343	977	344
November	104	238	108	450	6	115	192	441	319	952	366
December	97	281	106	484	---	124	196	498	351	1,045	267
Total	1,157	2,914	1,648	5,719	20	1,688	196	498	351	1,045	3,867
By districts:											
East Coast	268	1,075	586	1,929	20		38	143	57	238	
Appalachian No. 1	219	67	163	449			28	49	60	137	
Appalachian No. 2	-----	41	18	59			---	6	---	6	
Indiana, Illinois, Kentucky, etc	22	254	133	409	----		1	33	91	125	
Minnesota, Wisconsin, etc	-----	-----	-----	-----		1,574	---	---	---	---	
Oklahoma, Kansas, etc	254	221	88	563			45	21	7	73	
Texas Inland	76	-----	-----	76			31	---	---	31	NA
Texas Gulf Coast	216	564	374	1,154			25	62	115	202	
Louisiana Gulf Coast	91	335	82	508	----		21	101	5	127	
Arkansas, Louisiana Inland, etc	-----	-----	-----	-----			---	---	---	---	
New Mexico	-----	-----	-----	-----			---	---	---	---	
Rocky Mountain	11	66	22	99	----	114	7	20	16	43	
West Coast	-----	291	182	473	----		---	63	---	63	
Total	1,157	2,914	1,648	5,719	20	1,688	196	498	351	1,045	3,867

p Preliminary. NA Not available.

[1] Conversion factor: 280 pounds to the barrel.

Table 54.—Salient statistics of petroleum coke in the United States, by months and districts [1]

(Thousand barrels unless otherwise stated)

Month and district	1966 Marketable	1966 Production catalyst	1966 Total	1966 Yield (percent)	1966 Exports	1966 Stocks, end of period	1966 Domestic demand	1967 p Marketable	1967 p Production catalyst	1967 p Total	1967 p Yield (percent)	1967 p Exports	1967 p Stocks, end of period	1967 p Domestic demand
By months:														
January	3,394	4,394	7,788	2.6	921	7,752	6,504	3,505	4,179	7,684	2.6	830	7,445	6,706
February	2,901	3,860	6,761	2.5	778	7,732	6,003	3,087	3,617	6,704	2.5	1,550	7,372	5,227
March	3,174	4,214	7,388	2.6	976	7,919	6,225	3,693	3,922	7,615	2.6	560	7,266	7,161
April	2,993	3,913	6,906	2.5	1,204	7,849	5,772	3,235	3,864	7,099	2.5	1,554	7,100	5,711
May	3,217	4,023	7,240	2.5	1,184	7,813	6,092	3,735	3,992	7,727	2.6	1,590	6,860	6,377
June	2,843	4,254	7,097	2.5	1,349	7,759	5,802	3,674	4,001	7,675	2.5	1,716	6,933	5,886
July	3,148	4,203	7,351	2.4	1,102	7,910	6,098	3,923	4,101	8,024	2.6	1,484	7,253	6,220
August	3,366	4,285	7,651	2.5	1,408	7,781	6,372	3,581	4,118	7,699	2.5	1,263	7,039	6,650
September	3,003	4,024	7,027	2.4	1,555	7,528	5,725	3,522	4,122	7,644	2.5	1,558	7,066	6,059
October	3,422	3,969	7,391	2.5	1,493	7,418	6,008	3,627	3,986	7,613	2.4	1,490	7,001	6,188
November	3,420	4,169	7,589	2.7	1,243	7,294	6,470	3,503	3,914	7,417	2.5	1,448	6,684	6,286
December	3,627	4,238	7,865	2.6	1,253	7,297	6,609	3,859	4,173	8,032	2.5	1,236	6,821	6,659
Total	38,508	49,546	88,054	2.5	14,466	7,297	73,680	42,944	47,989	90,933	2.5	16,279	6,821	75,130
By districts:														
East Coast	5,317	8,335	13,652	2.9		849		6,225	8,151	14,376	3.1		1,112	
Appalachian No. 1	------	217	217	.5		-----		------	139	139	.3		-----	
Appalachian No. 2	------	289	289	.9		-----		------	92	92	.5		-----	
Indiana, Illinois, Kentucky, etc	8,385	10,177	18,562	3.0		1,354		8,637	9,980	18,617	2.8		734	
Minnesota, Wisconsin, etc	1,982	728	2,710	4.6		382		1,988	671	2,659	4.5		123	
Oklahoma, Kansas, etc	3,743	4,267	8,010	2.7		492		4,039	3,726	7,765	2.5		258	
Texas Inland	496	1,702	2,198	1.8	8,846	-----	NA	492	1,761	2,253	1.7	9,222	2	NA
Texas Gulf Coast	4,137	13,239	17,376	2.2		47		3,798	12,937	16,735	2.1		23	
Louisiana Gulf Coast	3,922	4,997	8,919	2.5		217		4,101	5,264	9,365	2.4		139	
Arkansas, Louisiana Inland, etc	1,157	813	1,970	4.1		440		1,240	767	2,007	4.0		323	
New Mexico	------	183	183	1.5		-----		------	190	190	1.5		-----	
Rocky Mountain	947	2,060	3,007	2.5		1,407		1,173	1,893	3,066	2.5		1,447	
West Coast	8,422	2,539	10,961	2.2	5,620	2,109		11,251	2,418	13,669	2.5	7,057	2,660	
Total	38,508	49,546	88,054	2.5	14,466	7,297	73,680	42,944	47,989	90,933	2.5	16,279	6,821	75,130

p Preliminary. NA Not available.

[1] Conversion factor: 5.0 barrels to the short ton.

Table 55.—Production of miscellaneous finished oils in the United States in 1967, by districts and classes

(Thousand barrels)

District	Absorption	Petrolatum	Specialty oils [1]	Petrochemicals	Other products	Total
East Coast	-----	-------	1,069	261	287	1,617
Appalachian No. 1	-----	121	33	-------	27	181
Appalachian No. 2	-----	-------	6	-------	-------	6
Indiana, Illinois, Kentucky, etc	-----	60	193	668	98	1,019
Minnesota, Wisconsin, North Dakota, South Dakota	-----	-------	-------	111	-------	111
Oklahoma, Kansas, etc	78	461	705	443	179	1,866
Texas Inland	228	-------	240	875	23	1,366
Texas Gulf	49	353	438	2,915	175	3,930
Louisiana Gulf	978	92	1	900	138	2,109
Arkansas, Louisiana Inland	216	-------	-------	10	-------	226
Rocky Mountain, New Mexico	19	-------	14	17	491	541
West Coast	31	24	1,694	799	953	3,501
Total:						
1967	1,599	1,111	4,393	6,999	2,371	16,473
1966	2,003	942	5,009	8,414	2,062	18,430

[1] Specialty oils include: Hydraulic, 38; insulating, 111; medicinal, 190; rust preventatives, 15; sand frac, 30; spray oils, 438; and other, 3,571.

Table 56.—Petroleum oils, crude and refined, imported into the United States, by months [1]

(Thousand barrels)

Year and class	January	February	March	April	May	June	July	August	September	October	November	December	Total
1966:													
Crude petroleum	41,956	34,658	38,765	36,508	37,330	38,959	39,062	41,458	36,004	36,019	34,413	31,988	447,120
Refined products:													
Motor gasoline	713	1,026	1,365	1,103	1,790	1,251	1,464	1,483	1,715	1,270	1,123	1,345	15,648
Special naphthas	330	2	278	2	318	149	154	141	137	3	241	140	1,895
Kerosine	27	------	------	------	130	------	------	------	------	62	------	------	219
Distillate fuel oil	1,054	564	750	1,424	1,194	1,784	1,062	1,019	1,128	1,372	909	1,585	13,845
Residual fuel oil	37,807	37,269	42,763	28,650	26,722	27,849	27,137	27,615	24,802	28,912	31,205	36,064	376,795
Jet fuel:													
Naphtha type	1,186	1,059	1,628	1,203	1,491	732	1,536	2,019	848	339	254	279	12,574
Kerosine type	1,098	1,286	1,469	1,440	1,330	1,729	1,822	1,978	1,565	1,662	1,562	1,823	18,764
Total	2,284	2,345	3,097	2,643	2,821	2,461	3,358	3,997	2,413	2,001	1,816	2,102	31,338
Lubricants	2	2	3	3	3	3	3	2	3	3	3	2	32
Wax	------	------	------	------	------	1	1	1	------	------	1	1	5
Asphalt (including natural)	385	378	286	207	446	510	846	749	749	943	362	243	6,104
Liquefied gases (including ethane)	1,013	950	949	727	594	720	659	846	831	935	1,108	1,157	10,489
Petrochemical feedstocks	85	18	88	------	90	40	31	20	64	------	------	------	436
Unfinished oils	3,193	1,906	3,479	2,803	3,126	2,598	2,904	3,962	3,334	2,246	2,436	3,249	35,236
Total refined	46,893	44,460	53,058	37,562	37,234	37,366	37,619	39,835	35,176	37,747	29,204	45,888	492,042
Total crude and refined	88,849	79,118	91,823	74,070	74,564	76,325	76,681	81,293	71,180	73,766	73,617	77,876	939,162
1967: p													
Crude petroleum	41,107	29,220	37,585	38,219	39,880	33,640	30,092	31,458	31,458	31,890	39,204	37,478	411,649
Refined products:													
Motor gasoline	1,472	1,623	1,202	1,891	1,818	1,063	771	823	1,244	1,129	1,101	1,078	15,215
Special naphthas	1	2	146	1	2	3	1	2	2	148	64	3	375
Kerosine	------	------	------	33	------	------	------	------	------	------	------	------	33
Distillate fuel oil	1,148	895	2,696	1,378	1,302	1,327	893	1,054	1,155	1,681	1,435	3,528	18,492
Residual fuel oil	44,340	38,274	41,129	36,542	30,839	26,587	23,128	26,472	24,208	35,406	30,885	37,944	395,754
Jet fuel:													
Naphtha type	237	177	682	622	159	767	959	417	262	499	289	380	5,450
Kerosine type	1,983	1,512	1,662	1,683	2,113	2,374	2,600	2,739	1,786	3,625	2,268	2,596	26,941
Total jet fuel	2,220	1,689	2,344	2,305	2,272	3,141	3,559	3,156	2,048	4,124	2,557	2,976	32,391
Lubricants	3	1	2	3	3	4	4	4	4	3	5	4	40
Wax	1	------	6	------	------	------	6	------	1	------	6	------	20
Asphalt (including natural)	859	90	238	247	343	716	733	819	770	539	813	280	6,447
Liquefied gases (including ethane)	1,130	1,340	907	637	651	548	460	600	637	873	1,057	1,045	9,885
Petrochemical feedstocks	21	------	21	86	------	------	------	76	------	------	76	------	280
Unfinished oils	4,138	2,673	3,338	3,230	3,220	3,623	2,388	2,343	2,667	2,643	2,436	2,526	35,225
Total refined	55,388	46,587	52,029	46,353	40,450	37,012	31,943	35,349	32,736	46,546	40,435	49,384	514,157
Total crude and refined	96,440	75,807	89,614	84,572	80,330	70,652	62,035	66,807	64,194	78,436	70,057	86,862	925,806

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[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.

Table 57.—Crude oil and petroleum products imported into the United States, by country and receiving district

(Thousands barrels)

Country	Crude oil [1]	Gasoline	Special naphtha	Kerosine [2]	Distillate fuel oil [2]	Residual fuel oil [2]	Military jet fuel	Commercial jet fuel	Liquefied gases	Asphalt	Unfinished oils [1]	Lubricants	Wax	Petrochemical feedstocks	Total
1966:															
North America:															
Canada	126,712	322	27	-----	196	1,880	46	1	10,382	205	338	25	5	-----	140,139
Mexico	-----	-----	-----	-----	-----	6,067	-----	-----	-----	-----	10,460	-----	-----	-----	16,527
Total	126,712	322	27	-----	196	7,947	46	1	10,382	205	10,798	25	5	-----	156,666
Central America and Caribbean:															
Panama	-----	572	-----	-----	-----	1,113	-----	-----	-----	-----	51	-----	-----	-----	1,736
Puerto Rico	-----	12,206	-----	219	4,692	4,749	-----	-----	-----	-----	-----	-----	-----	436	22,302
Total	-----	12,778	-----	219	4,692	5,862	-----	-----	-----	-----	51	-----	-----	436	24,038
South America:															
Argentina	-----	-----	-----	-----	-----	4,346	-----	-----	-----	-----	-----	-----	-----	-----	4,346
Bolivia	1,237	-----	-----	-----	-----	-----	-----	-----	-----	-----	87	-----	-----	-----	1,324
Colombia	14,424	-----	-----	-----	-----	3,515	-----	-----	-----	-----	-----	-----	-----	-----	17,939
Netherlands Antilles	-----	918	1,648	-----	4,818	100,101	5,570	8,313	-----	3,427	1,151	-----	-----	-----	125,946
Trinidad	-----	638	-----	-----	294	44,614	5,072	2,283	-----	46	2,859	-----	-----	-----	55,806
Venezuela	147,427	992	220	-----	3,656	194,676	1,886	8,167	7	2,426	12,060	-----	-----	-----	371,517
Total	163,088	2,548	1,868	-----	8,768	347,252	12,528	18,763	7	5,899	16,157	-----	-----	-----	576,878
Europe:															
Belgium	-----	-----	-----	-----	-----	682	-----	-----	-----	-----	-----	-----	-----	-----	682
France	-----	-----	-----	-----	-----	521	-----	-----	-----	-----	-----	-----	-----	-----	521
Italy	-----	-----	-----	-----	188	5,264	-----	-----	-----	-----	1,055	-----	-----	-----	6,507
Netherlands	-----	-----	-----	-----	-----	1,285	-----	-----	-----	-----	-----	7	-----	-----	1,292
Spain	-----	-----	-----	-----	-----	634	-----	-----	-----	-----	-----	-----	-----	-----	634
United Kingdom	-----	-----	-----	-----	-----	2,109	-----	-----	1	-----	-----	-----	-----	-----	2,110
West Germany	-----	-----	-----	-----	-----	1	-----	-----	-----	-----	-----	-----	-----	-----	1
Total	-----	-----	-----	-----	188	10,496	-----	-----	1	-----	1,055	7	-----	-----	11,747

Middle East:															
Abu Dhabi	4,781														4,781
Bahrain						824									824
Iran	30,833					845					801				32,479
Iraq	9,447										2				9,449
Kuwait	9,543					1,093					834				11,470
Neutral Zone	7,028														7,028
Qatar	176														176
Saudi Arabia	45,771					2,271			99		1,948				50,089
Turkey						200									200
Total	107,579					5,233			99		3,585				116,496
Africa:															
Algeria	1,400														1,400
Egypt	852										314				1,166
Libya	25,177														25,177
Morocco						3									3
Nigeria	4,114														4,114
Total	31,543					3					314				31,860
Asiatic area:															
India											1,174				1,174
Indonesia											177				177
Japan					1	2					658				661
Pakistan											115				115
Sumatra	18,198										1,152				19,350
Total	18,198				1	2					3,276				21,477
Total imports	447,120	15,648	1,895	219	13,845	376,795	12,574	18,764	10,489	6,104	35,236	32	5	436	939,162
Imports by PAD Districts:															
District 1	259,499	11,159	1,875	219	12,548	357,907	8,326	12,810	71	5,432	26,743	24	5	59	696,677
District 2	48,114		20		107	860		459	5,678	148	43	4			55,433
District 3	449	54			967	11,708		194		524	15	2		377	14,290
District 4	4,954					55			916						5,925
District 5	134,104	4,435			223	6,265	4,248	5,301	3,824		8,435	2			166,837

See footnotes at end of table.

Table 57.—Crude oil and petroleum products imported into the United States, by country and receiving district—Continued

(Thousand barrels)

Country	Crude oil [1]	Gasoline	Special naphtha	Kerosine [2]	Distillate fuel oil [2]	Residual fuel oil [2]	Military jet fuel	Commercial jet fuel	Liquefied gases	Asphalt	Unfinished oil [1]	Lubricants	Wax	Petrochemical feedstocks	Total
1967 p:															
North America:															
Canada	150,409	382	26	-----	838	1,319	6	1	9,786	160	1,200	33	4	-----	164,164
Mexico	-------	------	-----	-----	101	6,927	------	------	19	-----	10,744	-----	-----	-----	17,791
Total	150,409	382	26	-----	939	8,246	6	1	9,805	160	11,944	33	4	-----	181,955
Central America and Caribbean:															
Bahamas	-------	------	-----	-----	------	122	------	------	------	-----	------	-----	-----	-----	122
Dominican Republic	-------	------	-----	-----	------	-------	------	------	11	6	------	-----	-----	-----	17
Leeward and Windward Islands	-------	------	-----	-----	------	346	------	------	------	-----	------	-----	-----	-----	346
Panama	-------	241	-----	-----	116	852	------	257	------	-----	------	-----	-----	-----	1,466
Puerto Rico	-------	12,507	-----	-----	5,942	2,822	------	------	------	-----	------	-----	-----	280	21,551
Virgin Islands	-------	1,186	-----	33	1,808	9,439	------	------	------	-----	938	-----	-----	-----	13,404
Total	-------	13,934	-----	33	7,866	13,581	------	257	11	6	938	-----	-----	280	36,906
South America:															
Argentina	-------	------	-----	-----	------	4,371	------	------	------	-----	------	-----	-----	-----	4,371
Bolivia	7,016	------	-----	-----	------	-------	------	------	------	-----	275	-----	-----	-----	7,291
Brazil	-------	------	-----	-----	------	591	------	------	------	-----	------	-----	-----	-----	591
Chile	633	------	-----	-----	------	-------	------	------	------	-----	------	-----	-----	-----	633
Colombia	11,855	------	-----	-----	34	4,989	------	------	------	-----	457	-----	-----	-----	17,335
Netherlands Antilles	-------	486	288	-----	4,965	106,580	2,583	12,579	------	3,357	191	-----	-----	-----	131,029
Peru	-------	------	-----	-----	------	-------	------	------	------	-----	113	-----	-----	-----	113
Trinidad	-------	4	-----	-----	295	53,174	1,437	3,279	------	16	2,143	-----	-----	-----	60,348
Venezuela	131,089	409	61	-----	4,334	179,340	1,424	9,825	38	2,842	12,766	-----	-----	-----	342,128
Total	150,593	899	349	-----	9,628	349,045	5,444	25,683	38	6,215	15,945	-----	-----	-----	563,839
Europe:															
Belgium	-------	------	-----	-----	------	102	------	------	------	-----	------	1	-----	-----	103
France	-------	------	-----	-----	------	565	------	------	------	-----	------	-----	-----	-----	565
Italy	-------	------	-----	-----	58	9,714	------	124	------	-----	197	-----	-----	-----	10,093
Netherlands	-------	------	-----	-----	------	2,028	------	------	------	66	756	5	-----	-----	2,855
Rumania	-------	------	-----	-----	------	239	------	------	------	-----	------	-----	-----	-----	239

See footnotes at end of table.

Spain						1,096					260				1,356
United Kingdom						3,909									3,909
West Germany												1	16		17
Yugoslavia					1										1
Total					59	17,653		124		66	1,213	7	16		19,138
Middle East:															
Abu Dhabi	1,936														1,936
Aden						2,132									2,132
Bahrain						711					108				819
Iran	23,781					1,678					493				25,952
Iraq	1,716														1,716
Kuwait	6,859					109					1,401				8,369
Neutral Zone	4,006														4,006
Saudi Arabia	29,679					791			29		965				31,464
Total	67,977					5,421			29		2,967				76,394
Africa:															
Algeria	1,447					265									1,712
Angola						181									181
Canary Islands						606		876							1,482
Egypt	1,318														1,318
Gabon	661														661
Ivory Coast						124									124
Libya	15,293														15,293
Nigeria	1,432					402									1,834
Republic of South Africa						227									227
Total	20,151					1,805		876							22,832
Asiatic Area:															
Japan						3			2		474				479
Sumatra	22,519										1,744				24,263
Total	22,519					3			2		2,218				24,742
Total imports	411,649	15,215	375	33	18,492	395,754	5,450	26,941	9,885	6,447	35,225	40	20	280	925,806
Imports by PAD Districts:															
District 1	216,920	9,465	356	33	16,851	383,107	1,500	17,240	189	5,328	23,222	23	20		674,254
District 2	56,408	41	19		224	587		538	5,591	157	20	14			63,599
District 3	672				891	7,443		247	18	961	276	1		280	10,789
District 4	6,648					60			819						7,527
District 5	131,001	5,709			526	4,557	3,950	8,916	3,268	1	11,707	2			169,637

[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.

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	January	February	March	April	May	June	July	August	September	October	November	December	Total
1966:													
Crude petroleum	135	-------	108	290	1	130	240	186	83	95	88	121	1,477
Refined products:													
Gasoline [2]	226	254	177	123	342	452	196	410	576	412	348	270	3,786
Special naphthas	111	157	189	137	151	267	175	139	183	137	201	163	2,010
Kerosine	28	15	29	22	30	27	14	9	29	19	16	16	254
Distillate fuel oil	437	1,015	290	288	348	285	178	339	354	189	285	369	4,377
Residual fuel oil	1,085	1,075	1,852	842	1,123	1,074	888	887	1,438	785	700	1,146	12,895
Jet fuel	151	161	142	158	72	150	157	205	148	166	120	143	1,773
Lubricants	1,055	1,257	1,242	1,436	1,227	1,463	1,707	1,337	1,686	1,712	1,467	1,523	17,112
Wax	132	135	161	154	157	158	157	168	196	155	138	177	1,888
Coke	921	778	976	1,204	1,184	1,349	1,102	1,408	1,555	1,493	1,243	1,253	14,466
Asphalt	60	14	27	26	48	42	65	40	44	37	49	30	482
Petrochemical feedstocks	37	219	111	573	282	53	440	221	99	215	282	178	2,710
Liquefied gases (including ethane)	801	542	837	694	639	655	593	602	660	679	760	719	8,181
Miscellaneous	55	62	75	91	62	107	61	98	115	94	87	82	989
Total refined	5,099	5,684	6,108	5,748	5,665	6,082	5,733	5,863	7,083	6,093	5,696	6,069	70,923
Total crude and refined	5,234	5,684	6,216	6,038	5,666	6,212	5,973	6,049	7,166	6,188	5,784	6,190	72,400
1967 p													
Crude petroleum	27	-------	87	251	-------	1,830	8,526	8,188	5,994	1,421	124	54	26,502
Refined products:													
Gasoline [2]	283	404	311	349	307	190	706	631	706	294	385	323	4,889
Special naphthas	171	179	151	168	167	158	110	169	146	197	124	235	1,975
Kerosine	13	19	10	13	21	7	11	11	12	2	29	8	156
Distillate fuel oil	121	318	306	422	103	337	427	221	435	643	518	436	4,287
Residual fuel oil	1,594	1,384	1,607	1,281	1,659	1,560	1,956	2,556	2,835	1,857	2,463	1,203	21,955
Jet fuel	215	169	216	90	133	160	363	120	125	129	149	152	2,021
Lubricants	1,204	1,438	1,900	1,722	1,776	1,412	1,565	1,497	1,450	1,599	1,812	1,191	18,566
Wax	146	145	153	175	131	138	128	135	130	168	115	124	1,688
Coke	830	1,550	560	1,554	1,590	1,716	1,484	1,263	1,558	1,490	1,448	1,236	16,279
Asphalt	39	36	67	36	31	22	51	25	32	37	28	17	421
Petrochemical feedstocks	287	56	244	220	237	389	209	438	128	193	422	172	2,995
Liquefied gases (including ethane)	680	811	722	736	693	784	620	976	771	898	801	787	9,279
Miscellaneous	86	78	94	73	82	79	70	68	61	69	78	65	903
Total refined	5,669	6,587	6,341	6,839	6,930	6,952	7,700	8,110	8,389	7,576	8,372	5,949	85,414
Total crude and refined	5,696	6,587	6,428	7,090	6,930	8,782	16,226	16,298	14,383	8,997	8,496	6,003	111,916

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	Special naphtha	Jet fuel	Kerosine	Distillate oil	Residual oil	Lubricating oil	Asphalt	Liquefied petroleum gases	Wax	Coke	Petrochemical feedstocks	Miscellaneous products	Total
1966:															
North America:															
Canada	2	224	536	1	48	1,144	5,090	1,960	80	175	128	2,110	83	136	11,717
Mexico	203	806	36	78	9	2,319	2,276	311	188	7,312	195	373	7	45	14,158
Netherlands Antilles	------	328	1	-----	-----	111	265	20	(1)	(1)	1	------	(1)	(1)	726
Other	------	27	24	29	2	352	284	395	17	71	119	------	115	18	1,453
Total	205	1,385	597	108	59	3,926	7,915	2,686	285	7,558	443	2,483	205	199	28,054
South America:															
Argentina	------	(1)	94	-----	-----	-----	(1)	408	(1)	(1)	1	------	82	2	587
Brazil	------	(1)	24	-----	12	-----	(1)	1,198	24	1	90	45	37	88	1,519
Chile	------	(1)	(1)	-----	1	-----	(1)	209	26	------	37	------	2	13	288
Colombia	------	(1)	5	-----	(1)	(1)	2	64	2	(1)	129	(1)	2	13	217
Peru	------	(1)	1	-----	(1)	1	------	211	2	(1)	25	------	3	5	248
Venezuela	(1)	(1)	20	-----	(1)	1	(1)	45	2	(1)	19	2	2	10	101
Other	(1)	1	2	-----	(1)	-----	(1)	202	5	------	46	16	2	6	280
Total	(1)	1	146	-----	13	2	2	2,337	61	1	347	63	130	137	3,240
Europe:															
Belgium-Luxembourg	------	(1)	33	-----	3	-----	------	757	1	11	9	402	9	11	1,236
Denmark	------	(1)	(1)	-----	(1)	-----	------	101	(1)	(1)	10	(1)	3	7	121
France	(1)	5	63	(1)	(1)	(1)	43	98	17	(1)	48	744	445	4	1,467
Germany, West	------	45	258	-----	23	193	92	309	1	2	294	1,031	22	10	2,280
Greece	1	93	1	-----	(1)	1	(1)	25	(1)	(1)	1	126	(1)	1	249
Italy	------	223	15	-----	1	18	247	301	16	1	86	1,276	403	12	2,599
Netherlands	------	254	93	-----	(1)	1,049	(1)	238	2	1	46	1,384	316	23	3,406
Norway	(1)	-----	12	-----	(1)	-----	------	52	(1)	(1)	1	914	2	4	985
Sweden	------	(1)	(1)	-----	(1)	(1)	(1)	338	(1)	(1)	13	73	7	8	439
United Kingdom	431	3	332	1	9	129	997	1,048	7	580	71	199	364	44	4,215
Other	(1)	5	18	-----	1	1	1	298	4	1	82	242	59	29	741
Total	432	628	825	1	37	1,391	1,380	3,565	48	596	661	6,391	1,630	153	17,738
Africa:															
Congo (Kinshasa)	(1)	-----	2	-----	(1)	-----	(1)	44	2	------	4	------	2	------	54
South Africa, Republic of	------	(1)	47	-----	8	1	210	657	5	8	110	------	11	47	1,094
United Arab Republic	------	-----	3	-----	3	-----	------	119	------	------	------	------	------	24	149
Other	1	181	10	-----	11	(1)	(1)	300	5	(1)	44	136	10	25	723
Total	1	181	62	-----	17	1	210	1,120	12	8	158	136	23	96	2,020

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	Special naphtha	Jet fuel	Kerosine	Distillate oil	Residual oil	Lubricating oil	Asphalt	Liquefied petroleum gases	Wax	Coke	Petrochemical feedstocks	Miscellaneous products	Total
1966—Continued															
Asia:															
India	------	(1)	1	-----	3	1	2	1,514	3	(1)	3	------	7	105	1,639
Indonesia	30	(1)	-----	-----	(1)	-----	(1)	249	(1)	(1)	(1)	------	1	12	292
Japan	808	3	254	-----	65	684	3,674	2,260	2	8	50	4,985	190	108	13,091
Malaysia	------	(1)	(1)	-----	-----	-----	(1)	28	(1)	------	2	8	(1)	2	40
Philippines	------	(1)	14	-----	3	(1)	(1)	433	3	------	19	21	4	21	518
Turkey	------	45	2	-----	3	-----	1	607	1	(1)	1	------	7	12	679
Other	------	53	26	-----	16	1	1	1,756	19	2	122	80	18	56	2,150
Total	838	101	297	-----	90	686	3,678	6,847	28	10	197	5,094	227	316	18,409
Oceania:															
Australia	1	(1)	45	(1)	12	-----	4	261	1	2	58	299	470	56	1,209
French Pacific Islands	------	71	(1)	9	20	243	85	5	(1)	1	------	------	(1)	(1)	434
New Zealand	------	-----	12	-----	2	-----	1	75	(1)	------	13	------	13	26	142
Other	(1)	1	(1)	-----	-----	-----	------	2	(1)	2	------	------	------	------	5
Total	1	72	57	9	34	243	90	343	1	5	71	299	483	82	1,790
Grand total	1,477	2,368	1,984	118	250	6,249	13,275	16,898	435	8,173	1,877	14,466	2,698	983	71,251
Shipments from the United States to territories and possessions:															
Puerto Rico	------	813	25	6	(1)	-----	------	175	28	(2)	(2)	(2)	(2)	6	[3] 1,081
Virgin Islands	------	47	1	9	1	43	21	8	11	(2)	(2)	(2)	(2)	(1)	[3] 151
Wake	------	876	-----		1,637	59	------	------	------	(2)	(2)	(2)	(2)	------	[3] 2,572
Other	------	62	-----		6	325	5	37	8	(2)	(2)	(2)	(2)	------	[3] 443
Total	------	1,798	26		1,659	427	26	220	47	(2)	(2)	(2)	(2)	6	[3] 4,247
Exports from territories to foreign countries: Puerto Rico	------	380	(1)	-----	(1)	2,299	406	6	------	7	------	------	(1)	(1)	3,098
Total net shipments from the United States	1,477	3,786	2,010		2,027	4,377	12,895	17,112	482	[3] 8,181	[3] 1,888	[3] 14,466	[3] 2,710	989	[3] 72,400
1967:															
North America:															
Canada	3,688	158	719	-----	24	1,075	7,386	2,031	49	364	118	2,373	89	128	18,202
Mexico	18	154	49	17	1	1,903	2,032	551	163	7,551	230	295	8	47	13,019
Netherlands Antilles	------	(1)	1	-----	-----	-----	624	17	1	------	1	------	(1)	(1)	644
Trinidad and Tobago	645	-----	1	-----	-----	6	134	17	(1)	------	4	------	1	1	809
Other	------	30	36	4	4	89	1,752	396	14	102	115	15	109	18	2,684
Total	4,351	342	806	21	29	3,073	11,928	3,012	227	8,017	468	2,683	207	194	35,358

South America:															
Argentina	------	(1)	2	-----	-----	-----	(1)	183	(1)	79	1	------	1	3	269
Brazil	------	287	19	-----	10	-----	(1)	1,402	5	78	41	97	151	40	2,130
Chile	------	(1)	(1)	-----	1	(1)	------	201	4	------	35	------	1	4	246
Colombia	------	-----	2	-----	(1)	1	(1)	62	1	(1)	78	------	2	11	157
Peru	(1)	(1)	1	-----	-----	842	251	198	1	(1)	24	------	2	4	1,323
Venezuela	------	(1)	21	-----	1	(1)	(1)	40	1	(1)	4	1	3	10	81
Other	------	1	3	-----	(1)	1	------	166	2	------	59	------	1	6	239
Total	(1)	288	48	-----	12	844	251	2,252	14	157	242	98	161	78	4,445
Europe:															
Belgium-Luxembourg	188	(1)	31	-----	1	-----	76	604	1	23	8	1,046	9	20	2,007
Denmark	447	(1)	(1)	-----	(1)	-----	------	41	------	(1)	11	(1)	3	9	511
France	------	(1)	61	-----	(1)	2	(1)	134	30	(1)	49	502	452	8	1,238
Germany, West	2,121	(1)	296	-----	27	362	47	238	2	(1)	269	772	56	11	4,201
Greece	------	48	(1)	19	-----	-----	5	16	1	(1)	1	164	1	1	256
Italy	465	202	29	-----	4	29	22	530	32	2	78	1,361	629	15	3,398
Netherlands	833	409	90	-----	(1)	955	244	381	(1)	29	36	1,345	402	17	4,741
Norway	------	-----	(1)	-----	(1)	-----	------	33	(1)	------	2	815	3	5	858
Spain	550	28	22	-----	-----	-----	108	31	(1)	------	38	414	205	22	1,418
Sweden	------	(1)	1	-----	(1)	120	------	203	1	------	9	96	105	9	544
United Kingdom	16,959	1,790	277	1	-----	108	760	1,141	1	1,025	57	251	68	56	22,494
Other	------	77	2	220	(1)	169	2	100	3	(1)	40	148	7	14	782
Total	21,563	2,554	809	240	32	1,745	1,264	3,452	71	1,079	598	6,914	1,940	187	42,448
Africa:															
Congo (Kinshasa)	------	(1)	3	-----	(1)	-----	------	30	3	------	4	------	(1)	1	41
South Africa, Republic of	------	(1)	43	-----	2	-----	165	483	5	1	110	(1)	24	37	870
United Arab Republic	------	-----	3	-----	-----	-----	------	76	(1)	------	------	------	1	1	81
Other	1	195	8	-----	5	2	(1)	285	3	1	35	251	5	14	805
Total	1	195	57	-----	7	2	165	874	11	2	149	251	30	53	1,797
Asia:															
India	------	1	4	-----	1	-----	(1)	2,436	(1)	1	8	------	2	55	2,508
Indonesia	------	(1)	(1)	-----	-----	-----	------	178	(1)	------	2	------	(1)	6	186
Japan	587	4	453	-----	24	56	8,097	2,905	2	6	61	6,028	188	114	18,525
Malaysia	------	(1)	1	-----	-----	-----	(1)	12	(1)	(1)	2	28	(1)	3	46
Philippines	------	(1)	23	-----	1	(1)	1	447	3	(1)	17	22	7	26	547
Turkey	------	53	4	9	1	-----	(1)	616	1	(1)	1	------	4	7	696
Other	(1)	92	26	13	(1)	7	2	1,285	14	1	68	56	25	51	1,640
Total	587	150	511	22	27	63	8,100	7,879	20	8	159	6,134	226	262	24,148
Oceania:															
Australia	------	(1)	48	-----	20	-----	5	212	3	3	51	199	415	71	1,027
French Pacific Islands	------	74	(1)	-----	26	327	65	5	(1)	1	------	------	(1)	(1)	498
New Zealand	------	(1)	20	-----	4	-----	(1)	55	(1)	2	10	------	4	48	143
Other	------	-----	(1)	-----	1	-----	370	5	2	(1)	(1)	------	(1)	(1)	378
Total	------	74	68	-----	51	327	440	277	5	6	61	199	419	119	2,046
Grand total	26,502	3,603	2,299	283	158	6,054	22,148	17,746	348	9,269	1,677	16,279	2,983	893	110,242

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	Special naphtha	Jet fuel	Kerosine	Distillate oil	Residual oil	Lubricating oil	Asphalt	Liquefied petroleum gases	Wax	Coke	Petrochemical feedstocks	Miscellaneous products	Total
1967—Continued															
Shipments from the United States to territories and possessions:															
Puerto Rico	------	1,328	(2)		84	7	2	(2)	(2)	(2)	(2)	------	(2)	10	[3] 2,322
Virgin Islands	(1)	29	(2)		------	13	16	(2)	(2)	(2)	(2)	------	(2)	(1)	[3] 99
Wake	------	600	(2)		1,652	467	1	(2)	(2)	(2)	(2)	------	(2)	(1)	[3] 2,741
Other	(1)		(2)					(2)	(2)	(2)	(2)	------	(2)	(1)	
Total	------	1,957	(2)		1,736	487	19	(2)	(2)	(2)	(2)	------	(2)	10	[3] 5,162
Exports from territories to foreign countries: Puerto Rico	------	671	342		(1)	2,254	212	5	------	4	------	------	(1)	(1)	3,488
Total net shipments from the United States	26,502	4,889	[3] 1,975		2,177	4,287	21,955	[3] 18,566	[3] 421	[3] 9,279	[3] 1,688	16,279	[3] 2,995	903	[3] 111,916

[1] Less than ½ unit.
[2] Not separately classified.
[3] Includes data "Not separately classified."

Table 60.—World production of crude petroleum by countries [1]

(Thousand barrels) [2]

Country	1963	1964	1965	1966	1967 [p]
North America:					
Canada	[r] 257,662	274,626	[r] 296,419	[r] 320,543	352,526
Cuba [e] [3]	[r] 205	[r] 248	[r] 382	[r] 460	756
Mexico	114,867	115,576	117,959	121,149	133,042
Trinidad	48,678	49,731	48,859	55,603	64,995
United States	2,752,723	2,786,822	2,848,514	3,027,763	3,215,742
South America:					
Argentina	97,221	100,370	98,262	[r] 104,754	114,739
Bolivia	3,404	3,290	3,357	6,085	14,527
Brazil	35,714	33,310	34,342	42,446	53,515
Chile	13,206	13,687	12,704	12,428	12,369
Colombia	60,343	62,596	[r] 72,670	[r] 71,430	68,877
Ecuador	2,465	2,796	2,850	2,660	2,198
Peru	21,468	23,119	23,068	23,027	25,857
Venezuela	1,185,511	1,241,782	1,267,602	1,230,464	1,292,876
Europe:					
Albania	5,009	5,096	[r] 5,692	[r] 5,840	7,300
Austria	18,271	18,571	19,908	19,228	18,725
Bulgaria	1,266	1,168	1,672	2,920	3,642
Czechoslovakia	1,220	1,322	[r] 1,301	[r] 1,288	1,424
France	18,117	20,428	21,700	21,365	20,639
Germany, West	53,325	55,419	56,945	56,832	57,257
Hungary	13,408	13,741	13,746	13,009	12,864
Italy	12,155	18,184	15,055	11,974	11,595
Netherlands	15,377	15,758	16,630	16,438	15,438
Poland	1,577	2,092	2,514	2,971	3,335
Rumania	91,171	92,383	93,693	95,588	98,379
Spain	-------	-------	-------	197	560
U.S.S.R. [4]	1,504,300	1,643,500	1,786,000	1,948,000	2,116,000
United Kingdom	910	939	606	[r] 568	648
Yugoslavia	11,930	13,322	15,281	16,460	17,655
Africa:					
Algeria	[r] 184,288	[r] 204,711	[r] 201,754	[r] 257,122	[e] 282,200
Angola	5,776	6,535	4,734	4,560	3,880
Congo (Brazzaville)	820	627	535	467	380
Gabon, Republic of	6,446	7,668	9,161	10,484	25,203
Libya	167,786	315,660	445,374	[r] 552,712	636,504
Morocco	1,140	910	782	783	738
Nigeria	27,913	43,997	99,354	152,428	116,519
Tunisia	-------	-------	-------	[r] 4,741	17,068
United Arab Republic	38,759	43,915	45,556	[r] 43,300	[5] [e] 42,000
Asia:					
Bahrain	16,503	18,000	20,788	22,521	25,370
Burma	4,761	[r] 4,161	4,065	[r] 4,255	4,446
China, mainland [e]	54,750	62,050	73,000	95,000	80,300
India	12,266	16,965	22,494	34,228	42,190
Indonesia	[r] 166,885	[6] [r] 171,492	[6] [r] 178,991	[6] [r] 168,429	[e] 185,000
Iran	538,107	618,731	[r] 688,213	771,234	[e] 952,413
Iraq	422,581	461,961	482,461	505,428	445,821
Israel	1,091	1,440	1,469	[r] 1,359	[5] 956
Japan	[r] 5,646	[r] 4,818	[r] 4,726	[r] 5,463	5,539
Kuwait	705,471	774,815	791,903	830,537	836,719
Kuwait-Saudi Arabia Neutral Zone	114,535	131,415	132,285	153,419	152,862
Mongolia [e]	[e] [r] 365	[e] [r] 365	[r] 116	[r] 89	[e] 90
Muscat and Oman	-------	-------	-------	-------	23,030
Pakistan	3,514	3,743	3,943	2,502	[e] 3,700
Qatar	70,158	77,885	84,215	105,945	118,083
Sarawak and Brunei	29,639	26,265	29,342	[r] 35,732	38,289
Saudi Arabia	594,592	628,095	739,078	873,349	948,110
Taiwan	19	61	131	226	246
Thailand [e]	45	45	40	40	45
Trucial States	17,571	67,465	102,804	131,531	139,467
Turkey	5,090	[r] 5,894	[r] 9,818	[r] 13,062	17,459
Oceania:					
Australia	-------	1,491	2,622	3,390	7,594
New Zealand	4	4	[r] 4	4	[e] 4
West Irian	924	(6)	(6)	(6)	(6)
Total [7]	[r] 9,538,948	[r] 10,311,060	[r] 11,057,489	[r] 12,015,830	12,889,705

[e] Estimate. [p] Preliminary. [r] Revised.
[1] Compiled mostly from data available May 1968.
[2] 42-gallon barrels
[3] Natural naphtha and gas oil.
[4] U.S.S.R. in Asia (including Sakhalin) included with U.S.S.R. in Europe.
[5] Excludes Israeli production of Egyptian oilfields.
[6] Beginning May 1, 1963, West Irian transferred to Indonesia, production data for West Irian included for the years 1964, 1965, 1966 and 1967 under Indonesia.
[7] Totals are of listed figures only, no undisclosed data included.

Phosphate Rock

By Richard W. Lewis [1]

The heavy expansion of production facilities and opening of new mines and plants in 1966 gave rise to an exceptional increase in domestic marketable phosphate rock production in that year, nearly 33 percent more than in 1965. This coupled with a poor spring planting season resulted in excessive inventories of both marketable rock and triple superphosphate at the start of 1967. The demand in 1967, although nearly 4 percent greater than in 1966, was not enough to absorb the increased output, and the oversupply situation worsened.

Following popular usage, the quantity unit long tons was discontinued in favor of short tons for reporting phosphate rock statistical data beginning with the 1966 Minerals Yearbook.

Legislation and Government Programs.—The Federal Water Pollution Control Administration of the Department of the Interior had an active program underway to investigate the possibilities for removing phosphates from domestic wastes. Representatives of the soap and detergent industry at a meeting with Government officials agreed to cooperate with the Department of the Interior in a program to develop low-phosphate detergents.

A bill imposing a 5-percent severance tax on phosphates was introduced in the Florida State Legislature but was defeated.

The Federal acreage limitation on phosphate leases established in August 1964 was raised to 20,480 acres.[2]

[1] Commodity specialist, Division of Mineral Studies.
[2] Federal Register. Part 3160—Phosphate Leases; Prospecting Permits and Use Permits. V. 32, No. 139, July 20, 1967, p. 10654.

Table 1.—Salient phosphate rock statistics

(Thousand short tons and thousand dollars)

	1963	1964	1965	1966	1967
United States:					
Mine production	68,990	74,473	84,305	r 112,960	128,973
Marketable production	22,238	25,715	29,436	r 39,044	39,770
Value	$139,861	$161,067	$192,738	r 261,092	$265,947
Average per ton	$6.29	$6.26	$6.55	$6.69	$6.89
Sold or used by producers	22,243	24,731	29,039	r 36,443	37,835
Value	$140,642	$156,738	$188,590	r $245,182	$251,163
Average per ton	$6.32	$6.34	$6.49	$6.73	$6.64
Imports for consumption	180	175	148	178	139
Value	$3,651	$3,329	$2,980	$4,256	$3,261
Average per ton	$20.28	$19.02	$20.14	$23.91	$23.52
Exports	5,093	6,374	7,323	9,248	10,072
P_2O_5 content	1,658	2,055	2,313	2,803	3,290
Value	$31,881	$39,717	$51,109	$65,952	$69,479
Average per ton	$6.26	$6.23	$6.98	$7.13	$6.90
Consumption, apparent [1]	17,330	18,532	21,864	r 27,373	27,902
World: Production	53,753	62,938	70,389	83,215	86,969

r Revised.
[1] Measured by sold or used plus imports minus exports.

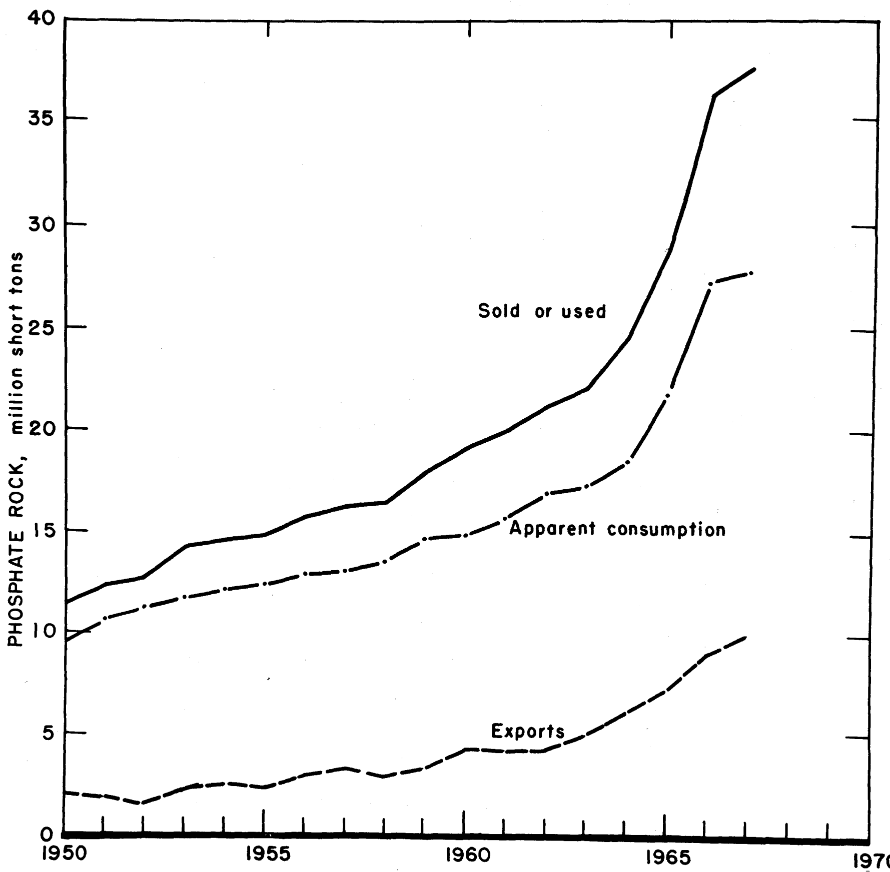

Figure 1.—Phosphate rock (sold or used), apparent consumption, and exports.

DOMESTIC PRODUCTION

Production of marketable phosphate rock in Florida again increased substantially. However, data for 1966 are not strictly comparable with earlier data due to the inclusion of North Carolina statistical data with that of Florida. Beginning in 1966, only one company was producing in North Carolina; therefore it was necessary to combine the phosphate statistics of the two States in order to avoid disclosure of company confidential data. Florida-North Carolina in 1967 accounted for 80 percent of the total domestic output; the Western States produced 12 percent and Tennessee, 8 percent. Florida-North Carolina production increased 7 percent over that of 1966, whereas both Tennessee and the Western States had a reduction in output, 4 percent and 20 percent, respectively.

American Cyanamid Co. added $1 million to its investment in air pollution control equipment at its Brewster plant. Four new scrubbing units were installed which, it was claimed, would reduce the fluorine emission to less than the allowable limit established by the Florida Air Pollution Control Commission. To increase production, Cyanamid put a new 45-cubic-yard dragline shovel into operation at its new Chicora mine in Florida.

Armour Agricultural Chemical Co. and Freeport Chemical Co., a division of Freeport Sulphur Co., cooperated in establishing a $20 million phosphate mine and beneficiation plant near Fort Meade, Fla. Under the Agreement each firm shares the cost of the project and acquires half of the product. Freeport Chemical will use its half of the expected 2-million-ton annual output to manufacture phosphoric acid at a new plant being built at Convent, La. The new mining and beneficiating facility was scheduled to go into production in mid-1968. Freeport's new acid plant with an annual capacity of 600,000 tons of P_2O_5, as 54 percent acid, was scheduled to go on stream soon thereafter.

Consumers Cooperative Association completed its new $22-million phosphate complex at Green Bay, east of Pierce, Fla., in 1966, and it was in full operation. The rated annual capacities of the plant units were as follows: 550,000 tons of sulfuric acid, 220,000 tons of diammonium phosphate and 80,000 tons of triple superphosphate.

International Minerals & Chemical Corp. (IMC) raised its annual production capacity in Florida to 8 million tons with the opening of its new Kingsford mine and plant near Mulberry. The plant was designed to produce 2 million tons of beneficiated rock annually. IMC also expanded its Bonnie chemical complex at Bonnie, Fla., adding a new feed-phosphate unit to produce both diammonium phosphate and calcium phosphate and a new superphosphoric acid plant.

The New Jersey Zinc Co. completed a phosphate fertilizer complex at Depue, Ill. The facility included a 390-ton-per-day phosphoric acid unit and a diammonium phosphate unit with a daily capacity of 900 tons. The firm announced plans to erect a phosphate rock production facility in De Soto County, Fla.

Occidental Corporation of Florida, a subsidiary of Occidental Petroleum Corp., planned a $20 million expansion of its phosphate facility near White Springs in Hamilton County, Fla. The plant had only reached full production in 1966. The fertilizer complex had a rated annual capacity of 470,000 tons of triple superphosphate, diammonium phosphate, and superphosphoric acid. The phosphate mine's original capacity of 1.5 million tons per year was being enlarged to 3 million. Also included in the expansion were port facilities on the Gulf coast and an increase of about 50 percent in the chemical fertilizer output.

F. S. Royster Guano Co. employed a new phosphate fertilizer facility near Mulberry, Fla. Engineered annual capacities for the units included were as follows: 90,000 tons of diammonium phosphate, 110,000 tons of granular triple superphosphate, and about 158,000 tons of run-of-pile superphosphate.

U.S. Phosphoric Products Division of Tennessee Corp., a subsidiary of Cities Service Co., brought into production a new mine and beneficiation plant located near Fort Meade, Fla. The facility was designed to produce 2 million tons annually for use by the firm's phosphoric acid plant and fertilizer complex at Tampa, Florida.

Production at the Swift & Co. Silver City mine and beneficiation plant underwent a $10 million expansion to increase output by 50 percent. Swift also combined its Agri-Chem and Phosphate Divisions into a single working unit, the Agricultural Chemicals Division.

Texas Gulf Sulphur Co. (TGS) began mining phosphate rock early in 1966 at its Lee Creek mine near Aurora, N.C., and nearly attained its capacity output of 3 million tons in 1967. Half of the total production of concentrates or about 1.4 million tons annually is used captively for the production of phosphoric acid and fertilizers in a complex, built at the mine site. The Lee Creek fertilizer complex was designed to make 357,000 tons of triple superphosphate, 220,000 tons of diammonium phosphate, and 90,000 tons of superphosphoric acid (70 percent P_2O_5) annually. For the control of air pollution, TGS installed a $1 million air-scrubbing system to remove pollutants from stack exhausts. All units were designed to facilitate expansion in the future. A comprehensive report on the TGS Lee Creek operation was published.[3]

Phillips Petroleum Co. was planning a $20 million phosphate rock processing plant near Arcadia, Fla. The firm owns about 12,000 acres of phosphate land in Manatee and De Soto Counties.

Stauffer Chemical Co. announced its intention of building a phosphate bene-

[3] Caldwell, A. Blake. Lee Creek Open-Pit Mine and Fertilizer Plants. Eng. and Min. J., v. 169, No. 1, January 1968, pp. 59–83.

fication plant at Moffit, south of Zolfo Springs, Fla. The concentrate would be shipped to the Victor Chemical Division, Stauffer Chemical Co. plant at Tarpon Springs, Fla.

Monsanto Co. acquired rights to large phosphate ore reserves in Columbia and Hamilton Counties in northern Florida from Owens-Illinois Inc.

Duval Corp. purchased a large tract of phosphate land in Hardee County, Fla., and Miscoa Chemical Co. purchased about 4,700 acres of land southeast of Fort Meade. Continental Oil Co. was also known to have acquired phosphate land in central Florida.

Stauffer Chemical Co. purchased the remaining outstanding shares of The Mountain Copper Co., Ltd. (London), thus becoming sole owner of the San Francisco Chemical Co. a phosphate rock producer in the West. Stauffer had already held a 42-percent interest in The Mountain Copper Co. and had shared equally with it in the ownership of San Francisco Chemical Co. Stauffer also purchased the phosphate leases in southeast Idaho held by Terteling Land Co. amounting to an estimated 100 million tons of reserve ore.

Susquehanna-Western Inc. was the successful bidder and leased a 7,000 acre tract of Federal phosphate land in Wyoming. This addition increased the firm's phosphate land holdings to nearly 15,000 acres.

Mountain Fuel Supply Co. was building a $4 million plant for washing and calcining phosphate ore near Soda Springs, Idaho. Also a 3-year contract was awarded for mining the ore and hauling it 21 miles to the plant. Production from the new mine and plant was expected late in 1967.

New Idria Mining and Chemical Co. leased 1,800 acres of land in the vicinity of Bakersfield, Calif., said to contain about 33 million tons of commercial phosphate ore. New Idria planned to mine the phosphate by open pit methods and to produce a commercial product within a year.

FMC Corp. was expanding the elemental phosphorus capacity at its Pocatello, Idaho, plant by about 15 percent to an annual output of 142,500 tons.

Table 2.—Production of phosphate rock in the United 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
1966:									
Florida [1]	99,760	15,452	44	9	29,783	9,612	29,827	9,621	$195,102
Tennessee	5,619	1,186	662	158	2,463	656	3,125	814	23,886
Western States [2]	[r] 7,581	[r] 1,906	2,801	715	[r] 3,291	962	[r] 6,092	1,677	[r] 42,104
Total	[r] 112,960	[r] 18,544	3,507	882	[r] 35,537	11,230	[r] 39,044	12,112	[r] 261,092
1967:									
Florida [1]	117,641	16,731	35	8	31,875	10,284	31,910	10,291	207,788
Tennessee	5,332	1,264	574	142	2,418	653	2,992	795	22,571
Western States [2]	6,000	1,509	2,941	772	1,927	606	4,868	1,378	35,588
Total [3]	128,973	19,503	3,551	922	36,220	11,542	39,770	12,464	265,947

[r] Revised.
[1] Includes North Carolina.
[2] Includes Arkansas (1966), Idaho, Montana, Utah, and Wyoming.
[3] Data may not add to totals shown because of independent rounding.

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			
1963	85	30	$723	$8.51	37	8	$269	$7.27
1964	86	30	747	8.69	31	6	225	7.26
1965	77	27	684	8.88	31	6	221	7.13
1966	49	17	437	8.92	45	9	293	6.51
1967	------	-------	----------	-------	36	7	266	7.42
	Land pebble				Total [1]			
1963	16,102	5,289	$100,749	$6.26	16,224	5,327	$101,741	$6.27
1964	18,203	5,971	115,513	6.35	18,320	6,007	116,485	6.36
1965	21,388	6,949	138,744	6.49	21,496	6,982	139,649	6.50
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

[1] Data may not add to totals shown because of independent rounding.
[2] Includes North Carolina.

CONSUMPTION AND USES

According to a report by the U.S. Department of Agriculture, the consumption of available P_2O_5 as fertilizers during the fiscal year ending June 30, 1967, amounted to 4,304,688 tons compared with the quantity for 1966 of 3,897,132 tons. This represented a 10 percent increase over the 1966 consumption.

Phosphate rock sold or used in 1967 by the producers for the production of triple superphosphate was 41 percent less than that for 1966. This was due to heavy expanded production in 1966 which exceeded the demand and resulted in a large build-up of inventories.

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
1963	2,682	700	$18,303	$6.82
1964	2,753	722	19,074	6.93
1965	2,969	772	22,385	7.54
1966	3,076	799	23,497	7.64
1967	3,032	808	22,494	7.42

Table 5.—Western States phosphate rock sold or used by producers

(Thousand short tons and thousand dollars)

Year	Idaho				Montana [1]			
	Rock	P_2O_5 content	Value: Total	Value: Average per ton	Rock	P_2O_5 content	Value: Total	Value: Average per ton
1963	1,948	484	$10,015	$5.14	1,389	419	$10,583	$7.62
1964	2,200	567	9,802	4.46	1,458	440	11,377	7.80
1965	W	W	W	W	4,574	1,261	26,556	5.81
1966	W	W	W	W	r 5,230	r 1,455	r 36,880	7.05
1967	W	W	W	W	4,971	1,393	35,121	7.06

r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Includes Arkansas (1963–66), Utah, Wyoming (1963–67), and Idaho (1965–67).

Table 6.—Phosphate rock sold or used by producers in the United States, by grades and States

(Thousand short tons)

Year and grade	Florida [1]		Tennessee		Western States		Total [2] United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1966:								
Below 60	78	18	2,816	724	2,581	634	5,475	1,376
60–66	807	236	194	55	499	145	1,500	436
66–70	13,944	4,343	66	20	[r] 1,878	[r] 586	[r] 15,888	[r] 4,949
70–72	2,004	649	-------	-----	--------	--------	2,004	649
72–74	6,800	2,293	-------	-----	[r] 272	[r] 90	[r] 7,072	[r] 2,383
Plus 74	4,504	1,564	-------	-----	--------	--------	4,504	1,564
Total	28,137	9,103	3,076	799	[r] 5,230	[r] 1,455	[r] 36,443	[r] 11,357
1967:								
Below 60	36	7	2,171	561	2,305	559	4,512	1,128
60–66	1,375	408	792	224	383	112	2,550	744
66–70	13,078	4,091	-------	-----	693	214	13,771	4,305
70–72	1,736	558	43	13	1,455	462	3,234	1,034
72–74	6,257	2,071	27	9	128	43	6,412	2,123
Plus 74	7,351	2,518	-------	-----	7	2	7,358	2,520
Total [2]	29,832	9,654	3,032	808	4,971	1,393	37,835	11,855

[r] Revised.
[1] Includes North Carolina.
[2] Data may not add to totals shown because of independent rounding.

Table 7.—Phosphate rock sold or used by producers, by uses and States

(Thousand short tons)

Use	Florida [1]		Tennessee		Western States		Total [2] United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1966:								
Domestic:								
Agricultural	19,297	6,416	W	W	[r] 1,389	[r] 440	W	W
Industrial	709	224	W	W	2,724	675	W	W
Total	20,006	6,640	3,076	799	[r] 4,113	[r] 1,115	[r] 27,195	[r] 8,554
Exports: Total	8,131	2,463	-------	-----	1,117	340	9,248	2,803
Grand total	28,137	9,103	3,076	799	[r] 5,230	[r] 1,455	[r] 36,443	[r] 11,357
1967:								
Domestic:								
Agricultural	20,461	6,582	W	W	1,280	407	W	W
Industrial	357	107	W	W	2,633	660	W	W
Total	20,817	6,689	3,032	808	3,914	1,068	27,763	8,565
Exports: Total	9,015	2,965	-------	-----	1,057	325	10,072	3,290
Grand total	29,832	9,654	3,032	808	4,971	1,393	37,835	11,855

[r] Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Includes North Carolina.
[2] Data may not add to totals shown because of independent rounding.

Table 8.—Phosphate rock sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1966 Rock	1966 P_2O_5 content	1966 Value	1967 Rock	1967 P_2O_5 content	1967 Value
Domestic:						
Phosphoric acid (wet process)	r 7,738	r 2,494	r $53,706	11,370	3,594	$70,970
Electric furnace phosphorus	6,443	1,678	r 45,552	5,987	1,563	40,863
Ordinary superphosphate	4,877	1,793	30,018	5,082	1,661	33,417
Triple superphosphate	r 7,511	r 2,391	r 45,615	4,433	1,460	29,652
Nitraphosphate, Direct application to the soil, Stock and poultry feed, Fertilizer filler (1967), Other fertilizers	626	198	4,339	883	283	6,718
Other uses	---	---	---	8	3	63
Total [1]	r 27,195	r 8,554	r 179,230	27,763	8,565	181,683
Exports: Total	9,248	2,803	65,952	10,072	3,290	69,479
Grand total [1]	r 36,443	r 11,357	r 245,182	37,835	11,855	251,163

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

STOCKS

Stocks held by producers at yearend were 1-percent higher than at yearend 1966. These include adjustments made by the companies and some unbeneficiated mined ore.

Table 9.—Producer stocks of marketable phosphate rock, December 31

(Thousand short tons)

Source	1966 Rock	1966 P_2O_5 content	1967 Rock	1967 P_2O_5 content
Florida [1]	6,885	2,210	8,142	2,591
Tennessee	126	36	85	23
Western States	r 3,107	r 872	1,994	514
Total [2]	r 10,118	r 3,118	10,221	3,127

r Revised.
[1] Includes North Carolina.
[2] Data may not add to totals shown because of independent rounding.

PRICES

The Flordia land pebble phosphate rock producers raised prices $0.25 per ton on all grades of phosphate rock in July 1966. These prices remained steady throughout 1967, however, on negotiated contracts phosphate rock was sold at prices considerably lower than those quoted. Price cutting on the contracts was due chiefly to an oversupply situation.

Prices in January were based on the cost of fuel oil, $2.35 per bbl of 42 gal, and the cost of labor, $1.80 per hour.

Table 10.—Prices of Florida land pebble, unground, washed and dried phosphate rock, in bulk, carlots, at mine, in 1967

(Per short ton)

Grade (percent B.P.L.)	Jan. 2	Dec. 25
66 to 68	$6.50	$6.50
68 to 70	7.50	7.50
70 to 72	8.15	8.15
74 to 75	9.20	9.20
76 to 77	10.20	10.20

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE

The quantity of phosphate rock exported increased 11 percent over that of 1966. However, the average value per ton was $6.90, 23 cents less than the previous year. The most significant percentage increase (30 percent) was noted in the amount of rock produced in the Western States shipped to Canada. Japan, West Germany, and Canada, increased their purchases of Florida land pebble phosphate by about 10 percent; however, shipments to Italy, the other principal foreign customer, were 47,000 tons less than in 1966.

Of the small amount of phosphate rock imported, 80 percent came from the Netherlands Antilles and 19 percent from Mexico; chiefly for use as animal feed supplement due to the rock's low fluorine content.

Table 11.—U.S. exports of phosphate rock, by grades and countries

(Thousand short tons and thousand dollars)

Grade and destination	1966		1967	
	Quantity	Value	Quantity	Value
Florida phosphate rock:				
Australia	843	$7,795	603	$5,631
Austria	31	237	46	378
Belgium-Luxembourg	8	66	139	1,000
Brazil	114	1,068	201	1,837
Canada	1,065	11,771	1,218	12,784
Colombia	26	252	35	268
Denmark	21	170	11	96
El Salvador	7	60	8	70
France	134	1,475	135	1,174
Germany, West	1,162	8,291	1,321	9,262
India	30	278	87	698
Italy	1,165	8,530	1,118	8,243
Japan	1,845	15,643	2,132	18,410
Korea, South	11	89	156	1,577
Malaysia	22	402	11	169
Mexico	326	2,577	361	2,506
Netherlands	167	1,284	147	1,311
New Zealand	309	3,015	140	1,415
Norway	6	54	2	15
Peru	-------	----------	10	85
Philippines	60	521	147	1,317
Rumania	50	383	39	302
South Africa, Republic of	11	105	----------	----------
Spain	231	2,090	263	2,250
Sweden	37	371	82	591
Switzerland	-------	----------	3	36
United Kingdom	344	2,888	343	2,934
Uruguay	34	297	13	128
Viet-Nam, South	32	611	(1)	(1)
Yugoslavia	16	125	24	166
Other	6	73	9	80
Total	8,113	70,521	8,804	74,733
Other phosphate rock: [2]				
Belgium-Luxembourg	1	38	(1)	12
Brazil	4	62	3	95
Canada	1,094	14,404	1,416	18,942
France	(1)	3	8	63
Germany, West	5	32	34	207
Japan	4	34	3	18
Mexico	7	96	2	60
Viet-Nam, South	26	564	(1)	1
Other	1	81	12	282
Total	1,142	15,314	1,478	19,680
Grand total	9,255	85,835	10,282	94,413

[1] Less than ½ unit.
[2] Includes colloidal matrix, sintered matrix, soft phosphate rock, and Tennessee, Idaho, and Montana rock.

Table 12.—U.S. exports of superphosphates (acid phosphates), by countries

(Thousand short tons and thousand dollars)

Destination	1966 Quantity	1966 Value	1967 Quantity	1967 Value
Argentina	-----	----------	5	$206
Australia	1	$38	2	139
Brazil	48	2,372	80	3,521
Canada	132	5,267	123	5,925
Chile	192	9,927	85	3,963
Colombia	48	2,845	12	708
Costa Rica	1	77	6	259
Dominican Republic	3	167	7	321
Ecuador	3	130	3	147
France	3	151	2	98
India	1	116	-------	----------
Italy	-----	----------	3	128
Jamaica	2	95	6	185
Japan	3	152	16	787
Korea, South	203	10,246	75	3,664
Mexico	(1)	13	15	791
Nansei and Nanpo Islands	4	183	4	164
Netherlands	13	576	113	4,971
New Zealand	13	670	(1)	17
Nicaragua	2	87	1	26
Pakistan	85	7,221	151	7,631
United Kingdom	(1)	7	4	164
Uruguay	-----	----------	3	186
Venezuela	5	269	12	472
Yugoslavia	-----	----------	10	407
Other	1	96	5	259
Total	763	40,705	743	35,139

[1] Less than ½ unit.

Table 13.—U.S. imports for consumption of phosphate rock and phosphatic fertilizers

(Thousand short tons and thousand dollars)

Fertilizer	1966 Quantity	1966 Value	1967 Quantity	1967 Value
Phosphates, crude and apatite	178	$4,256	139	$3,261
Phosphatic fertilizers and fertilizer materials	67	3,740	105	6,167
Ammonium phosphates, used as fertilizers	179	13,756	212	17,720
Bone ash, bone dust, bone meal and bones crude, steamed, or ground	7	499	7	395
Manures, including guano	(1)	1	(1)	7
Basic slag	(1)	4	(1)	15
Dicalcium phosphate	22	1,109	6	322

[1] Less than ½ unit.

WORLD REVIEW

Algeria.—Production from the Djebel Onk mine was considerably behind schedule early in the year but increased during the remainder of the year. Exports were seriously affected by the closing of the Suez Canal and only reached 125,000 short tons by yearend. It was reported late in the year that the Algerian Government was increasing its interest in Djebel Onk to 66 percent. The development of the deposit, estimated to have 500 million tons of reserves, involved the construction of a 60-mile railroad as well as a beneficiation plant. The ore, averaging 53 to 61 percent bone phosphate of lime (B.P.L.), requires a considerable amount of processing to raise the grade to the desired 75 percent B.P.L. When the facility is in full operation a production rate of 1 million tons is expected. The first shipment of phosphate by rail from Djebel Onk to the port of Annaba (formerly Bone) was made late in 1966.

Angola.—An exploitable phosphate rock reserve of about 27 million tons (15 million tons in Cabinda and 12 million north of Ambrizete on the Northwest Coast) was reported in 1966 by the Provincial Government.

Australia.—Threatened exhaustion of phosphate rock deposits on the Pacific Islands, currently supplying over 75 percent of Australia's imports of phosphate, produced a flurry of prospecting activity both on land and offshore. The Federal Government, in 1966, offered rewards to discoverers of promising deposits.

It was reported that 15 exploration groups were active in offshore exploration for minerals on the Australian Continental Shelf in November 1966.[4] A total of 162,290 square miles was held by 23 leases, eight of which were specifically licensed for phosphate mineral exploration.

[4] Engineering and Mining Journal. Australia's Shelf Potential Sparks a Leasing Rush. V. 168, No. 4, April 1967, pp. 112–114, 204.

Table 14.—World production of phosphate rock, by countries [1] [2]

(Thousand short tons)

Country	1963	1964	1965	1966	1967 p
North America:					
United States	22,238	25,715	29,436	r 39,044	39,770
Mexico	r 38	r 37	r 44	r 61	54
Netherlands Antilles	[3] 141	[3] 132	[3] 127	r [3] 163	127
South America:					
Brazil:					
Apatite (ores and concentrates)	237	215	211	r 325	e 330
Phosphate rock	70	56	96	r 92	e 100
Chile:					
Apatite	15	14	r 11	--------	NA
Guano	24	17	24	17	NA
Peru (guano)	206	226	187	61	72
Venezuela	-------	-------	e 7	e 66	e 30
Europe:					
Belgium	15	24	e 24	e 24	NA
France (phosphatic-chalk)	56	48	38	r 26	NA
Poland	71	98	103	e 103	e 100
U.S.S.R.:					
Apatite e	r 5,250	r 7,360	r 8,650	r 9,300	9,760
Sedimentary rock	r 4,200	r 4,800	r 6,670	r 7,440	8,270
Africa:					
Algeria	384	80	95	e 88	e 386
Morocco	9,423	11,131	10,830	10,405	11,624
Senegal:					
Aluminum phosphate	139	133	149	160	167
Calcium phosphate	518	746	956	1,091	1,229
Seychelles Islands (guano) [3]	8	4	7	r 4	NA
South Africa, Republic of	501	638	672	1,172	e 1,433
Togo	567	829	1,065	1,228	e 1,323
Tunisia	2,613	3,032	3,351	3,527	e 3,527
Uganda (apatite)	8	11	18	17	NA
United Arab Republic	675	676	654	728	e 675
Asia:					
China, mainland e	800	900	1,000	1,100	1,100
Christmas Island (Indian Ocean) [3]	730	868	828	1,065	e 1,000
India (apatite)	14	4	r 8	18	NA
Indonesia	1	4	e 4	e 11	NA
Israel	331	265	428	e 441	e 661
Jordan	677	666	913	1,142	e 1,100
Korea, North (apatite) e	220	220	220	r 276	276
Viet-Nam, North:					
Apatite	1,020	e 1,100	e 1,100	e 1,100	e 1,100
Phosphate rock e	55	55	55	55	55
Oceania:					
Australia	6	6	5	r 6	NA
Makatea Island (French Oceania)	370	428	340	r 195	-------
Nauru Island [3]	1,733	2,038	r 1,649	2,245	e 2,200
Ocean Island [3]	399	362	r 414	419	e 500
Total	r 53,753	r 62,938	r 70,389	r 83,215	86,969

e Estimate. p Preliminary. r Revised. NA Not available.
[1] A negligible amount of phosphate rock was produced in Cambodia, Jamaica, Philippines, and Tanzania and of guano in Argentina, Territory of South-West Africa, and Philippines.
[2] Compiled mostly from data available April 1968.
[3] Exports.

In 1966, Broken Hill South Ltd. found the first extensive deposit of phosphate rock on the continent.[5] Further exploration in 1967, confirmed the presence of a major deposit. Some of the outcroppings were 40-feet thick and the area covered about 45 square miles. The deposit is located at Duchess, near Cloncurry in central Queensland, 550 miles inland from Townsville and about 300 miles from the Gulf of Carpentaria.

Eastern Prospectors, Pty., 76 percent of which is owned by Mid-Eastern Oil N.L., located phosphate deposits north of Cooktown in Queensland, on the East Coast of Cape York Peninsula. These deposits are along the coastal plain and easily accessible by sea. However, it was reported that the samples tested had a grade of 6 percent or less P_2O_5, not high enough to be of commercial importance. Additional exploration in the area may expose higher grade ore.

International Minerals & Chemical Corp. (U.S.A.) reported the discovery of a large phosphate deposit, 15-feet thick and covering an area of about 15 square miles, about 150 miles from the Gulf of Carpentaria and 600 miles southeast of Darwin. The deposit was reported to contain about 500 million tons of medium grade ore. The ore is covered by about 35 feet of overburden making open pit mining feasible. Additional exploration is required before exploitation of the mineral can be justified.

Belgium.—The Directors of International Minerals & Chemical Corp. (U.S.A.) and of Société de Prayon S.A. (Belgium) approved a joint venture to build a $16 million, 325,000-ton-per-year phosphoric acid plant on the banks of the Scheldt near the Netherlands border. Plans called for the plant to go on stream in 1969.[6]

Brazil.—New phosphate deposits with estimated reserves of 20 million tons were discovered in the State of Pernambuco. Phosphate deposits in Brazil were estimated to be about 132 million short tons averaging 20 percent P_2O_5. The deposits, in the States of Pernambuco (88 million tons) and Paraiba (44 million tons), extend about 90 miles between Recife and Joao.[7]

Canada.—Electric Reduction Company of Canada, Ltd. (ERCO) has a new $40 million phosphorus plant under construction at Long Harbour, Newfoundland. The facility includes two electric furnaces and is expected to be on stream in 1969. Two ships were being built for Albright & Wilson Ltd. (London), the parent company of ERCO, to transport liquid phosphorus in bulk from the new plant. Each ship will have a capacity of 5,000 tons. The phosphate rock to feed the furnaces will be imported from Florida.

Simplot Chemical Co., Ltd. put on stream, one of the world's largest ammonium phosphate plants, having an annual capacity of over 300,000 tons. The plant at Brandon, Manitoba, is part of a $30-million fertilizer complex.

The diammonium phosphate (DAP) plant planned in 1965 as a joint venture by ERCO and Brunswick Mining and Smelting Corp. Ltd. was not built. Instead, new plans were made for constructing a DAP plant with an annual capacity output of about 420,000 tons. An agreement was signed by the two companies and a new firm, Belledune Fertilizer Ltd., was formed to operate the plant being built at Belledune Point, New Brunswick.

Imperial Oil Ltd., a subsidiary of Standard Oil of New Jersey, started construction on a $50 million fertilizer plant near Redwater, Alberta, about 45 miles north of Edmonton. The plant, when completed in early 1969, will have an annual output of more than half a million tons of nitrogenous and phosphatic fertilizer. The plant will include a double-train diammonium phosphate unit.

Colombia.—Reportedly, a $20 million phosphoric acid plant is to be built at Barranquilla and to be in full production by the end of 1969. Phosphate rock from deposits at San Vicente de Chucuri, Province of Santander, is expected to supply the plant at a rate of about 1,500 tons daily.

India.—The new phosphate plant built for Albright, Morarji & Pandit Ltd. at

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[5] World Mining. Australia-Broken Hill South Geologists Discover Two Phosphate Bearing Sediment Outcrops. V. 2, No. 13, December 1966, p. 30.

[6] The Mines Magazine. Largest Phosphoric Acid Plant in the European Common Market. V. 57, No. 6, June 1967, p. 30.

[7] Mining Journal (London). Brazilian Phosphate Deposits. V. 268, No. 6872, May 5, 1967, p. 343.

Ambernath, Maharashtra, was on stream. The phosphoric acid unit has a rated annual output capacity of 18,000 tons of P_2O_5 as acid. Some of the output is being used to manufacture 14,000 tons of sodium tripolyphosphate per year; the rest is being shipped to Dharamsi Morarji Chemical Co. Ltd. nearby for the production of triple superphosphate.

The Geological Survey of India intensified its search for phosphorites, concentrating on a black shale-chert horizon in the Mussoorie synform. Results indicated that phosphorite horizons with 20 percent or more P_2O_5 content occur in several areas of Uttar Pradesh.[8]

Iran.—A phosphoric acid plant and related facilities were being designed for Shahpur Chemical Co. Ltd. at Bandar-e-Shahpur. The plant is part of a $150 million joint venture of Allied Chemical Corp. (U.S.) and National Petrochemical Co. (Iran). The complex when completed in 1969 will include a plant to produce sulfur by gas desulfurization and units to produce ammonia, urea, sulfuric acid, phosphoric acid, diammonium phosphate, and triple superphosphate. The phosphoric acid plant is being designed for a daily output of about 525 tons of P_2O_5 as 54 percent acid.

Israel.—A new phosphate deposit was discovered at Har Masa in the Negev Desert. Reserves were estimated at about 8 million tons of rock having a P_2O_5 content of 26 to 28 percent.

The phosphate plant at Oron owned by Chemical and Phosphates Ltd. increased its kiln capacity to 660,000 short tons of phosphates annually. The firm has another plant with an annual output of about 275,000 tons.

The construction of a chemical complex including a 180,000-ton phosphoric acid plant and facilities to produce composite fertilizers from potash and phosphates was agreed upon by the Ministry of Development and its American partner, Madera Corp. Locally produced hydrochloric acid was selected over imported sulfuric acid for the manufacture of the phosphoric acid. The plant was planned for the Negev area at Arad, but no commencement date was announced.

A new plant to produce 100,000 tons of potassium nitrate and 23,000 tons of phosphoric acid annually as under construction at Haifa.

Mexico.—The Government scheduled two phosphatic fertilizer plants to be built by U.S. companies each with an annual capacity of about 400,000 tons; they are due on stream in 1969. A third plant, at least as large, is to be built at a later date. The combined productions of the three new plants will be much greater than Mexican consumption. The distribution and price of the fertilizers will be controlled by the Government through Guanos y Fertilizantes, but it was reported that the companies would be free to export the major portion of their products. Phosphate rock is to be imported from Florida and the sulfur provided from domestic sources.[9]

An Alliance for Progress loan of $19 million was made by the Export-Import Bank to Fertilizantes Fosfatados Mexicanos, S.A. de C.V. (FFM), to help finance a new phosphate fertilizer plant under construction on the southern coast of the Bay of Campeche in Veracruz. Banco Nacional de Mexico, S.A., is the major stock holder in FFM, and Pan American Sulphur Co. is a minority owner through its affiliate Azufrera Panamericana, S.A. Sulfur will be supplied by Pan American, and the phosphate rock will be shipped in from Florida. The plant is expected to reach its full daily production capacity of 760 tons of triple superphosphate and 1,245 tons of phosphoric acid in 1971.[10] The entire output reportedly will be exported.

Morocco.—The chemical fertilizer complex at Safi started producing diammonium phosphate as well as triple superphosphate. Negotiations continued throughout the year on the Occidental Petroleum Corp. project to establish a superphosphoric acid plant. Where the plant is to be located and when construction will start were not announced.

Nauru.—Representatives of the Nauru local government council and of the governments of Australia, New Zealand, and the United Kingdom entered into an agreement providing for the future of the phosphate industry. The agreement was put in force on July 1, 1967; it

[8] Chaterji, G. C. Sedimentary Phosphorite Deposits of Mussoorie Area, Uttar Pradesh. J. of Mines, Metals & Fuels (Calcutta), v. 15, No. 4, April 1967, pp. 97–98.
[9] Foreign Trade (Canada). Fertilizer Nationalized. V. 128, No. 4, Aug. 19, 1967, p. 22.
[10] Commercial Fertilizer. Mexico. V. 115, No. 1, July 1967, p. 22.

calls for management of the phosphate operations by the British Phosphate Commissioners for 3 years. The management will then pass to the newly established Nauru Phosphate Corp. if payments for the assets are completed.[11] The assets were estimated to be valued at about $22.4 million. Nauru will continue to supply phosphate to the three countries of the agreement at the rate of 2 million tons per year. A basic price of $11 per ton in each of the three years was established. However, if the assets have been paid in full by June 30, 1969, the basic price in the third year will be raised to $12 per ton.[12]

Pakistan.—The East Pakistan Industrial Development Corp. (EPIDC) planned to erect seven new fertilizer plants within the next 5 years. Included in the EPIDC plan was two triple superphosphate plants at Chittagong. Plant No. 1, designed for an annual production of 32,000 tons, was under construction and scheduled for completion in August 1968. Plant No. 2, designed for an annual output of 120,000 tons, was scheduled on stream in mid-1969. Also, a plant to produce 80,000 tons of ammonium phosphate annually was planned for Habiganj in the Sylhet District with a target date for completion in late 1973 or early 1974.[13]

Peru.—Kaiser Aluminum & Chemical Corp. completed its acquisition of Texada Mines Ltd. of Canada resulting in the acquisition of an 80-percent interest in the Sechura deposits. Details of the acquisition and of the agreement for developing these phosphate deposits were reported.[14] The project plans, subject to certain conditions, called for the annual production of 2 million tons of phosphate concentrates beginning in October 1971. The capital expenditure was raised from $15 million to $60 million with Kaiser Industries spending an additional $1 million on the project by June 4, 1968.

South Africa, Republic of.—African Metals Corporation, Ltd. (Amcor) had on stream a new phosphate plant at Langebaanweg, Cape Province. The plant beneficiates low-grade phosphate sand at the mine site by flotation. The annual production rate was reportedly 150,000 tons of fertilizer and 50,000 tons of concentrates.[15]

A new 15,000-kv elemental phosphorus furnace was completed for Amcor at its Kookfontein plant near Meyerton, Transvaal. The unit, the first of its kind to be put into operation on the African continent, cost about $6 million and took 2 years to build.

Spanish Sahara.—The Spanish Government-owned mining company, Empresa Nacional Minera del Sahara, S.A. (ENMINSA), in 1966 offered for open bidding, a 45-percent interest in a joint venture to develop an extensive phosphate deposit at Bu-Craa about 54 miles southeast of El Aaiun. More than 18 foreign companies including British, French, German, Canadian, and United States interests were at one time bidding. Finally late in May 1967, a bid by International Minerals & Chemical Corp. (IMC) was apparently accepted giving IMC a 25-percent interest in the $185 million phosphate project. The Spanish Government retained 55 percent and 20 percent was to be open to participation bids by European firms. However, negotiations between the Spanish Government and IMC were discontinued in January 1968.

Syrian Arab Republic.—Bulgarian and Syrian representatives signed a cooperation protocol for the exploitation of the phosphate deposits in the Palmyra district, according to a press release by the official Syrian Arab News Agency. Bulgaria was to provide all the necessary economic and technical studies related to the project as well as its financing. The cost was to be repaid over a period of 15 years from the proceeds obtained by selling the phosphates to Bulgaria at international market prices.[16]

Togo.—W. R. Grace & Co. (U.S.), the largest single stockholder (43 percent) in the Compagnie Togolaise des

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11 Bureau of Mines. Mineral Trade Notes. V. 64, No. 10, October 1967, pp. 31–32.
12 Fertiliser & Feeding Stuffs Journal (London). Nauru Phosphate Agreement. V. 64, No. 14, July 19, 1967, p. 497.
13 Bureau of Mines. Mineral Trade Notes. V. 64 No. 7, July 1967, pp. 21–22.
14 Northern Miner. Midepsa Industries Details Agreement Phosphate Project. No. 30, Oct. 19, 1967.
15 South African Mining & Engineering Journal (Johannesburg). Amcor's Phosphate Plant At Full Capacity. V. 78, Pt. 1., No. 3865, Mar. 3, 1967, p. 495.
16 U.S. Embassy Beirut, Lebanon. State Department Airgram A-357, Oct. 24, 1967, p. 1.

Mines du Benin, submitted to the Togolese Government a project for the production of superphosphate. This was a revival of a three-year-old plan and would cost about $800,000.

Turkey.—In 1966, the discovery of large phosphate deposits in the southeast covering an area of about 58 square miles was reported. The discovery was made by the Turkish Supply Research Institute which reported that the exploitable ore may amount to 200 million tons of 10- to 12-percent P_2O_5 grade.

Tunisia.—The proposed $40 million Industries Chimiques Maghrebines ammonium phosphate and ammonium nitrate plant planned for Gabes was deferred. An engineering study was made of the project but efforts to obtain foreign capital were unsuccessful.[17]

Uganda.—Plans for exploiting the extensive apatite deposits in the Tororo area and producing triple superphosphate were announced by the Uganda Development Corp. The superphosphate facility was to be a joint venture with Imperial Chemical Industries, Ltd. (ICI) of the United Kingdom. ICI completed feasibility studies on the superphosphate plant which was estimated to cost $11 million.[18]

U.S.S.R.—A triple superphosphate plant was put into operation at the Vinniza chemical combine in the Ukraine. It was reportedly the first such plant in production in the Soviet Union.[19]

[17] Bureau of Mines. Mineral Trade Notes. V. 64, No. 7, July 1967, p. 34.
[18] Bureau of Mines. Mineral Trade Notes. V. 64. No. 11, November 1967, pp. 34–35.
[19] Chemical Age (London). U.S.S.R. Opens First Plant for Triple Superphosphate. V. 97, No. 2479, Jan. 14, 1967, p. 12.

Table 15.—Selected African countries: Exports of phosphate rock in 1967, by countries

(Short tons)

Destination	Algeria	Morocco	Senegal	Togo	Tunisia	Total
North America:						
Canada	--	125,306	--	--	--	125,306
Cuba	--	32,493	--	--	--	32,493
South America:						
Brazil	--	21,689	--	--	--	21,689
Chile	--	--	11,000	--	--	11,000
Uruguay	--	--	11,000	--	47,400	58,400
Europe:						
Albania	--	55,173	--	--	--	55,173
Austria	--	48,311	--	--	--	48,311
Belgium	--	1,264,647	--	71,650	--	1,336,297
Czechoslovakia	--	180,838	--	--	87,080	267,918
Denmark	--	234,952	--	--	23,590	258,542
Finland	--	113,195	--	--	--	113,195
France	15,430	1,993,209	228,438	460,000	628,760	3,325,837
Germany:						
East	--	64,738	--	--	--	64,738
West	8,820	282,679	184,158	71,650	171,520	718,827
Greece	--	131,534	55,108	--	228,840	415,482
Hungary	--	2,188	--	--	--	2,188
Ireland	--	405,555	--	--	--	405,555
Italy	16,535	435,405	19,880	47,400	206,460	725,680
Netherlands	--	558,312	5,460	276,680	--	840,452
Norway	--	33,533	--	20,000	1,870	55,403
Poland	--	350,063	--	--	272,270	622,333
Portugal	--	327,873	--	--	--	327,873
Spain	4,410	755,912	--	--	146,390	906,712
Sweden	--	346,566	--	--	5,730	352,296
Switzerland	--	19,650	--	--	2,645	22,295
United Kingdom	--	977,278	155,723	13,230	28,770	1,175,001
Yugoslavia	--	14,770	--	--	342,160	356,930
Africa:						
Canary Islands	--	24,687	--	--	--	24,687
South Africa, Republic of	--	--	100,537	--	--	100,537
Asia:						
China	--	713,153	--	--	64,700	777,853
India	57,320	11,000	--	36,375	29,980	134,675
Japan	--	476,719	212,178	116,845	12,455	818,197
Taiwan	--	128,077	--	--	--	128,077
Oceania: Australia	--	50,158	49,875	123,460	--	223,493
Other countries	--	37,506	--	--	156,740	194,246
Total	102,515	10,217,169	1,033,357	1,237,290	2,457,360	15,047,691

United Kingdom.—In 1966, a pact was signed by Imperial Chemical Industries, Ltd. (ICI) with the U.S.S.R. calling for ICI to take between 500,000 and 750,000 tons of Soviet produced phosphate rock concentrate over the next four years. The first specific order under the agreement was for 120,000 tons of concentrate to be delivered between June 1967 and May 1968.[20]

TECHNOLOGY

A paper was published in which a hydropneumatic froth flotation cell was evaluated for the recovery of coarse Florida phosphate. Comparisons were made to belt flotation which was currently being used. Results of the tests showed that the hydropneumatic cell was superior to the mechanical cell and the belt circuit.[21]

The Standard I.M.I. Process, a phosphoric acid process based on the acidulation of phosphate rock with hydrochloric acid with subsequent separation of the phosphoric acid by solvent extraction, and the I.M.I. Purification Process, a solvent extraction technique for purifying wet-process phosphoric acid from acidulated with sulfuric acid, were fully described in a published paper.[22] The Standard I.M.I. Process was developed by Israel Mining Industries Institute for Research and Development several years ago and was in use in a commercial plant in Japan in 1962. The I.M.I. Purification Process was more recently developed by the same organization.

A new solvent process for concentrating and purifying wet-process phosphoric acid was developed by Toyo Soda Manufacturing Co., Ltd. (Japan). The process was reported to produce an 85 percent acid, pure enough to use as a food additive and in manufacturing detergents, etc.[23]

Two processing techniques to produce and granulate ammonium phosphate more economically were developed by Fisons Fertilizers Ltd. In the first process inexpensive powdered monoammonium phosphate (MAP) is produced from wet-phosphoric acid by the addition of ammonia under pressure. A slurry is produced which is easily handled although it has a low water content. In the second process, an improvement in the granulation of mixtures of MAP and ammonium nitrate, water is removed before granulation and anhydrous molten mixtures are produced at temperatures below the melting points of their component salts.[24]

Interest in nitrophos fertilizers or nitric phosphates grew in the United States due to the short supply of sulfur and accompanying price increase. Several processes have been developed to produce phosphatic fertilizer using nitric acid instead of sulfuric acid which is necessary for the production of superphosphates. The development history, production methods, economics of processing, and agronomic considerations of nitric phosphates were discussed in a series of published articles.[25] Also, a new method for producing nitrophos fertilizer was announced by Chemical Construction Corp. (Chemico). The engineering firm claimed that the new process, covered by a patent application, would produce highly effective fertilizer for less money than is now being spent on comparable products.

A new stabilized nickel-chromium-molybdenum-copper alloy was developed which may solve the serious scale formation and corrosion problems that have always beset phosphoric acid producers and users. The addition of 2 percent niobium stabilized the new alloy which was named Hastelloy alloy G. The alloy was still being tested but a report on research studies to date was published.[26]

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[20] Oil, Paint and Drug Reporter. Phosphate Rock Deal: Soviets to Supply UK. V. 191, No. 6, February 1967, pp. 4, 44.

[21] Bucci, Philip A. Evaluation of a Hydro-Pneumatic Froth Flotation Cell in Recovery of Coarse Florida Phosphate. Soc. Min. Eng. AIME, Preprint. No. 66B324, 1966, 20 pp.

[22] Wasselle, L. A., E. F. Lasseter, and R. A. Brosh. Pure Phosphoric Acid From Hydrochloric or Sulfuric Acidulated Rock—I.M.I. Process. Soc, of Min, Eng., AIME. Preprint No. 66B321, 1966, 23 pp.

[23] Chemical Week. Wet-Acid Purifier. V. 99. No. 11, Sept. 10, 1966, pp. 62, 66.

[24] Chemical Engineering. New Processes Boost Ammonium Phosphate Stature. V. 73, No. 26, Dec. 19, 1966, p. 58.

[25] Slack A. V. It's Time To Consider Nitric Phosphates. Part 1.—Background and History. Farm Chem., v. 130, No. 4, April 1967, pp. 28–30, 32, 34; Part 2.—Process Technology. No. 5, May 1967, pp. 24, 26, 28, 29, 62–64; Part 3.—Economic Considerations. No. 6, June 1967 pp. 124–132, Part 4.—Agronomic Considerations. No. 7, July 1967, pp. 30–44.

[26] Leonard, R. B. Bidding to Balk Corrosion in Phos-Acid Concentration. Chem. Eng., v. 74, No. 12, June 5, 1967, pp. 158–162.

Dental scientists discovered that the use of sodium phosphate as a tooth decay preventative showed great promise. A study was made on 500 children; half of them ate regular sugar-coated cereal; the other half ate phosphate-coated cereal. The results showed a 20- to 40-percent reduction in tooth decay in the group given the phosphate. Good results were also claimed for phosphate chewing gum. Neither of these products was produced for marketing in 1967.

The Bureau of Mines study of the Western phosphate industry was completed, and the last three reports of a series of five were published.[27] The Bureau of Mines published progress report on the results of mining tests made using a pneumatic vibrating-blade planer on the phosphate bed of the Douglas mine near Drummond, Mont.[28] These tests showed that it was not economical to use the planer for mining ore at the Douglas mine. They further indicated that a competent bed with a hardness of 3 to 4 on the Mohs' scale could not be mined economically with a planer. Planer mining however was feasible where the bed was fractured enough that a 4-inch-deep cut could be consistently maintained.

Studies were conducted by the Bureau of Mines to develop a commercial process for beneficiating Western phosphorite, chiefly intermediate- and marginal-grade ores from deposits in Southeast Idaho. The process developed included the production of a coarse concentrate by attrition scrubbing and sizing, desliming, flotation to recover phosphate values from intermediate sizes, roasting the combined concentrates to remove organic carbon and combined water, and sulfur dioxide leaching to remove magnesium and nonapatitic calcite. Results of pilot-plant tests conducted on different ore types showed that about 80 percent of the available phosphate was recoverable at a grade suitable for phosphoric acid production. A paper describing the research and results obtained was presented at the Society of Mining Engineers fall meeting at Tampa, Fla.[29]

New or improved beneficiation techniques for producing electric furnace phosphorus concentrates from low-grade Tennessee brown phosphate rock was the objective of phosphate research at the Bureau of Mines, Tuscaloosa Metallurgy Research Center, Tuscaloosa, Ala. The major phase of the flotation study was directed at the rejection of iron and aluminum oxides in the ore in order to produce a phosphate rock concentrate suitable either for converting to wet-process acid or for blending with low-grade ore to produce a furnace-grade feed. Flotation studies were made also in an effort to improve recovery of the phosphate values lost in the washer slime fraction. Preliminary results indicated that improved recovery was obtainable.

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[27] Service, A. L. An Evaluation of the Western Phosphate Industry and Its Resources (in Five Parts). Pt. 3. Idaho. BuMines Rept. of Inv. 6801, 1966, 201 pp.

Coffman, J. S., and A. L. Service. An Evaluation of the Western Phosphate Industry and Its Resources (in Five Parts) Pt. 4. Wyoming and Utah. BuMines Rept. of Inv. 6934, 1967, 158 pp.

Service, A. L., and N. S. Petersen. An Evaluation of the Western Phosphate Industry and Its Resources (in Five Parts) Pt. 5. Trends and Outlook. BuMines Rept. of Inv. 6935, 1967, 131 pp.

[28] Anderson, Webster S. Test Operation of a Pneumatic Vibrating-Blade Planer. A Progress Report on Phosphate Mining Research. BuMines Rept. of Inv. 6863, 1966, 16 pp.

[29] Rule, Albert, R., and W. A. Stickney. Improved Processing Techniques for Phosphate Recovery, Presented at Soc. Min. Eng. Fall Meeting and Exhibition, Tampa, Fla., Oct. 15, 1966, 16 pp. (Unpublished.) Available for inspection at Division of Mineral Studies, Bureau of Mines, Department of the Interior Washington, D.C.

Platinum-Group Metals

By R. A. Heindl [1]

Supplies of platinum and most of the other metals of the platinum group were insufficient to meet demand. Compared with 1966, supplies were down approximately 500,000 troy ounces—net imports were 205,000 ounces less and there were no Government sales compared with sales of 316,000 ounces in 1966. Commercial sales of platinum-group metals to domestic consumers during 1967 were down 20 percent. Such sales, however, were 13 percent higher than in 1965. Most of the decline below 1966 shipments was accounted for by decreased shipments of palladium; shipments of platinum were also somewhat lower. This decrease probably was due in large part to the decline in palladium imports from U.S.S.R. and the continued low level of platinum imports from this source.

Table 1.—Salient platinum-group metals statistics

(Troy ounces)

	1963	1964	1965	1966	1967
United States:					
Mine production [1]	49,750	40,487	35,026	51,423	16,365
Value	$2,442,840	$2,395,877	$2,041,102	$3,106,993	$1,428,863
Refinery production:					
New metal	80,208	71,090	61,723	73,615	29,663
Secondary metal	117,099	120,147	108,525	103,321	365,799
Exports (except manufactures)	63,012	146,306	103,097	205,456	279,602
Imports for consumption	1,003,608	882,705	1,172,643	r 1,352,256	1,219,298
Stocks Dec. 31: Refiner, importer, dealer	699,575	767,264	926,373	1,129,604	869,211
Consumption	1,003,194	1,117,680	1,186,701	1,675,795	1,334,296
World: Production	2,038,805	2,545,764	2,968,890	3,039,449	3,154,434

r Revised.
[1] From crude platinum placers and byproduct platinum-group metals recovered largely from domestic gold and copper ores.

Demand continued at a high level and as a result yearend stocks at refineries, importers, and dealers were lower than at yearend 1966.

The supply-demand imbalance was further aggravated by the prolonged strike in the copper industry. This strike sharply curtailed domestic output of byproduct platinum metals, with the result that production was down 68 percent to 16,000 troy ounces.

Legislation and Government Programs.—Ruthenium was the only metal of the platinum group sold from the Government stockpiles during the year. Invitations to bid on 4,200 troy ounces of ruthenium sponge were issued by the General Services Administration (GSA) on September 7. Awards totaling 1,600 ounces were announced September 28 at prices ranging from $38.00 to $41.25 per ounce.

A November 16 offering of 2,500 ounces of ruthenium resulted in no acceptable bids, according to GSA. It was then stated that offers would be considered for up to 2,500 ounces of the metal on a negotiated basis.

A bill to allow disposal of the 115,000 ounces of platinum was passed by the House on December 14, but no Senate action had been taken by yearend.

[1] Commodity specialist, Division of Mineral Studies.

The Office of Emergency Planning Stockpile Procurement Directive for fiscal year 1968, issued November 9, 1967, provided for the exchange of excess materials for 249,948 troy ounces of palladium and the upgrading of up to 300 ounces of iridium and up to 10,000 ounces of palladium.

On August 31 a contract was entered into providing for the acquisition of 200,000 ounces of palladium for delivery by June 30, 1968. Payment for this material was being made in other excess stockpile materials. Deliveries under the contract as of December 31 totaled 104,856 ounces.

Table 2.—Government inventory of platinum-group metals, December 31, 1967

(Troy ounces)

Metal	National stockpile	Supplemental stockpile	Objective	
			Conventional war	Nuclear war
Iridium	[1] 13,937	----------	17,000	3,100
Palladium	[2] 200,822	747,680	1,300,000	630,000
Platinum	[3] 400,038	49,999	335,000	235,500
Ruthenium	----------	11,999	----------	----------

[1] Excludes 184 ounces nonstockpile grade.
[2] Excludes 6,394 ounces nonstockpile grade.
[3] Excludes 36 ounces nonstockpile grade.

DOMESTIC PRODUCTION

As a result of the closure of copper refineries for nearly half the year because of labor strikes, domestic production of platinum-group metals was 16,365 troy ounces, only 32 percent of the previous year's production. However, despite the strike, byproduct platinum metals from copper and gold refiners provided the major part of U.S. mine production. Placer mines in Alaska contributed substantially to domestic production and a small quantity was produced from California placers.

Toll refining of platinum metals increased 15 percent in 1967 to a total of 2,014,111 ounces, 1,849,059 ounces or 91 percent from used material and the remaining 165,052 ounces from virgin material. With the exception of osmium, all metals showed an increase in the amount refined on toll. Toll refined platinum increased 21 percent to 1,221,098 ounces. Palladium refined on toll increased 8 percent to 708,966 ounces and rhodium was up 15 percent to 69,120 ounces. The quantities of iridium, osmium, and ruthenium toll refined in 1967 amounted to 7,703, 608, and 6,616 ounces, respectively.

A sharp increase in the recovery of secondary metals reported by domestic refiners was attributed partly to expanded coverage of the industry, and partly to decreased supplies of primary metal and higher market prices.

Table 3.—New platinum-group metals recovered by refiners in the United States by sources

(Troy ounces)

Year and source	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1963	40,290	32,799	2,270	189	3,421	1,239	80,208
1964	30,539	27,301	3,981	515	6,274	2,480	71,090
1965	25,247	26,339	2,628	1,199	4,858	1,452	61,723
1966:							
From domestic sources:							
Crude platinum; gold and copper refining	18,103	29,907	1,513	219	2,361	558	52,661
From foreign crude platinum	11,945	1,460	2,466	1,314	3,289	480	20,954
Total	30,048	31,367	3,979	1,533	5,650	1,038	73,615
1967:							
From domestic sources:							
Crude platinum; gold and copper refining	6,736	8,142	754	151	57	11	15,851
From foreign crude platinum	13,560	120	-----	-----	132	-----	13,812
Total	20,296	8,262	754	151	189	11	29,663

Table 4.—Secondary platinum-group metals recovered in the United States

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1963	54,084	59,993	440	273	1,990	319	117,099
1964	66,043	49,879	764	928	2,338	195	120,147
1965	53,562	50,025	960	763	2,590	625	108,525
1966	49,563	50,009	402	728	2,434	185	103,321
1967 [1]	126,377	215,162	7,748	2,377	11,505	2,630	365,799

[1] Increase over prior years due in part to expanded coverage of the industry.

CONSUMPTION AND USES

Consumption of platinum-group metals, as indicated by sales to consuming industries, was down 20 percent from the 1966 total. Consumption of platinum was down 8 percent, of palladium down 30 percent, and of rhodium down 21 percent. Iridium and ruthenium consumption increased 10 and 26 percent, respectively Osmium consumption was essentially unchanged.

The major consuming industries for platinum and palladium were the same in 1966 and 1967. In both years 87 percent of the platinum shipments went to the petroleum, chemical, electrical, and glass industries, in the order listed. Also in both years 92 percent of the palladium went, in descending order, to the electrical, chemical, and dental and medical industries.

In 1967, 33 percent of the total platinum-group metals consumed went to the electrical industry, 28 percent to the chemical industry, and 19 percent to the petroleum industry. This pattern was not significantly different from the 1966 pattern.

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
1963	424,344	526,527	9,832	1,056	37,068	4,367	1,003,194
1964	451,350	591,432	9,652	1,379	55,426	8,441	1,117,680
1965	411,435	717,085	9,554	1,634	38,910	8,083	1,186,701
1966:							
Chemical	191,429	221,559	3,746	1,483	14,210	3,048	435,475
Petroleum	201,955	28,760	1,251	------	517	202	232,685
Glass	90,556	1,011	1	------	34,491	------	126,059
Electrical	117,156	531,545	1,722	22	9,216	1,147	660,808
Dental and medical	24,296	67,102	832	252	335	1,336	94,153
Jewelry and decorative	40,549	32,215	2,628	------	9,100	433	84,925
Miscellaneous	24,846	12,020	813	79	1,819	2,113	41,690
Total	690,787	894,212	10,993	1,836	69,688	8,279	1,675,795
1967:							
Chemical	159,384	192,011	4,610	823	17,770	4,984	379,582
Petroleum	245,560	3,506	514	------	397	21	249,998
Glass	45,150	301	128	------	11,281	8	56,868
Electrical	99,686	324,684	2,528	1	11,736	1,479	440,114
Dental and medical	24,630	56,085	195	871	77	315	82,173
Jewelry and decorative	33,342	18,676	2,685	------	8,775	1,419	64,897
Miscellaneous	26,112	25,878	1,426	128	4,916	2,204	60,664
Total	633,864	621,141	12,086	1,823	54,952	10,430	1,334,296

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
1963	320,601	315,756	18,907	1,531	32,900	9,880	699,575
1964	378,896	517,691	20,022	1,936	38,388	10,331	767,264
1965	422,804	427,450	18,374	1,502	44,531	11,712	926,373
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

PRICES

Prices of the platinum-group metals during 1967 reflected the short supplies that persisted throughout the year. While the producers' price for platinum showed a small increase during the year, dealers' prices were up sharply.

At the start of the year the producers' price for platinum was $100 per troy ounce. Effective January 24 the price was increased to $109 to $112 and was unchanged until December when sales were made at prices to $125 per ounce. Dealers' prices, which started the year at $157 to $160 per ounce, began to increase in May, and by the year's end were $225 to $230 per ounce. The producers' price for palladium, which was $35 to $37 per ounce effective October 3, 1966, increased to $37 to $39 on January 9 and was unchanged the remainder of the year. The dealers' price for palladium started the year at $38 to $39 per ounce and by the end of the year was $41 to $42. The price of rhodium, $197 to $200, as quoted by the producers, increased in January, March, and again in December when it reached the yearend price of $245 to $250 per ounce. The producers' price for iridium, which was $180 at the beginning of the year, was increased to $185 to $190 on March 20 and was unchanged at the year's end. The producers' prices for ruthenium, $55 to $60 per ounce, and for osmium, nominally $300 to $450 per ounce, were unchanged throughout the year.

FOREIGN TRADE

The quantity of platinum exported in 1967 was 58 percent greater than that of 1966 and 120 percent greater than such exports in 1965. Recipients of major quantities were West Germany, 31 percent, and United Kingdom, 27 percent. Slightly more than 10 percent each went to Japan and Italy. Comparing 1967 figures with those of 1966 showed sharp increases in exports of platinum to Canada, France, West Germany, Italy, and Japan. Declines occurred in exports to Belgium-Luxembourg and Brazil.

Exports of palladium and other metals of the platinum group (excluding platinum) showed a small increase from the high level of the previous year, thus apparently confirming the trend toward higher exports of these metals. During the 4 years prior to 1966 these exports ranged from 10,000 to 30,000 troy ounces. In 1966 exports jumped to 103,000 ounces and then to 118,000 ounces in 1967.

Exports of palladium and other platinum-group metals (excluding platinum) to Canada, West Germany, Italy, Japan, Mexico, and Switzerland increased over those of the previous year while exports to the Netherlands and Sweden declined.

U.S. imports of platinum-group metals during 1967 decreased 10 percent or 131,000 troy ounces from the previous year, with declines in imports of unrefined material, palladium, and rhodium. Imports of platinum were up 18 percent and ruthenium imports were up from 10,000 ounces to more than 56,000 ounces. Imports of unrefined primary material from the United Kingdom were down sharply, but the increase in platinum imports from the same source more than offset the decline. Platinum imports from the U.S.S.R. continued to decline and were down to 2,053 ounces from 7,676 ounces in 1966. Palladium imports from the U.S.S.R., declined to 189,000 ounces from 438,000 ounces in 1966. Canada and the United Kingdom were the only suppliers of ruthenium in 1967, the first supplying slightly more than 50 percent of the total.

The balance of trade improved for both platinum and palladium and other platinum-group metals in 1967, although again far more of each was imported than was exported. Exports of platinum as ore and crude metal increased over 50 percent to 161,585 troy ounces, whereas a large rise in imports of refined platinum from the United Kingdom left total imports double the amount exported. Exports of palladium and other platinum-group metals (as metal and alloys including scrap) increased only slightly, but the sharp decline in imports of refined palladium from the U.S.S.R. reduced the import-export ratio from over 9:1 to about 7:1.

Table 7.—U.S. exports of platinum-group metals, by countries

Year and destination	Platinum (ore, concentrates, ingots, bars, sheets, wire, sponge, and other forms, including scrap)		Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap)		Platinum group manufactures, except jewelry (value thousands)
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	
1965	72,925	$9,838	30,172	$3,758	$2,515
1966:					
Australia	------	------	376	6	42
Belgium-Luxembourg	6,575	729	3,463	146	646
Brazil	2,218	434	460	71	------
Canada	3,928	435	3,078	262	2,034
Chile	48	2	30	2	2
Colombia	181	29	------	------	42
France	6,810	809	3,498	384	337
Germany, West	21,222	2,670	25,983	2,184	46
Hong Kong	345	127	------	------	(1)
India	15	4	14	3	80
Israel	10	2	52	5	------
Italy	2,646	356	8,530	463	2
Japan	8,144	2,401	16,199	1,430	136
Mexico	855	83	2,153	200	98
Netherlands	8,321	996	14,229	1,065	113
Philippines	12	(1)	------	------	2
South Africa, Republic of	------	------	45	1	19
Sweden	261	5	19,036	2	27
Switzerland	118	70	2,695	219	3
United Kingdom	39,552	4,225	1,669	197	97
Venezuela	66	11	729	10	9
Other	704	26	1,186	61	59
Total	102,031	13,414	103,425	6,711	3,794
1967:					
Argentina	555	65	50	8	------
Australia	5	1	1,906	76	58
Belgium-Luxembourg	3,027	211	4,093	159	26
Brazil	362	26	1,653	103	5
Canada	6,087	623	4,799	243	1,563
Chile	252	23	50	2	3
Colombia	20	3	795	17	87
France	11,907	1,420	3,626	375	51
Germany, West	49,824	6,582	33,030	3,593	94
Hong Kong	711	117	34	1	8
India	24	4	232	33	3
Italy	16,408	1,819	16,019	874	(1)
Japan	17,646	2,832	19,600	1,451	191
Mexico	1,059	88	5,962	226	72
Netherlands	9,023	1,054	13,139	1,682	56
Philippines	8	1	186	6	8
South Africa, Republic of	------	------	50	1	15
Sweden	30	(1)	24	(1)	18
Switzerland	197	22	7,064	346	15
United Kingdom	44,189	4,338	4,067	456	73
Venezuela	------	------	24	(1)	3
Other	251	19	1,614	71	29
Total	161,585	19,248	118,017	9,723	2,378

[1] Less than ½ unit.

Table 8.—U.S. imports for consumption of platinum-group metals

Year	Troy ounces	Value (thousands)
1965	1,172,643	$68,953
1966	[r] 1,352,256	83,481
1967	1,219,298	85,240

[r] Revised.

Table 9.—U.S. imports for consumption of platinum-group metals (unmanufactured), by countries [1]

(Troy ounces)

Year and country	Unrefined material	Refined metals					Total
	Primary	Platinum	Palladium	Iridium	Rhodium	Ruthenium	
1966:							
Argentina	729	------	------	------	------	------	729
Australia	------	------	------	------	64	------	[2] 72
Belgium-Luxembourg	37	1,003	1,482	------	------	------	2,522
Canada	697	1,779	130,634	3,410	22,200	4,800	[2] 163,884
Colombia	16,147	1,633	------	------	------	------	17,780
Ethiopia	860	------	------	------	------	------	860
France	------	------	2,539	------	688	------	3,227
Germany, West	498	1,304	[r] 97,766	525	3,020	547	[r] [2] 103,816
Gibraltar	------	------	1,860	------	------	------	1,860
Ireland	------	[3] 26	------	------	------	------	[3] 26
Italy	------	[3] 825	------	------	------	------	[3] 825
Japan	------	------	1,183	------	------	------	1,183
Mexico	------	------	133	------	------	------	133
Netherlands	------	999	12,635	------	198	------	13,832
Norway	3,350	3,175	5,150	------	------	------	11,675
Panama	354	------	------	------	------	------	354
South Africa, Republic of	------	------	------	------	160	------	160
Sweden	321	------	970	------	414	------	1,705
Switzerland	6,458	4,633	115,924	------	------	------	127,015
U.S.S.R.	4,479	7,676	438,292	------	18,012	------	468,459
United Kingdom	52,770	250,280	93,808	4,226	21,105	4,817	[2] 432,139
Total:							
Troy ounces	86,700	273,333	[r] 902,376	8,161	65,861	10,164	[r] 1,352,256
Value (thousands)	$9,498	$31,741	$28,010	$1,130	$11,984	$385	$83,481
1967:							
Australia	------	------	------	------	128	------	128
Belgium-Luxembourg	------	1,172	1,730	------	------	------	2,902
Canada	795	5,526	155,312	5,600	14,812	28,800	[2] 210,963
Colombia	24,987	2,780	------	------	------	------	27,767
France	------	------	3,862	------	------	------	3,862
Germany, West	------	3,019	18,359	200	325	------	[2] 22,003
Italy	------	275	------	------	------	------	275
Japan	641	------	------	------	------	------	641
Netherlands	------	------	184,845	------	2,622	------	187,467
Norway	5,170	1,275	4,676	------	------	------	11,121
Panama	1,520	489	97	------	------	------	2,106
Switzerland	------	6,929	35,100	------	50	------	42,079
U.S.S.R.	1,585	2,053	189,329	------	15,029	------	207,996
United Kingdom	7,100	299,246	143,772	2,984	14,723	27,763	[2] 499,988
Total:							
Troy ounces	41,798	322,764	737,082	8,784	47,689	56,563	1,219,298
Value (thousands)	$5,195	$38,282	$27,504	$1,505	$10,079	$2,049	$85,240

[r] Revised.
[1] Certain items reported by the Bureau of the Census as "scrap" have been reclassified by the Bureau of Mines and included with "platinum refined metal" in this table.
[2] Includes in 1966: 4,902 ounces ($439,458) of osmiridium from United Kingdom and 8 ounces ($1,175) from Australia; and in 1967: United Kingdom 4,179 ounces ($457,942), Canada 118 ounces ($58,880), and in 1966, 364 ounces ($151,553) of osmium from Canada, 231 ounces ($80,818) from United Kingdom; and 156 ounces ($59,488) from West Germany; in 1967: United Kingdom 221 ounces ($72,125), West Germany 100 ounces ($37,000).
[3] Includes 26 ounces of scrap, ($4,002) from Ireland and 825 ounces of scrap, ($82,124) from Italy.

WORLD REVIEW

World production of platinum-group metals in 1967 was approximately 4 percent larger than that of 1966. Evidently, however, apparent world demand continued to exceed production as the supply-demand imbalance continued to push world markets toward higher price levels for most platinum metals.

On an individual country basis, the 1967 data generally indicate little change from the previous year. The three major producers, U.S.S.R., Republic of South Africa, and Canada, recorded small increases. Production in the United States, reflecting the strike in the copper industry, was down 35,000 troy ounces.

South Africa, Republic of.—Union Corp., Ltd., announced plans to open a new platinum mine on the Merensky Reef in the Bafonkeng tribal area 15 miles west of Rustenburg and 70 miles from Johannesburg. It was stated that production would begin in about 2 years. While initially some refining would be done overseas, the company plans to establish refining facilities in South Africa.

Production is to start in late 1969 at a minimum rate of 100,000 ounces of platinum per year, plus an estimated 50,000 ounces of other platinum-group metals. Output at this rate will make Union Corp. the third largest platinum producer —after Rustenburg Platinum Mines, Ltd., and The International Nickel Co., Inc. Development of the property was expected to cost $40 million.

Additional platinum supplies came in view when Rustenburg announced plans to increase further its annual production to 850,000 ounces of platinum. The expansion, which is to cost $50 million, will also increase the company's annual capacity for other platinum-group metals to 375,000 ounces.

Prior expansion programs raised the mine and mill capacity to 600,000 ounces of platinum in 1967 and will further raise capacity to 750,000 ounces in late 1968. The latest announced expansion, to 850,000 ounces annually, was to be completed by the end of 1969.

As a result of the series of expansions in production planned by Rustenburg Platinum Mines, Ltd., Johnson, Matthey & Co., Ltd., announced they would construct a $700,000 platinum refinery at Wadeville, near Johannesburg. The refinery, scheduled to begin operation in 1969, will treat residual slimes from Matte Smelters (Pty.) Ltd., which extracts copper and nickel electrolytically from matte produced at Rustenburg's

Table 10.—World production of platinum-group metals [1]

(Troy ounces)

Country	1963	1964	1965	1966	1967 p
North America: [2]					
Canada:					
Platinum and platinum-group metals	357,651	376,238	463,127	r 396,059	403,270
United States:					
Placer platinum and from domestic gold and copper refining	49,750	40,487	35,026	51,432	16,365
South America: [2]					
Colombia:					
Placer platinum	22,983	20,647	11,141	r NA	NA
Europe:					
U.S.S.R.:					
Placer platinum and from platinum-nickel-copper ores e	r 1,300,000	1,500,000	1,700,000	r 1,800,000	1,900,000
Africa:					
Congo (Kinshasa):					
Palladium from refineries	3	----------	----------	----------	NA
Platinum from refineries	4	1	----------	----------	NA
Ethiopia:					
Placer platinum	e 180	e 180	353	r 318	NA
South Africa, Republic of:					
Platinum-group metals from platinum ores e	300,000	600,000	750,000	780,000	825,000
Osmiridium from gold ores [3]	r 5,185	r 4,135	r 3,820	r e 3,400	e 3,400
Asia:					
Japan:					
Palladium from refineries	1,326	1,875	2,952	r 5,494	3,327
Platinum from refineries	1,714	2,199	2,466	2,733	3,072
Oceania:					
Australia [4]	4	----------	----------	r 13	NA
New Guinea [5]	5	2	5	----------	NA
Total [6]	r 2,038,805	r 2,545,764	r 2,968,890	r 3,039,449	3,154,434

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Compiled mostly from data available May 1968.
[2] U.S. imports include platinum from other Western Hemisphere countries which are not listed as producers.
[3] Sales.
[4] Incomplete data.
[5] Year ended June 30.
[6] Total is of listed figures only; no undisclosed data included.

smelter. Prior to construction of the new plant, South Africa's first platinum refinery, all slimes were being shipped to Johnson, Matthey's plant in the United Kingdom where they are treated along with the Rustenburg gravity concentrates.

Since its founding 150 years ago Johnson, Matthey & Co., Ltd., has been a major factor in the platinum industry. The firm serves as importer, refiner, and exporter of the crude metal produced by Rustenburg Platinum Mines, Ltd. The metal refinery is in the United Kingdom. In addition, production from Goodnews Bay, Alaska, is purchased by Johnson, Matthey and refined for them by its affiliate Matthey Bishop, Inc. (formerly J. Bishop & Co. Platinum Works), Malvern, Pa. To commemorate this anniversary a full account of the growth of the company was prepared.[2]

TECHNOLOGY

Research continued at a high level on the properties and development of fuel cells for the direct conversion of chemical energy into electrical energy. Success was reported in developing high-activity platinum electrocatalysts. The use of high-area platinum blacks and the use of carbon-supported platinum were both effective in reducing the amount of platinum required for a given amount of power from a direct hydrocarbon fuel cell.[3]

Direct utilization in fuel cells of low-cost gases containing both hydrogen and carbon monoxide, requires an electrocatalyst resistant to poisoning by the carbon monoxide. The three catalysts investigated, platinum-ruthenium, platinum-rhodium, and platinum-iridium, showed exceptional tolerance for carbon monoxide in hydrogen.[4]

Platinum black is the most widely used catalyst for acid media oxidation of methanol in fuel cells. However, the use of electrodeposited platinum-rhenium catalysts shows an appreciable decrease in polarization under these conditions and reasonable current densities can be drawn at a potential of +0.3 to 0.4 volt to the hydrogen electrode.[5]

The advantages of the platinum-group metals in fuel cells were described and methods of dispersing and supporting the metals in such cells were listed. It was predicted that if metal usage could be reduced to $10 worth of platinum per kilowatt of generating capacity and ample supplies of platinum are available a multitude of fuel cell systems based on noble metal catalysts can be expected.[6]

A review article summarized information on palladium from its occurrences through its utilization. The useful qualities of the metal as well as its limitations were described.[7]

Because platinum is available in high purity in substantial quantity, has a high melting point, and is relatively stable in air and other atmospheres (except hydrogen), it is useful as a standard reference material. In addition, since the thermal conductivity of platinum is near the geometric mean for metals and alloys, the National Bureau of Standards (NBS) determined the thermal conductivity and electrical resistivity of the metal. It was concluded that before platinum can be established as a thermal conductivity reference standard, additional measurements are indicated on samples of differing purity.[8]

Similar but broader studies were reported by the National Physical Labora-

[2] South African Mining and Engineering Journal (Johannesburg). An Anniversary Review of Johnson Matthey's Role in the Economic History of Platinum. V. 78, pt. 1, No. 3864, Feb. 24, 1967, pp. 446–456.

[3] Cairns, E. J., and E. J. McInerney. High Activity Platinum Electrocatalysts for the Direct Anodic Oxidation of Saturated Hydrocarbons. J. Electrochem. Soc., v. 114, No. 10, October 1967, pp. 980–985.

[4] Niedrach, L. W., D. W. McKee, J. Paynter, and I. F. Danzig. Electrocatalysts for Hydrogen/Carbon Monoxide Fuel Cell Anodes. I. The Platinum-Ruthenium System. Electrochem. Tech., v. 5, Nos. 7–8, July–August 1967, pp. 318–323; II. The Platinum-Rhodium and Platinum-Iridium Systems. Electrochem. Tech., v. 5, Nos. 9–10, September–October 1967, pp. 419–423.

[5] Biegler, T., and D. F. A. Koch. Adsorption and Oxidation of Methanol on a Platinum Electrode. J. Electrochem. Soc., v. 114, No. 9, September 1967, pp. 904–909.

Cathro, K. J. The Use of Platinum-Rhenium Catalysts for the Oxidation of Aqueous Methanol. Electrochem. Tech., v. 5, Nos. 9–10, September–October 1967, pp. 441–445.

[6] Murphy, Daniel J. Platinum Metals in the Fuel Cell. Metal Prog., v. 91, No. 3, March 1967, pp. 156, 160–161.

[7] Sanderson, L. Palladium—Its Occurrence, Recovery, Property and Uses. Canadian Min. J. (Quebec, Canada), v. 88, No. 5, May 1967, pp. 70–71.

[8] Flynn, D. R., and M. E. O'Hagan. Measurements of the Thermal Conductivity and Electrical Resistivity of Platinum From 100 to 900° C. J. Res. NBS, v. 71C, No. 4, October–December 1967, pp. 255–284.

tory of the United Kingdom. These investigations, which included polycrystalline samples of all the platinum-group metals and single crystals of ruthenium, also resulted in determination of the thermal conductivity and electrical resistivity.[9]

Because the refining of the platinum-group metals is a complicated process, research has been undertaken to ascertain if advantages could result from the more extensive use of solvent extraction techniques to separate and purify the metals. A procedure was developed for purifying rhodium based on its extraction from dilute hydrochloric acid by a complex sulfonic acid in *n*-heptane. Separation of the element from iridium. platinum, palladium, and silver was essentially complete.[10]

New methods were described for applying strong, thick protective coatings of platinum and palladium on refractory metals. Electrodeposits of the two metals in thicknesses ranging from 0.005 to 0.024 inch were made on tungsten, molybdenum, and other refractory metals. By etching and cleaning the surface to be covered and then preplating with a thin coat of one metal before a thick coat of the other metal was applied, it was possible to achieve adherent crack-free coats.[11]

To take advantage of the high strength-to-weight ratio and strength at high temperature of graphite for use in frontal sections of manned-space reentry systems, a method was developed for coating graphite with iridium. The method involved deposition of the iridium by a plasma-spraying technique followed by an isostatic pressure compaction at elevated temperatures. The study, which demonstrated that the technique is acceptable for producing defect-free, uniform coatings of iridium with a good bond to the graphite, is part of a broader study of iridium coatings.[12]

A study sponsored by the American Petroleum Institute concluded that the cost of making gasoline with an increased aromatic and lower olefin content would be more than 2 cents per gallon. Although such gasoline would decrease air pollution because the need for lead antiknock compounds would be eliminated, it was stated that $4.25 billion in new processing equipment would be required. Refiners would have to buy 3.4 million troy ounces of platinum per year, approximately 5 times the total domestic consumption of platinum.[13]

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[9] Powell, R. W., R. P. Tye, and Margaret J. Woodman. The Thermal Conductivity and Electrical Resistivity of Polycrystalline Metals of the Platinum Group and of Single Crystals of Ruthenium. J. Less-Common Metals (Amsterdam, Netherlands), v. 12, No. 1, January 1967, pp. 1–10.

[10] Khan, M. Ali, and D. F. C. Morris. Application of Solvent Extraction to the Refining of Precious Metals. J. Less-Common Metals (Amsterdam, Netherlands), v. 13, No. 1, July 1967, pp. 53–61.

[11] Andrews, R. L., S. D. Cramer, C. B. Kenahan, and D. Schlain (assigned to U.S. Department of the Interior). Method for Obtaining Thick Adherent Coatings of Platinum Metals on Refractory Metals. U.S. Pat. 3,309,292, Mar. 14, 1967.

Cramer, S. D., C. B. Kenahan, R. L. Andrews, and D. Schlain. Electrodeposition of Thick Coatings of Platinum and Palladium on Refractory Metals From Aqueous Electrolytes. BuMines Rept. of Inv. 7016, 1967, 64 pp.

[12] Battelle Technical Review. Iridium Coatings for Graphite. V. 16, No. 5, May 1967, p. 23.

[13] Chemical & Engineering News. Eliminating Lead Antiknock Compound From Gasoline Would Require $4.25 Billion. V. 45, No. 22, May 22, 1967, p. 53.

Potash

By Richard W. Lewis [1]

The continued increase in world demand for fertilizers was reflected by increased production and sales of potash, one of the three major plant food elements. Production expansion, however, again exceeded world demand, resulting in an oversupply and a generally weak price structure. Facing strong foreign competition, domestic producers began to curtail output. Domestic potash retained only 59 percent of the U.S. market, compared with 63 percent in 1966, 67 percent in 1965, and over 90 percent in 1960.

Table 1.—Salient potash statistics

(Thousand short tons and thousand dollars)

	1963	1964	1965	1966	1967
United States:					
Production of potassium salts, marketable quantity	4,871	4,954	5,401	5,701	5,649
Approximate K_2O equivalent ------do	2,864	2,897	3,140	3,320	3,299
Value	$110,164	$114,095	$129,767	$122,210	$105,313
Sales of potassium salts by producers quantity	4,587	5,201	5,027	5,377	5,363
Approximate K_2O equivalent ------do	2,709	3,045	2,931	3,133	3,126
Value at plant	$103,828	$120,284	$121,161	$116,340	$100,566
Average value per ton	$22.64	$23.13	$24.10	$21.64	$18.75
Imports for consumption of potash materials quantity	1,041	1,254	1,867	2,544	2,925
Approximate K_2O equivalent ------do	594	737	1,108	1,491	1,706
Value	$31,137	$35,797	$52,675	$71,821	$73,491
Exports of potash materials --------quantity	722	1,048	1,099	1,053	1,175
Approximate K_2O equivalent ------do	425	618	648	621	693
Value	$25,519	$37,586	$42,494	$38,159	$39,896
Apparent consumption of potassium salts [1] quantity	4,906	5,407	5,795	6,868	7,113
Approximate K_2O equivalent ------do	2,878	3,164	3,391	4,003	4,139
World: Production, marketable: Approximate K_2O equivalent --------quantity	12,500	13,500	15,200	16,000	16,900

[1] Measured by sold or used plus imports minus exports.

Legislation and Government Programs.—In July, two bills were introduced in the House of Representatives and referred to the Committee on Ways and Means, H.R. 11740, a bill to provide an additional investment tax credit for potash mining equipment, and H.R. 11741, a bill to amend the tariff schedules of the United States with respect to potassium chloride, changing its rate of duty from "free" to 8 percent ad valorem. Neither of these bills was reported out of committee during the year.

In October, S. 2551 and H.R. 13566, identical bills that proposed "annual quotas on the quantity of potassium chloride or muriate of potash which may be imported into the United States," were introduced in the Senate and the House of Representatives. Specifically, these bills stated: "That the total quantity of potassium chloride which may be imported into the United States during the calendar year 1968 or any subsequent calendar year shall not exceed the quantity equal to 25 percentum of the estimated United States consumption of potassium chloride for such calendar year." S. 2551 was referred to the Committee on Finance and H.R. 13566 was referred to the Committee on

[1] Commodity specialist, Division of Mineral Studies.

Ways and means. No action was taken on these bills.

Complaints were filed with the Treasury Department claiming that potash from Canada, West Germany, and France was sold in the United States at "less than fair prices" and in violation of the Anti-Dumping Act of 1921. These claims were under investigation at yearend by the Treasury Department.

DOMESTIC PRODUCTION

Production of marketable potassium salts, potassium monoxide (K_2O) equivalent, in 1967 was slightly less than in 1966, with New Mexico accounting for 87.4 percent of the total output. The calculated average grade of the crude potassium salts mined in New Mexico was 18.16 percent K_2O, compared with 17.55 in 1966.

The slight drop in domestic output was in part due to world potash production exceeding world demand for the second consecutive year; the gradual depletion of high-grade potash in the New Mexico deposits; and the free entry of foreign potash into the United States. This curtailment of domestic production resulted in serious reductions in employment in the Carlsbad, N. Mex., district. During the first half of the year about 4,000 workers were employed by the New Mexico potash producers. International Minerals & Chemical Corp. reduced its labor force by 400 on July 1, but rehired about 100 at a later date. Duval Corp. reduced its working force by 50 in September, suspending mining operations temporarily at one of its three mines in the area. United States Borax & Chemical Corp. ceased its mining operations on November 10, resulting in a layoff of about 850 workers.

Table 2.—Production and sales of marketable potassium salts in the United States, in 1967, by product

(Thousand short tons and thousand dollars)

Product	Production			Sales		
	Gross weight	K_2O equivalent	Value [1]	Gross weight	K_2O equivalent	Value
Muriate of potash, 60 percent K_2O minimum:						
Standard	2,342	1,428	$39,584	2,415	1,481	$40,813
Coarse	1,530	934	27,921	1,340	817	25,126
Granular	935	567	17,880	776	471	15,556
Total	4,807	2,929	85,385	4,531	2,769	81,495
Other potassium salts [2] [3]	842	370	19,928	832	357	19,071
Grand total	5,649	3,299	105,313	5,363	3,126	100,566

[1] Derived from reported value of "Sold or used."
[2] Figures for refined muriate and manure salts are included with potassium sulfate and potassium-magnesium sulfate to avoid disclosing individual company confidential data.
[3] Includes sulfate manufactured from captive production of muriate.

American Potash & Chemical Corp. completed a new plant for producing a coarse grade of sulfate of potash at its Trona, Calif., facility. Shipments of products from the new plant, which has an output capacity of 30,000 tons per year, started in April. In addition, the firm began a $5 million project to provide more power facilities at Trona. The project was scheduled for completion by February 1968. Late in the summer, a merger of the company into Kerr-McGee Corp. was reportedly under consideration. The merger had not been completed by yearend.

Potash Company of America made several technological improvements throughout its mine and plant in Carlsbad during 1966, including a $1 million expansion in its chemical-grade muriate plant. In 1967, the proposed three-way merger with Ideal Cement Co. and American Crystal Sugar Co. ended in a two-way merger with Ideal. The parent company, renamed Ideal Basic Industries, Inc., was organized with two divisions: Potash Company of America and Ideal Cement Co.

Table 3.—Production and sales of potassium salts in New Mexico

(Thousand short tons and thousand dollars)

Year	Crude salts [1]		Marketable potassium salts					
	Mine production		Production			Sales		
	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Value [2]	Gross weight	K_2O equivalent	Value
1963	16,414	3,083	4,504	2,643	$100,458	4,213	2,484	$94,925
1964	17,356	3,122	4,585	2,675	104,861	4,815	2,814	110,772
1965	18,557	3,363	4,919	2,848	117,771	4,607	2,677	110,424
1966	20,105	3,528	5,096	2,953	108,653	4,872	2,827	104,668
1967	18,906	3,434	4,950	2,883	91,098	4,797	2,784	88,788

[1] Sylvite and langbeinite.
[2] Derived from reported value of "Sold or used."

International Minerals & Chemical Corp. cut production at its Carlsbad, N. Mex., mine by about 50 percent on July 1. Later in the year, however, the firm started a $2 million project to install a newly developed process which would economically recover both sylvite and langbeinite from mixed ore. Heretofore, this mixed ore could not be processed profitably because the recovery of one mineral resulted in the loss of the other. The firm's production rate of about 400,000 tons per year was not expected to increase when the new process becomes operational sometime in 1968.

Texas Gulf Sulphur Co. (TGS) began construction of a new crystallizer system at its Cane Creek potash operation near Moab, Utah. Target date for completion was January 1968. The unit was designed to convert 175,000 tons per year of muriate fines, which are screened from the flotation product, into larger crystals and a premium product. TGS also was drilling a second shaft at its Cane Creek mine for use in hoisting men and supplies. It was expected to be in operation by yearend.

Kaiser Chemicals Co., Bonneville division, was improving its potash brine operation at Wendover, Utah. Completion of the new collection system and solar evaporation pan would require 2 years.

Lithium Corporation of America, Inc., and Chemsalt, Inc., a wholly owned subsidiary of Salzdetfurth, A.G. of West Germany, were proceeding with plans to build facilities at Great Salt Lake, Utah, to produce potash, sodium sulfate, magnesium, and salt from the lake brine.

Southwest Potash Division of American Metal Climax, Inc., tripled the prilling capacity for agricultural nitrate of potash at its Vicksburg, Miss., plant in 1966 and, in 1967, expanded production of the nitrate by 25 percent at a cost of about $450,000.

On January 1, 1966, a group of New Mexico investors formed the Carlsbad Potash Co., and were granted a 2-year option to purchase the potash mining property of United States Borax & Chemical Corp. near Carlsbad, N. Mex. At yearend 1967 the option had not been exercised.

CONSUMPTION AND USES

The apparent consumption of potassium salts in the United States was 3.4 percent greater in 1967 than in 1966. The use of potassium salts in fertilizers accounted for 94.5 percent of consumption. The remainder was consumed by a variety of chemical uses.

Deliveries for agricultural use showed a gain of 3.4 percent whereas chemical deliveries decreased 3.0 percent. The quantity of potash delivered in 1966 into New Mexico was revised downward to 7,248 short tons, resulting in a revised U.S. total of 3,782,546 tons. Illinois remained the leading State for deliveries, followed in decreasing order by Indiana, Iowa, and Minnesota. Imported potash is included, but deliveries do not necessarily correspond to consumption because much of that delivered is used in mixed fertilizers and resold.

Table 4.—Deliveries of potash salts in 1967, by States of destination

(Short tons K_2O equivalent)

Destination	Agricultural potash	Chemical potash	Destination	Agricultural potash	Chemical potash
Alabama	107,128	24,722	Montana	2,243	40
Alaska	---------	---------	Nebraska	21,901	329
Arizona	704	11	Nevada	79	1,552
Arkansas	55,109	563	New Hampshire	492	69
California	41,350	13,819	New Jersey	23,057	2,479
Colorado	5,728	153	New Mexico	[1] 3,732	621
Connecticut	4,039	408	New York	50,702	73,476
Delaware	9,690	13,976	North Carolina	157,571	651
District of Columbia	523	---------	North Dakota	8,753	---------
Florida	192,207	915	Ohio	268,599	7,607
Georgia	226,090	921	Oklahoma	17,953	480
Hawaii	22,293	---------	Oregon	11,271	1,127
Idaho	5,257	---------	Pennsylvania	40,565	4,942
Illinois	451,047	26,314	Rhode Island	1,580	432
Indiana	318,254	4,818	South Carolina	96,680	75
Iowa	288,820	546	South Dakota	6,133	---------
Kansas	22,130	1,151	Tennessee	89,389	---------
Kentucky	66,569	11,532	Texas	192,864	8,529
Louisiana	36,608	749	Utah	486	67
Maine	15,420	122	Vermont	5,233	---------
Maryland	101,686	1,683	Virginia	137,669	560
Massachusetts	6,293	502	Washington	19,721	1,809
Michigan	110,112	2,254	West Virginia	1,260	12,617
Minnesota	280,552	392	Wisconsin	180,732	101
Mississippi	43,412	17	Wyoming	346	---------
Missouri	159,946	1,573			
			Total	3,909,978	224,704

[1] Includes company adjustments and shipping losses.
Source: American Potash Institute, Washington, D.C.

STOCKS

Stocks of potassium salts held by producers at yearend reached an alltime high of 863,000 short tons K_2O equivalent, an increase of 25 percent over 1966 stocks. Some potash shipped into the United States from Canada during 1966 and 1967 went into warehouse storage, but there was no record of the quantity. Stocks on hand at yearend included the material sold for delivery during the 1968 spring planting season.

Table 5.—Stocks of potassium salts in the United States

(Thousand short tons)

Year	Stocks, Dec. 31		
	Number of producers	Gross weight	K_2O equivalent
1963	10	762	478
1964	10	519	295
1965	12	892	504
1966	12	1,215	690
1967	12	1,501	863

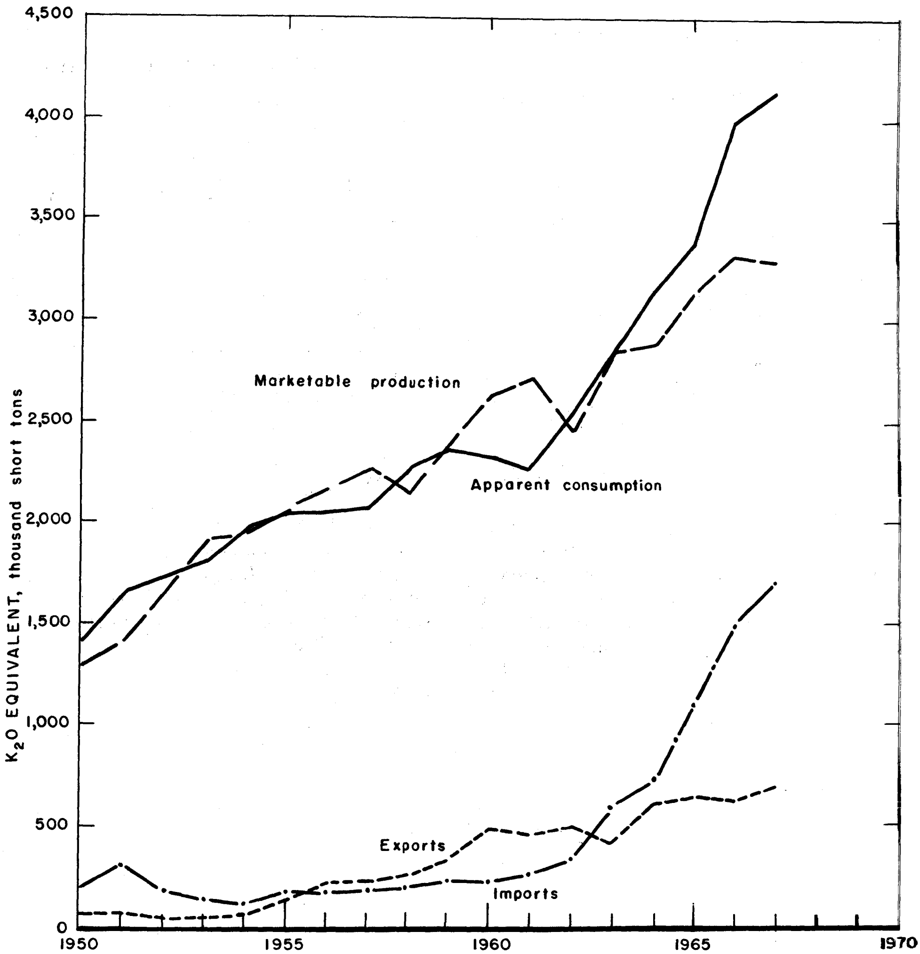

Figure 1.—Marketable production, apparent consumption, exports, and imports, K_2O equivalent.

PRICES

Bulk prices for muriate of potash were weak throughout the year and in July declined to a low of 26 cents per unit for the standard grade on contracts made before July 1, 1967. Prices of all grades also were reduced. Even chemical grade was selling at $5 per ton less in July than at the beginning of the year. On contracts made after June 30, 1967, producers increased prices by 2 cents per unit. An additional $6 per short ton was charged by most companies for muriate shipped in 100-pound bags. All producers reserved the right to adjust prices to meet delivery prices of competitors.

New prices were established for imported West German and Spanish potash. Standard and semicoarse muriate of potash was priced at 52 cents per unit K_2O on a 1-year contract, 51 cents on a 2-year contract, 50 cents on a 3-year contract, and 49 cents per unit K_2O on a 4-year contract. Sulfate price per unit-ton, f.o.b. cars was quoted at 85 cents. These prices reflected a change in the method of pricing which relieved the buyer of the wharfage and handling expenses by pricing f.o.b. cars instead of ex vessel.

Table 6.—Bulk prices for New Mexico potash [1]

(Cents per unit K_2O)

Product	1967		1968	
	June–Sept.	Oct.–Dec.	January	Feb.–May
Muriate, 60 percent K_2O minimum:				
Standard	26	28	28	30
Coarse	29.5	31	31	33.5
Granular	32.5	34.5	34.5	36.5
Sulfate of potash, standard	70	75	75	80
Manure salts, 20 percent K_2O minimum	17.65	17.65	17.65	17.65

[1] Carlots, f.o.b. Carlsbad on contracts made prior to July 1, 1967. Not quoted by all producers.

Table 7.—Bulk prices for California potash [1]

(Cents per unit K_2O)

Product	1967		1968	
	June–Sept.	Oct.–Dec.	January	Feb.–May
Muriate, 60 percent K_2O minimum:				
Standard	40	39	39	42
Coarse	45	47	47	49
Sulfate, 52 percent K_2O minimum	80	85	85	90

[1] Quoted by American Potash & Chemical Corp., carlots, f.o.b. Trona, Calif., on contracts made prior to July 1, 1967. Price list published June 1, 1967.

FOREIGN TRADE

The total quantity of potassium salts exported increased nearly 12 percent; however, the value was less than 5 percent above that of 1966. Two years of worldwide oversupply of potash resulted in sharp bidding for world markets by the major exporting nations: Canada, West Grmany, France, and the United States.

Of the total potassium muriate imported, Canada supplied 84 percent. Imports of muriate from Canada, over 2 million tons, were 13 percent above the quantity received in 1966.

Table 8.—U.S. exports of potash materials, by countries

Destination	Fertilizer				Chemical			
	1966		1967		1966		1967	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	1,461	$48	3,861	$128	262	$71	479	$119
Australia	127,965	4,007	101,216	3,078	2,164	209	664	195
Belgium-Luxembourg	339	22	683	33	567	138	187	103
Brazil	74,188	2,272	39,235	946	2,143	473	1,051	236
Canada	56,166	2,132	64,722	2,496	5,723	1,293	8,744	1,468
Chile	15,909	415	16,116	454	70	20	236	24
Colombia	40,541	1,552	21,980	825	185	45	76	34
Costa Rica	9,658	280	19,120	571	4	3	4	2
Denmark	--------	------	50	2	502	107	579	128
Dominican Republic	3,687	157	3,025	100	24	5	5	3
El Salvador	7,510	233	81	7	7	10	7	17
Finland	8,761	260	206	9	12	7	10	6
France	1,902	64	148	5	508	132	854	188
Germany, West	4,532	200	14,011	706	2,216	599	1,621	491
India	--------	------	49,732	1,727	134	18	407	94
Ireland	6	(1)	--------	------	13	20	4	5
Italy	124	4	319	11	1,595	474	1,371	311
Jamaica	692	26	15,563	422	32	17	19	15
Japan	380,828	11,966	428,317	13,349	13	16	11	11
Korea, South	102,966	3,091	111,300	2,811	5,519	267	------	------
Leeward and Windward Islands	3,880	126	3,856	111	1	1	2	(1)
Mexico	54,648	1,559	44,791	1,211	1,362	277	1,322	251
Netherlands	21,610	783	--------	------	544	165	530	206
Netherlands Antilles	8,265	266	4,408	133	3	1	3	5
New Zealand	36,638	1,097	36,274	1,298	61	21	72	17
Pakistan	13,570	520	11,262	299	4	4	3	15
Peru	285	12	3,084	126	44	27	45	27
Philippines	2,835	107	21,675	513	58	32	85	52
South Africa, Republic of	20,097	584	19,769	451	100	27	7,237	128
Sweden	4,940	154	7,777	255	25	16	79	27
Taiwan	--------	------	61,811	1,406	38	14	29	11
Turkey	--------	------	53	2	260	51	148	29
United Kingdom	1,248	61	1,423	69	1,057	252	1,216	306
Venezuela	52	3	8,084	341	318	116	261	75
Viet Nam, South	10,124	465	6,994	260	2,146	169	226	37
Other countries	9,569	401	25,185	855	775	195	1,473	250
Total	1,024,996	32,867	1,146,131	35,010	28,489	5,292	29,060	4,886

[1] Less than ½ unit.

Table 9.—U.S. imports for consumption of potash materials

Material	Approximate equivalent as potash (K_2O) (percent)	1966 Short tons	1966 Approximate equivalent as potash (K_2O) Short tons	1966 Approximate equivalent as potash (K_2O) Percent of total	1966 Value [1] (thousands)	1967 Short tons	1967 Approximate equivalent as potash (K_2O) Short tons	1967 Approximate equivalent as potash (K_2O) Percent of total	1967 Value [1] (thousands)
Used chiefly as fertilizers:									
Muriate (chloride) [2]	60	r 2,401,058	r 1,440,635	r 96.6	r $61,386	2,748,637	1,649,182	96.7	$62,228
Potassium nitrate, crude [2]	40	r 21,912	r 8,765	r .6	r 763	15,455	6,182	.4	539
Potassium sodium nitrate mixtures, crude	14	40,100	5,614	.4	1,629	44,825	6,276	.4	1,702
Potassium sulfate, crude [2]	50	56,728	28,364	1.9	2,129	67,980	33,990	2.0	2,390
Other potash fertilizer materials	6	9,890	593	.0	380	30,886	1,853	.0	218
Total	----------	r 2,529,688	r 1,483,971	99.5	r 66,287	2,907,783	1,697,483	99.5	67,077
Used chiefly in chemical industries:									
Bicarbonate	46	1,118	514		126	1,858	855		203
Bitartrate: Cream of tartar	25	1,277	319		594	1,229	307		591
Carbonate	61	1,433	874		215	4,562	2,783		652
Caustic	80	2,178	1,742		402	1,127	902		233
Chlorate and perchlorate	36	1,111	400		235	851	306		190
Cyanide	70	1,165	816	0.5	542	930	651	0.5	439
Ferricyanide	42	r 641	r 269		r 407	656	276		405
Ferrocyanide	44	r 2,132	r 938		r 806	1,921	845		714
Nitrate	50	941	471		99	1,260	630		146
Rochelle salts	22	338	74		126	289	64		118
All other	31	2,090	648		1,982	2,616	811		2,723
Total	----------	14,424	7,065	0.5	5,534	17,299	8,430	0.5	6,414
Grand total	----------	r 2,544,112	r 1,491,036	100.0	r 71,821	2,925,082	1,705,913	100.0	73,491

r Revised.
[1] Adjusted by the Bureau of Mines.
[2] Some information furnished by The American Potash Institute, Inc., Washington, D.C.

Table 10.—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)[1]	Potassium nitrate, crude	Potassium sodium nitrate mixtures, crude	Potassium nitrate (saltpeter), refined	Potassium sulfate[1]	All others	Total: Quantity	Total: Value[2] (thousands)
1966:												
Belgium-Luxembourg	--------	6	--------	--------	16,598	--------	--------	--------	2,315	693	19,612	$996
Canada	--------	--------	--------	--------	[r] 2,036,296	[r] 537	99	--------	122	7,377	[r] 2,044,431	[r] 51,686
Chile	--------	--------	--------	--------	1,102	21,176	40,001	--------	--------	--------	62,279	2,432
France	3	386	--------	90	124,960	20	--------	--------	18,932	1,172	145,563	4,652
Germany:												
East	--------	--------	--------	--------	--------	--------	--------	--------	--------	77	77	39
West	--------	1,486	45	469	182,187	179	--------	438	20,854	[r] 2,432	[r] 208,090	[r] 6,897
Italy	817	--------	--------	--------	--------	--------	--------	466	11,143	2,615	15,041	1,092
Netherlands	--------	7	--------	192	--------	--------	--------	--------	--------	[r] 2,148	[r] 2,347	[r] 796
Spain	382	--------	--------	--------	24,114	--------	--------	37	3,362	172	28,067	1,063
Sweden	--------	290	688	--------	--------	--------	--------	--------	--------	--------	978	268
United Kingdom	--------	--------	--------	167	--------	--------	--------	--------	--------	167	334	149
Other countries	75	3	378	247	15,801	--------	--------	--------	--------	789	17,293	1,751
Total	1,277	2,178	1,111	1,165	[r] 2,401,058	[r] 21,912	40,100	941	56,728	17,642	[r] 2,544,112	[r] 71,821
1967:												
Belgium-Luxembourg	--------	47	--------	--------	25,887	--------	--------	--------	4,149	1,855	31,938	1,808
Canada	--------	--------	--------	11	2,298,531	--------	170	--------	223	560	2,299,495	53,192
Chile	--------	--------	--------	--------	4,417	15,300	37,372	--------	--------	--------	57,089	2,183
France	11	303	--------	110	129,404	25	5,559	--------	15,549	1,674	152,635	4,188
Germany:												
East	--------	--------	--------	--------	--------	--------	--------	--------	--------	73	73	37
West	50	475	15	483	176,514	130	1,724	787	29,668	4,765	214,611	7,095
Italy	691	--------	--------	--------	--------	--------	--------	403	18,391	30,630	50,115	1,410
Netherlands	--------	9	--------	--------	--------	--------	--------	--------	--------	2,369	2,378	716
Spain	366	--------	--------	--------	49,991	--------	--------	70	--------	89	50,516	1,454
Sweden	--------	289	615	--------	--------	--------	--------	--------	--------	--------	904	257
United Kingdom	--------	1	--------	103	3,001	--------	--------	--------	--------	182	3,287	213
Other countries	111	3	221	228	60,892	--------	--------	--------	--------	591	62,041	938
Total	1,229	1,127	851	930	2,748,687	15,455	44,825	1,260	67,980	42,788	2,925,082	73,491

[1] Some information furnished by The American Potash Institute, Inc.
[2] Adjusted by Bureau of Mines.

WORLD REVIEW

Australia.—Texada Mines Pty., Ltd., conducted research on the feasibility of recovering potassium chloride and common salt from the brines of Lake McLeod near Carnarvon, Western Australia. The firm expected to establish a 200,000-ton-per-year potash recovery plant if the studies indicate its commercial feasibility.

Brazil.—A project to mine and process potassium salt reserves near Carmópolis was approved in 1966 by the Brazilian Government. The formation of a 5,000-million-cruzeiro semi-state corporation to develop the reserve, estimated 11 million tons, was proposed. The new corporation, Fertilizantes do Brasil, S. A., would be based at Aracaja. No new developments were reported in 1967.

Canada.—Potash producton in Saskatchewan increased by 22 percent in 1967, making Canada a major producer and on a par with the large European producers. International Minerals & Chemical Corp. (Canada) Ltd., Potash Company of America, and Kalium Chemicals, Ltd., were the only producers in 1967. Six other companies, however, were developing their properties with all expecting to be in production by 1971.

Allan Potash Mines, Ltd., owned by United States Borax & Chemical Corp., Homestake Mining Co., and Swift & Co., made excellent progress in developing its mine and refinery facilities, 35 miles southeast of Saskatoon, Saskatchewan. In 1966, progress was delayed in shaft No. 1 owing to flooding, but shaft No. 2 reached potash in July. The company expected production to begin in the spring of 1968 with a full production rate of 1.5 million tons of product per year by early 1969.

Alwinsal Potash of Canada, Ltd., a joint project of the French Government-controlled Mines Domaniales de Potasse d'Alsace and two West German potash producers, Wintershall A. G. and Salzdetfurth A. G., struck the main potash bed with its 18-foot shaft. A refining plant that will have a rated capacity of 1.0 million tons was under construction. Production was expected to start early in 1968.

Cominco Ltd., a Canadian firm, continued sinking two shafts simultaneously to its potash deposit at Vade, Saskatchewan. This development project was reportedly about 1 year ahead of schedule and was expected to be in production early in 1969. The rated capacity of the facility was given at 1.2 million tons of product per year. The firm reportedly completed an agreement with the Ametalco Group to handle the sales of its products in world markets, specifically in Australia, New Zealand, Europe, Africa, and Latin America. The Ametalco Group is a worldwide sales organization with principal offices in New York and London.

Table 11.—World production of marketable potash, by countries

(Short tons, K_2O equivalent)

Country	1963	1964	1965	1966	1967 p
North America:					
Canada	626,860	858,351	1,491,301	r 1,990,040	2,432,984
United States	2,864,000	2,897,000	3,140,000	3,320,000	3,299,000
South America: Chile (nitrate) e	20,540	14,881	15,650	16,200	16,000
Europe:					
France	1,897,661	1,991,390	r 2,080,794	r 1,964,418	1,962,332
Germany:					
East	2,034,000	2,046,990	2,123,049	r 2,211,234	e 2,400,000
West	2,147,300	2,426,184	2,628,722	r 2,525,392	e 2,500,000
Italy	r 180,779	r 210,541	r 265,657	e r 287,703	e 276,000
Spain	r 331,165	r 379,913	r 474,643	r 522,225	515,881
U.S.S.R. e	2,260,000	2,425,000	2,590,000	2,800,000	3,040,000
Asia: Israel [1]	r 124,561	281,640	e 341,700	410,100	e 419,000
Total [2]	r 12,486,866	r 13,531,890	r 15,151,516	r 16,047,312	16,861,197

e Estimate. p Preliminary. r Revised.
[1] Year ended March 31 of year following that stated.
[2] Total is of listed figures only; no undisclosed data included.

Noranda Mines Ltd. was making excellent progress in sinking two 16-foot-diameter shafts on its property about 23 miles southwest of Saskatoon, Saskatchewan. The operation, which has a designed capacity of 1.2 million tons of product annually, was scheduled to start producing late in 1969.

Duval Corp., about 7 miles west of Saskatoon, was engaged in sinking twin 16-foot-diameter shafts to its ore body about 3,500 feet below the surface. The facility has a rated capacity of 1 million tons of product annually and is scheduled for completion in 1969.

The sixth company engaged in developing its property, Sylvite of Canada, allotted two contracts, one to AMC-Harrison Ltd. for sinking twin shafts on its property at Rocanville in southeast Saskatchewan, and the other to Wellman-Lord Inc. on a turnkey basis, to design, construct, and equip the refinery and other above-ground facilities. Preparations for shaft sinking were underway at yearend. The facility, which was scheduled for operation in 1971, was to be designed to produce 1 million tons of product per year and to be capable of an expansion to 2 million tons.

International Minerals & Chemical Corp. completed its K–2 mine and refinery at Esterhazy, 6 miles from the K–1 mine, and started production. The facility's output capacity was rated at 1.5 million tons of product per year.

Potash Company of America began sinking a second shaft to its deposit near Saskatoon, early in the year. The new shaft was designed with a hoisting capacity of 3 million tons of product annually. Construction of additional surface facilities to handle the increased capacity (the present capacity being only 700,000 tons) was to be considered at a later date, based on market conditions. The new shaft is expected to cost about $12 million and take 4 years to complete.

Plans were made by Kalium Chemicals Ltd. to increase output capacity by 50 percent. The expansion is to cost over $10 million and includes process modifications as well as additions to the facilities. A construction contract was awarded, but no completion date was announced.

Two additional companies having potash property in Saskatchewan, Potasse Première Corp. and Southwest Potash Corp., a division of American Metal Climax, Inc., were seriously considering development projects, but no definite starting dates were announced.

Representatives from Hungary and potash mining experts from East Germany examined the potash leases held by Great Canadian Potash Corp., a company that is 50 percent owned by The Goldfield Corp. (New York). It was reported that if these representatives were satisfied with their findings they would sink two shafts and construct surface facilities to produce 1 million tons of product per year.[2] The financing was to be made available through Swiss banking facilities.

Lynbar Mining Corp., with potash holdings about 65 miles north of Regina, Saskatchewan, signed agreements with a Polish Government trade agency whereby pilot plant tests on the property would be under the supervision of Polish technicians. Under the agreement, if the technicians are satisfied with the tests, the Polish corporation would design and build a 1-million-ton-per-year mine and plant. Preparations for pilot plant studies were being completed, and the plant was scheduled to be running early in 1968.[3]

Congo (Brazzaville).—Compagnie des Potasses du Congo, owned by a French syndicate and the Congolese Government, continued planning for an $82 million potash dvelopment at Saint-Paul. Financial credits were being established through a $9 million loan from the European Investment Bank and a $30 million credit from the World Bank. The proposed facility, which should produce 500,000 tons of product per year, was scheduled to start production in 1969.

France.—It was reported in September that Mines Domaniales de Potasse d'Alsace, the State-owned potash mines, and Office National Industriel de l'Azote, the nitrogen production agency, were regrouped into a new company, l'Enterprise Miniere et Chimique. The new unit was to control 20 percent of French fertilizer production of potash, nitrate, and derived products.[4]

Germany, East.—The East German State Corporation, Vereinigung Votksei-

[2] Northern Miner (Toronto, Canada). European Interests Examine Possibility of Potash Facility. No. 31, Oct. 12, 1967, pp. 1, 12.

[3] Northern Miner (Toronto, Canada). Polish Agencies Propose Finance Lynbar's Potash. No. 32, Nov. 2, 1967, pp. 1, 16.

[4] Bureau of Mines. Mineral Trade Notes. V. 64, No. 12, December 1967, pp. 14–15.

gener Betriebe Kali, was engaged in several major expansion projects to raise production by 1.5 million short tons by 1970. One of the major projects was an expansion of VVB Kaliéwerke Zielitz, which will become the largest single potash plant in Europe.[5]

Israel.—The Dead Sea Works continued its efforts toward increasing potash output capacity to 1.2 million tons by 1970. On May 2, the Ministerial Economic Committee approved the formation of a giant chemical combine which brought together six major companies: Dead Sea Works, Ltd., Israel Petrochemicals, Chemicals and Phosphates Ltd., Haifa Refineries Ltd., Haifa Chemicals, and Arad Chemicals.[6]

Morocco.—An agreement was signed in 1966 with Interexport of Belgrade, Yugoslavia, and Centrozap of Warsaw, Poland, for the development of a carnallite potash deposit at Khemisset, 50 miles east of Rabat. In an area of about 115 square miles, the known reserves were estimated at 200 million tons of carnallite at depths of 1,600 to 2,600 feet.[7] In 1967, the United Nations Technical Assistance Bureau also was assisting in this development, placing a geologist at the disposal of the Moroccan Agency Bureau de Recherches et de Participations Minières to advise Moroccan technicians in surveying the carnallite deposits.

Spain.—The Spanish Industry Ministry approved the Potasas de Navarra S.A. plan for a new plant to treat 7,000 tons of carnallite and 1,000 tons of sylvinite daily. This expansion project was scheduled for completion in the summer of 1969. The present annual potash output of 240,000 tons will be increased to nearly 500,000 tons.

U.S.S.R.—Potash production at the Soligorsk deposits was scheduled to total 6.6 million tons K_2O by 1970. The first plant, in operation since 1964, has an annual capacity of 2 million tons. A second plant was in partial operation, and eventual capacity was expected to be 2.2 million tons. A third was under construction which, when completed bv 1970, will add another 2.4 million tons K_2O capacity.[8]

United Kingdom.—Imperial Chemical Industries, Ltd., and a holding company, Charter Consolidated, Ltd., were reportedly planning to finance a $70 million potash mining operation in Yorkshire. This would be the first major development of potash reserves in the United Kingdom. Output capacities between 850,000 and 1.25 million tons annually were mentioned. No construction schedule was announced. Rio Tinto-Zinc Corp. and Armour Chemical Industries Ltd. also were interested in the Yorkshire potash area.

TECHNOLOGY

Pipeline transportation of potash from the mines in Saskatchewan to Vancouver, British Columbia and to Chicago was envisioned several years ago and considerable research was conducted. In 1967, a study of transportation of solids by pipeline was undertaken in a joint Federal and Province of Alberta program. The project involved the construction of a 3,500-foot pilot pipeline, 4 inches in diameter, to carry 100-foot-long "capsule trains" made up of solid material. In addition to the movement of potash by pipelines, other solids such as coal, sulfur, and possibly wheat were being considered.

The U. S. Bureau of Mines metallurgy research program included studies on potash ore processing. In July 1967, research was started at the Bureau's Tuscaloosa, Ala., laboratory on the development of a new flotation process for the economic recovery of potassium minerals from high clay and complex ores of the Permian Basin of New Mexico. Functional research was conducted on heavy-liquid sink-float processing of industrial minerals which included potash. A paper on heavy-liquid cyclone concentration of New Mexico ores was published.[9] A new process was developed by the Bureau's Salt Lake City, Utah Metallurgy Research Center, to produce potassium salts from complex brines employing ion exchange metathesis techniques.

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[5] Mining Journal (London). V. 267, No. 6850, Dec. 2, 1966, pp. 422–423.

[6] Phosphorus and Potassium (London). Israel. No. 29, May–June 1967, p. 44.

[7] Engineering and Mining Journal. V. 167, No. 8, August 1966, p. 150.

[8] Chemical Age (London). Huge Potassium Fertiliser Project in USSR. V. 97, No. 2500, June 10, 1967, p. 20.

[9] Tippin, R. B., and J. S. Browning. Heavy Liquid Cyclone Concentration of New Mexico Potash Ores. Trans. AIME, v. 235, 1966, pp. 360–366.

Pumice

By Timothy C. May [1]

Domestic pumice and pumiceous materials sold and used by producers in 1967 increased 7 percent in quantity and decreased 24 percent in value from that in 1966. Larger sales of lower quality material resulted in the decline in value. Domestic consumption patterns remained relatively unchanged from those of the previous year. However, the usage declined for concrete admixture and railroad ballast, because of the drop in activity for these consuming industries.

DOMESTIC PRODUCTION

Pumice production was reported by 15 States and American Samoa in 1967. Output came from 129 companies, including railroads, individuals, highway departments, and Government agencies at a total of 152 operations. Production by States was as follows:

Volcanic cinder was produced in 11 States with Arizona providing 38 percent of total production, and California, Oregon, Hawaii, and New Mexico accounted for an additional 58 percent.

[1] Commodity specialist, Division of Mineral Studies.

State	Number of mines	Percentage of U.S. production	State	Number of mines	Percentage of U.S. productions
Arizona	11	31	New Mexico	18	6
California	42	25	Oregon	32	24
Hawaii	22	8	Other States	20	3
Nevada	7	3	Total	152	100

Table 1.—Pumice 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
1963	1,050	$3,321	1,568	$3,257	2,618	$6,578
1964	1,165	4,094	1,611	2,349	2,776	6,443
1965	483	2,442	2,888	4,108	3,371	6,550
1966	549	2,629	2,669	4,136	3,218	6,765
1967	776	1,446	2,670	3,685	3,446	5,131

[1] Values 1963–66 f.o.b. mine and/or grinding plant; values 1967 f.o.b. mine.

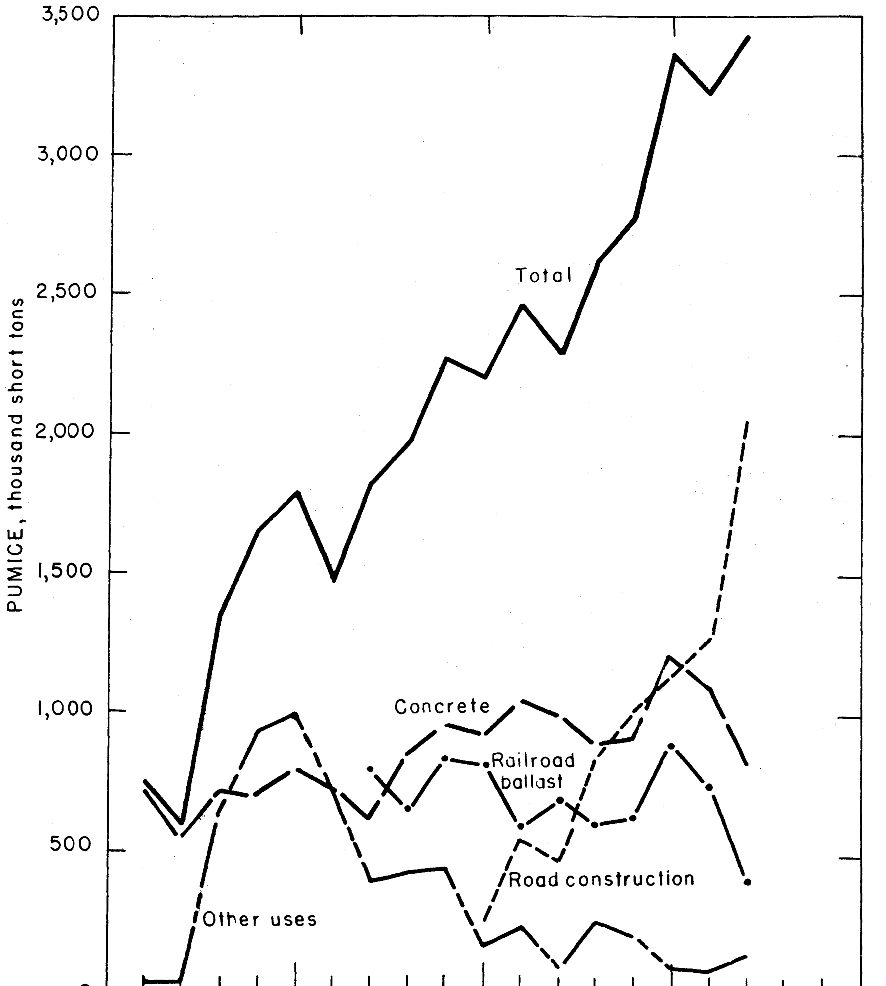

Figure 1.—Pumice sold or used by producers in the United States, by uses.

Table 2.—Pumice sold [1] or used by producers in the United States [2]

(Thousand short tons and thousand dollars)

State	1966 Quantity	1966 Value	1967 Quantity	1967 Value	State	1966 Quantity	1966 Value	1967 Quantity	1967 Value
Arizona	1,103	$1,674	1,064	$904	New Mexico	245	$787	220	$639
California	580	1,763	866	1,357	Oregon	714	1,256	834	1,195
Colorado	46	104	18	105	Other States [3]	24	163	49	132
Hawaii	374	716	290	562					
Idaho	55	107	W	W	Total	3,218	6,765	3,446	[4] 5,131
Montana	22	5	-----	-----					
Nevada	55	190	105	236	American Samoa	17	22	28	24

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes pumicite and volcanic cinder.
[2] Values 1966 f.o.b. mine and/or grinding plant; values 1967 f.o.b. mine.
[3] Idaho, Kansas, Nebraska, Oklahoma, Texas, Utah, Washington, and Wyoming.
[4] Data do not add to total shown because of independent rounding.

Table 3.—Pumice [1] sold or used by producers in the United States, by uses [2]

(Thousand short tons and thousand dollars)

Use	1966 Quantity	1966 Value	1967 Quantity	1967 Value
Abrasive: Cleaning and scouring compounds	10	$242	14	$56
Concrete admixture and concrete aggregates	1,098	2,967	833	1,761
Railroad ballast	740	639	412	355
Road construction [3]	1,277	1,605	2,049	2,236
Other uses [4]	93	1,312	138	724
Total	3,218	6,765	3,446	[5] 5,131

[1] Includes pumicite and volcanic cinder.
[2] Values 1966 f.o.b. mine and/or grinding plant; values 1967 f.o.b. mine.
[3] Includes servicing, ice control, and maintenance.
[4] Includes abrasive uses (miscellaneous), acoustic plaster, asphalt, fertilizer, filler, filtration, glass, insecticides, landscaping, roofing aggregate, and miscellaneous uses.
[5] Data do not add to total shown because of independent rounding.

CONSUMPTION AND USES

Road construction required 60 percent of the domestic output of pumice compared with 40 percent in 1966. Concrete admixture accounted for 24 percent of consumption compared with 34 percent in 1966. The decline in consumption of pumice for concrete admixture was caused by the reduction of activity in the construction industry. Railroad ballast used 11 percent of production compared with 23 percent in 1966. The remaining 15 percent was used in cleaning and scouring, landscaping, paint, and other miscellaneous uses.

PRICES

Nominal price quotations, covering domestic and imported pumice, were carried regularly in trade publications, and have remained unchanged since 1964. In 1967, The Oil, Paint and Drug Reporter quoted the following average prices, per pound, bagged, in ton lots: Domestic, fine and coarse, $0.0430; domestic, medium $0.0480; imported (Italian), silk-screened, coarse, $0.0675; imported (Italian), fine, $0.0450 to $0.0475. Imported (Italian) sundried, coarse and fine, was quoted at $75 to $79 per ton.

Metals Week quoted prices of pumice for 1967, f.o.b. New York or Chicago, in barrels, powdered $0.0350 to $0.0600 per pound, and lump, $0.0600 to $0.0800 per pound, the same as for 1966.

The average value of crude pumice sold or used in 1967 was $1.13 per ton, or $0.10 less per ton than in 1966, and the average for prepared pumice was $2.19, compared with $2.87 in 1966. The weighted average for the two categories was $1.49, compared with $2.10 in 1966.

The average price per ton of pumice, for use as concrete aggregate and admixture, was $2.11; for road construction, $1.09; for railroad ballast, $0.86; and for abrasive uses, $18.30.

FOREIGN TRADE

Exports of pumice and pumicite in 1967 totaled 343 tons valued at $64,000, an increase of 15 percent in quantity and a decrease of 3 percent in value over that of 1966. Canada received 74 percent of the material exported; the remainder went to Mexico, Japan, Dominican Republic, and 7 other countries.

All categories of pumice imports showed significant decreases in both quantity and value. Total material imported for consumption was equal to 7 percent of the quantity of domestic pumice reported sold or used. Italy and Greece were the major sources of imports.

Tariff.—At the end of 1967, all tariffs applicable to pumice were reduced by Presidential Proclamation. The duty per pound on imported pumice was reduced to the following: Crude pumice valued at $15 per ton and under, $0.038; crude pumice valued at over $15 per ton, $0.07; millstones, abrasive wheels, and abrasive articles, not specifically provided for, 12½ percent ad volorem. Pumice stone to be used in the manufacture of concrete masonry products continued to be imported duty free.

Table 4.—U.S. imports for consumption of pumice, by countries

Country	Crude or unmanufactured				Wholly or partly manufactured			
	1966		1967		1966		1967	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Italy	9,202	$88	5,650	$48	4,310	$163	2,083	$76
Other	191	3	52	1	-------	------	-------	------
Total	9,393	91	5,702	49	4,310	163	2,083	76

Country	Pumice [1]				Manufactured n.s.p.f.	
	1966		1967		1966	1967
	Short tons	Value (thousands)	Short tons	Value (thousands)	Value (thousands)	Value (thousands)
Greece	137,456	$258	125,554	$271	---------	--------------
Italy	131,536	302	111,736	231	$9	$9
Other	36	(2)	900	2	16	13
Total	269,028	560	238,190	504	25	22

[1] To be used in manufacturing concrete masonry products.
[2] Less than ½ unit.

WORLD PRODUCTION

Table 5.—World production of pumice by countries [1]

(Short tons)

Country [2]	1963	1964	1965	1966	1967 [p]
Argentina [3]	13,467	4,383	[r] 7,158	8,900	NA
Austria: Trass	23,349	25,223	22,516	23,238	24,950
Cape Verde Islands: Pozzolan	13,035	11,296	4,562	[e] 4,400	3,100
Chile: Pozzolan	142,002	155,885	156,094	160,291	147,905
France:					
Pumice	849	1,010	780	[r] 888	NA
Pozzolan	601,488	645,547	782,136	[r] 740,370	NA
Germany, West (marketable)	7,043,761	6,416,547	5,617,372	5,941,686	[e] 5,300,000
Greece:					
Pumice	[r] 111,858	[r] 252,500	[e] 220,000	[e] [r] 330,000	[e] 390,000
Santorin earth	262,764	[r] 345,745	[e] [r] 440,000	[e] [r] 390,000	[e] 550,000
Iceland	[r] 13,800	[r] 11,000	[e] 11,000	[e] 11,000	[e] 11,000
Italy:					
Pumice	722,917	679,206	508,729	[r] 582,258	NA
Pumicite	308,646	382,061	[r] 391,972	NA	NA
Pozzolan	4,765,354	4,483,622	4,265,113	[r] 4,197,750	NA
Kenya	1,245	1,585	1,145	874	134
New Zealand	18,599	22,980	120,807	20,204	NA
Spain [4]	1,685	2,528	[r] 62,099	NA	NA
United Arab Republic [e] [5]	[r] 5,600	[r] 14,000	[r] 15,100	----------	NA
United States (sold or used by producers):					
Pumice and pumicite	1,050,178	1,165,379	484,047	548,433	776,388
Volcanic cinder	1,567,825	1,611,093	2,888,006	[6] 2,685,324	[6] 2,697,913
Total [7]	[r] 16,668,422	[r] 16,231,590	[r] 15,998,636	[r] 15,645,616	9,901,390

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] Compiled mostly from data available June 1968.
[2] Pumice is also produced in Japan, Mexico, and U.S.S.R. (sizable quantity), but data on production are not available. Japan's last available output figure was 120,000 tons in 1958.
[3] Includes volcanic ash and cinders, and pozzolan.
[4] In 1963 and 1964, Spain produced pumice in the Canary Islands only. Production in continental Spain began in 1965.
[5] Estimated on basis of 1 cubic meter = 1,300 pounds.
[6] Includes American Samoa.
[7] Totals are of listed figures only, no undisclosed data included.

Rare-Earth Minerals and Metals

By John G. Parker [1]

The apparent domestic industrial consumption of rare-earth and yttrium compounds and concentrates, expressed as rare-earth oxide (REO), was about 85 percent that of 1966, the highest year on record. A large quantity of REO, in materials excess to those needed for a conventional war emergency, was authorized for disposal from the national stockpile. Requirements for high-purity yttrium and europium oxides in color television tubes decreased substantially.

Legislation and Government Programs.—At yearend the General Services Administration (GSA) held a total of 15,788 tons of equivalent rare-earth oxides (REO) in various forms in the strategic and supplemental stockpiles. The strategic stockpile held 9,975 and the supplemental, 5,813 tons. Of the 12,788 tons excess to that needed for a conventional warfare emergency, 7,640 tons of REO in rare-earth materials was authorized for disposal by H.R. 5787 signed by the President on November 22. The customary 6-month waiting period was waived. On December 21, successful bids by two companies led to sales of 319 short tons equivalent REO, mostly in the form of rare-earth sodium sulfate. Of the additional stockpile materials currently authorized for disposal, rare-earth sodium sulfate constituted almost 62 percent and bastnaesite the remainder.

In 1966, over 84,000 pounds of excess yttrium-bearing material consisting of yttrium metal, alloys, oxide, fluoride, and concentrate was sold to four companies by GSA.

DOMESTIC PRODUCTION

Concentrate.—Output at the mine and mill at Mountain Pass, Calif., owned by Molybdenum Corporation of America, increased slightly during 1967 to 25.5 million pounds REO in bastnaesite concentrates compared with 25.2 million pounds the previous year. A new mill had been completed in May 1966 and its capacity had been expanded to 50 million pounds REO in December of that year.

In Folkston, Charlton County, Ga., Humphreys Mining Co. processed alluvial deposits on E. I. du Pont de Nemours & Co., Inc., property, thereby recovering substantial byproduct monazite with titanium and zirconium mineral concentrate. Also, near Jacksonville, Fla., Carpco Research and Engineering, Inc., under contract with Titanium Alloy Manufacturing Division of National Lead Co., reclaimed monazite and a small quantity of xenotime from former beach sand processing residues. The Climax Molybdenum Co. mine at Climax, Colo., recovered monazite-wolframite concentrate from molybdenum mine tailings and sold low-grade monazite concentrate for further upgrading. Metal Traders, Inc., New York City, sold the last of low-grade yttrium oxide concentrate which had been produced from former GSA residues by Colorado School of Mines Research Foundation, Inc., Golden, Colo. Late in 1966, Michigan Chemical Corp., a subsidiary of Chicago and Northwestern Railway Co., with a rare-earth processing plant in St. Louis, Mich., bought the Porter Brothers Corp. mining and concentrating operation in Bear Valley, Idaho, thereby assuring itself of a long term rare-earth and yttrium raw material source.

Compounds and Metals.—Production of europium oxide at Mountain Pass dropped

[1] Commodity specialist, Division of Mineral Studies.

to 9,000 pounds compared with 11,400 pounds in 1966. The decrease in production and sales was attributed to accumulation of excessive inventories of color television phosphors and to improved efficiency in applying phosphors to picture tubes. Company shipments of rare-earth and yttrium materials for phosphors dropped but those for petroleum cracking catalysts increased from 6.9 percent to 14.5 percent of the total sales of $10.2 million, 2 percent greater than 1966 sales. Also at Mountain Pass, cerium hydrate, lanthanum hydrate, and lanthanum carbonate production circuits were installed in the chemical plant. In December, after Molybdenum Corp. had acquired full control of Yttrium Corporation of America by buying the minority interest held by The Pyrites Co., Inc., the subsidiary was merged into the parent corporation. The Yttrium Corp. plant at Louviers, Colo., continued using solvent extraction to produce high-purity yttrium oxide, and production began in the fall on rare-earth materials such as high-purity neodymium and praseodymium oxides.[2]

Other chemical firms processing large quantities of rare-earth and yttrium concentrates to compounds included American Potash & Chemical Corp., Rare Earth Division, West Chicago, Ill.; and W. R. Grace & Co., Davison Chemical Division, Chattanooga, Tenn., and Pompton Plains, N. J. The Pompton Plains plant made principally rare-earth polishing powders. Besides Yttrium Corp., yttrium oxide producers included American Potash, W. R. Grace, Michigan Chemical Corp., and Research Chemicals, Division of Nuclear Corporation of America, Phoenix, Ariz. Small producers of rare-earth compounds were Atomergic Chemetals Co., Division of Gallard-Schlesinger Chemical Manufacturing Corp., Carle Place, N. Y., which made some yttrium oxide, and Transelco, Inc., Penn Yan, N. Y., which specialized in making low-cost cerium oxide for polishing compounds. Rare-earth bearing silicon compounds, for use as metal additives, were produced by Molybdenum Corporation of America, Washington, Pa., and by Union Carbide Corp., Alloy, W. Va. Production at Alloy was about 26 percent that of the previous year.

The two companies which produced misch metal were Ronson Metals Corp., Newark, N. J., and American Metallurgical Products Co., Inc., New Castle, Pa. Misch metal sales were about 5 percent greater than those of 1966 and 20 percent greater than those of 1965. Producers of higher purity rare-earth metals included American Potash, Gallard-Schlesinger, Michigan Chemical, Ronson, and Lunex Co., Pleasant Valley, Iowa. Lunex produced about 119 pounds of high-purity metals on contract, of which about 31 percent was yttrium, 20 percent was lanthanum, 18 percent was gadolinium, and 10 percent was erbium. These metals were said to be destined for research and development.

Stockholders near yearend 1967 voted a merger between American Potash & Chemical Corp. and Kerr-McGee Corp., with American Potash to become a subsidiary of Kerr-McGee.

CONSUMPTION AND USES

The apparent domestic industrial consumption of rare-earth and yttrium compounds and concentrates, based largely on shipments from chemical processors, dropped 15 percent to about 4,850 tons of rare-earth oxide equivalent valued at about $15 million. This was compared with a weight of 5,740 tons and value of nearly $21 million in 1966. In addition to domestic sales, a considerable quantity of concentrate was shipped abroad. Comparative percentage figures for domestic shipments of europium and yttrium oxides, by weight and value, were as follows: 1967, 1 percent and 50 percent, and 1966, about 2 percent and almost 70 percent. Based on value, 1967 industrial consumption of other rare-earth compounds consisted of about 17 percent in glass, usually as polishing powders, and some in ceramics and glazes; 10 percent in petroleum catalysts; 5 percent in steel and alloy production and ~~in~~ the making of misch metal and lighter flints; 5 percent in carbon arc production; 5 percent in electronics; and 8 percent in other applications.

In terms of oxide equivalent, use of oxides constituted 35 percent of the total; chlorides, 29 percent; hydrates, 11 percent: fluorides, 6 percent, and bastnaesite and lanthanum concentrates, and rare-

[2] Molybdenum Corporation of America. 1967 Annual Report. Mar. 15, 1968, 8 pp.

earth oxalate, chlorate, nitrate, carbonate, and silicide the remainder.

Nearly 10,000 pounds of high-purity metal valued at about $235,000 reportedly was sold but about nine-tenths of this was too low in value to be of the highest purity. The low unit value of an additional 30,000 pounds of metal indicated that it was probably an alloy such as misch metal.

The use of yttrium and europium oxides in color television phosphors is well established. Combinations of these in several compounds provide a superior red color. For instance, at least one company was said to use an yttrium oxysulfide, and it is known that others use an yttrium orthovanadate, both compounds being doped with europium. Terbium is being tried in a green phosphor but the merits have not been fully established. Some firms said that blue and green phosphors employing rare-earth materials do not have energy efficiencies equal to those of conventional phosphors. A glass filter plate, containing neodymium oxide, laminated onto the viewing surface of color television tubes, was said to improve the brightness and contrast and to produce more saturated red, green, and blue colors. Recently developed fluorescent lamps coated with phosphors containing europium and yttrium oxides were stated to have higher light output and better color balance. Also, industrial mercury vapor lamps are improved by the combination of dysprosium with mercury and argon gas in the inner arc tube.

Yttrium iron garnet was said to have become the most widely used ferrite material in microwave applications. It is available in polycrystalline and, more recently, in single crystal forms weighing as much as one-half pound. Polycrystalline garnets can be operated in low magnetic fields in the lower microwave frequencies and have a low susceptibility to temperature changes, particularly when the yttrium is partly replaced with gadolinium. Single crystals have been used as insulating magnetic material in lasers, light modulators, and ultrasonic devices. Yttrium aluminum garnets (YAGS) doped with neodymium oxide were used in a sun-pumped laser capable of carrying television modulation. Hydrogen-free solvents, containing rare-earth oxides such as neodymia in solution, were believed to be at least as efficient as some of the crystalline lasers and have the advantage that the liquid can be cooled by circulation. Neodymium glass lasers showed promise in microwelding applications.

Most of the misch metal produced was used in producing ferrocerium lighter flints, alloyed with iron to impart strength, hardness, and brittleness. In other instances, misch metal was used to desulfurize, refine grain size, and increase the impact strength and ductility of certain steel alloys, and promote resistance to creep and improve fatigue properties in magnesium and aluminum alloys at intermediate temperatures. Misch metal and magnesium iron silicides containing rare-earth metals received increased attention as nodulizing alloys that promote ductility in cast iron by producing graphite spheroids in the matrix. Adding rare-earth elements and subsequently treating with hydrogen to eliminate brittleness overcame hot shortness due to deleterious impurities in magnesium-zinc alloys, thereby providing good castability and ductility.

Yttrium in chromium alloys promoted workability and acted as a grain refiner. In iron-chromium alloys, 1 percent yttrium was equal to 5 percent aluminum in improving resistance to oxidation at elevated temperatures.

Yttrium, and rare-earth metals such as cerium, praseodymium, and samarium, showed promise in new permanent-magnet materials because they were easily fabricated by powder metallurgy methods and could be densely packed, giving a remanent flux density close to the saturation of massive material. Economically, magnets using the pure rare-earth materials probably can compete only with certain expensive grades of Alnico magnets or with platinum cobalt magnets, but cerium-rich misch metal added to cobalt in these intermetallic compounds was believed to be competitive with medium-grade Alnicos, ESD magnets, and anisotropic ferrites.

Much of the output of lower purity, commercial-grade rare-earth compounds went to the glass and ceramic industries. Cerium and mixed rare-earth oxides powders were used extensively in polishing eyeglasses, camera and instrument lenses, mirrors, television tubes, and plate glass, although the latter use has been reduced by the introduction into this country of the Pilkington float-glass process.

Less important in the glass industry was the use of certain rare-earth oxides as ingredients in the glass. For example, cerium oxide is used as a glass decolorizer; also, in larger quantities in the glass, cerium oxide and neodymium oxide absorb ultraviolet light in welders goggles and in special sunglasses and optical filters. Due to its ultraviolet absorptive properties, cerium oxide in glass prevents spoilage of food in transparent containers. Glass is colored lavender by neodymium oxide, greenish yellow by praseodymium oxide, and yellow or brown by cerium oxide forming cerates with titanium or lead. Cerium oxide also prevents discoloration due to radiation in television tube glasses and can be used as a white opacifier in glass and enamel. In optical uses, especially in certain borosilicate or borate camera lenses, lanthanum oxide increases the refractive indices and decreases dispersion. Praseodymium oxide mixed with zirconium oxide is used in a bright yellow ceramic tile stain.

A new single-phase, polycrystalline ceramic material, a solid solution of 90 percent yttrium oxide and 10 percent thorium oxide, has the advantages of being transparent and melting at a temperature in excess of 2,200° C, almost twice that of the softening of glass. It has received consideration for use in high-intensity incandescent and discharge lamps, in windows in high-temperature furnaces, and in microscope lenses used to study molten samples. Yttrium oxide is well known as a stabilizer of zirconium dioxide.

Rare-earth elements are used in petroleum cracking and in dehydrogenating reforming catalysts. Rare-earth chloride is an important component of a petroleum cracking catalyst and is used in a copper catalyst employed to recover chlorine from byproduct hydrochloric acid.

Rare-earth oxides and fluorides are used in core materials for carbon-arc electrodes emitting intense white light, useful in military searchlights and in color motion picture photography and projection.

The high thermal-neutron cross section of certain rare-earth elements has proved of value in some nuclear applications. Oxides of europium, gadolinium, dysprosium, and samarium have been dispersed in control rods in a few commercial nuclear power reactors. In a new development, rare-earth oxides such as dysprosium and erbium, were combined with hafnium oxide, another material with high neutron cross section, into rare-earth pyrohafnates. This was said to provide an inexpensive means of incorporating hafnium into control rods. New ceramic pellets made of aluminum and samarium oxides or aluminum and gadolinium oxides were developed as atomic fire extinguishers. These can be inserted rapidly into a reactor to absorb excess neutrons whenever the reactor approaches a dangerous operating level. Lastly, highly efficient radiation shields were developed which contain layers of carbon and lead, dysprosium and lead, gadolinium alone and mixed with lead and tungsten, and a final layer of lead or tungsten with depleted uranium.

Crucibles composed of yttrium oxide were used in reducing uranium oxide to the metal. Other high-temperature metal casting crucibles were made from mixed cerium-thorium sulfides. Gadolinium selenide has been offered commercially in thermoelectric generating equipment. Other rare-earth sesquisulfides, such as those of samarium and cerium, withstand high operating temperatures in these generators.

STOCKS

At yearend, bastnaesite concentrate held by the principal domestic mining company and chemical processors was almost three times larger than at the close of 1966. The yearend supply of monazite concentrate, held almost entirely by two chemical processing firms, was slightly less than that at the end of the previous year, but stocks of rare-earth sodium sulfate, held by one processor, were about 33 percent greater than that at yearend 1966. Stocks of refined yttrium oxide were eight times those of 1966 and those of europium oxide showed an even larger comparative increase. Misch metal stocks held by the two main producers and some of the principal users decreased 22 percent, but those of pure metals more than doubled.

PRICES

According to Metals Week nominal prices per pound of imported monazite, c.i.f. U.S. ports, remained as follows for over half the year: Massive, 55 percent rare-earth oxides, 14 cents; sand, 55 percent, 8 cents; sand, 60 percent, 10 cents; and sand, 66 percent, 12 cents. In August price quotations for the massive variety were discontinued and the nominal price for a long ton of monazite sand was quoted at $180 to $200. On the London market, average c.i.f. prices per long ton of Australian monazite containing a minimum of 60 percent rare-earth oxides plus thoria varied from an early year quote of £70 to £85 ($196 to $238) to £80 to £90 ($192 to $216) near yearend. A general increase in freight rates and higher packaging costs part way through 1966 had been responsible for the higher prices in 1967 compared with those of early 1966. Domestic bastnaesite concentrates, which had been quoted for the first time in January 1966, remained at, per pound f.o.b. Nipton, Calif.: 55 to 60 percent rare-earth oxides, 30 cents, and 68 to 72 percent rare-earth oxides, 35 cents. Rare-earth oxide from the same source was quoted at 45 cents per pound for 88 to 92 percent pure material.

Prices for mixed or lower grade rare-earth compounds, called production chemicals by American Potash & Chemical Corp., were the same as those of 1966. In lots of 50 to 99 pounds, ceric hydrate sold for $1.75 to $2.00 per pound and ceric oxide sold for $1.90 per pound. Similar-sized lots of didymium and rare-earth chlorides were $0.55 per pound and didymium carbonate was $1.30 per pound. Other quoted prices were $1.40 to $1.74 per pound for cerium hydrate in lots of 100 pounds or more, depending upon purity, and $1.85 to $1.90 per pound for optical grade ceric oxide in lot sizes of 50 pounds or more, delivered in bags.[3]

Price lists were available from chemical processors such as Research Chemicals, American Potash & Chemical, and Michigan Chemical, and some products were quoted in trade journals.[4]

According to these sources, the price per pound of various oxides, in the common lot size of 2 to 99 pounds was cerium oxide 99.9 percent pure $7.50 to $9.50; neodymium oxide $30.00 to $37.50; europium oxide $850 to $950; gadolinium oxide $85 to $95; yttrium oxide $44 to $55; and lutetium oxide $3,000 to $3,500. The price of europium oxide from American Potash dropped to $850 per pound from $1,350 in 1966, but because prices on large quantities are lower and are subject to negotiation, this oxide may sell at $550 to $800 per pound, depending upon purity. Fluorides from one company were priced the same as the oxides, and other salts, including chlorides, nitrates, oxalates, and sulfates in quantities and purities such as the previously mentioned oxides, were generally priced at 60 percent of the prices of the oxides.

In 50- to 100-pound lots, prices for 99.8 percent misch metal from Ronson Metals Corp. increased to $3.00 per pound in April 1967 from $2.90 in 1966. Cerium-free misch metal remained at $5.00 per pound, didymium metal of 97 percent purity stayed at $15 per pound, cerium metal of 99.9 percent purity stayed at $20, and lanthanum metal of 99.9 percent purity stayed at $27.50.

In general, prices of high-purity metals decreased. The price list of Research Chemicals, Division of Nuclear Corp. of America, quoted some rare-earth metal prices as follows:

Metal ingots, 99.9 percent pure, small lots	*Dollars per pound 1966*	*1967*
Cerium	75	70
Europium	5,000	3,600
Lanthanum	75	70
Neodymium	150	115
Samarium	220	160
Yttrium	180	160

Prices for distilled metals were about 50 percent greater than the ingots. Metal powders in 1-pound lots generally were $40 to $50 per pound greater than the ingot prices for lower priced metals and up to $200 to $300 per pound greater than the ingot prices in the rare and higher priced metals such as lutetium and thulium.

[3] Oil, Paint and Drug Reporter. Current Prices of Chemicals and Related Materials. V. 191, Nos. 1–26, Jan. 2-June 26, 1967; V. 192, Nos. 1–26, July 3-Dec. 25, 1967.

[4] American Metal Market. V. 74, Nos. 1-250, Jan. 3-Dec. 29, 1967.

FOREIGN TRADE

Pyrophoric alloys, including ferrocerium, were shipped to Canada, United Kingdom, West Germany, and 20 other countries and totaled 141,338 pounds valued at $303,499. The average unit value of these exports was $1.25 per pound less than that in 1966.

Monazite sand concentrate totaling 2,091 short tons valued at $270,063 was received from Australia (74 percent of weight), Malaysia (13 percent), Nigeria (6 percent), Indonesia (3 percent), and South Korea and West Germany (4 percent). The average unit value of these imports was $15.60 per short ton more than that in 1966. One company reported that it imported a small quantity of xenotime from Japan.

Cerium chloride imports, mostly from Canada, totaled 33,486 pounds and was valued at $3,135. The unit value of the Canadian material was much lower than chloride prices quoted by U.S. processors. Cerium oxide from United Kingdom, Finland, France, Austria, and Switzerland totaled 18,249 pounds valued at $22,274. Cerium salts and other cerium compounds, from France, United Kingdom, West Germany, Austria, and Switzerland in decreasing quantity, totaled 12,890 pounds worth $13,727. The Swiss materials were of high unit value indicating that they were of a special high purity. Rare-earth metals, having a reported value of $30,152, were received from three countries, United Kingdom, U.S.S.R., and West Germany. The unit values of the material from United Kingdom and U.S.S.R. were high, indicating high-purity metals, but over 99 percent of the material, from West Germany, had a very low unit value, to be expected of low-value alloys. Imports of low-value alloys, including misch metal, were reported as totaling 10,484 pounds worth $13,339, mostly from West Germany and some from the United Kingdom. Other alloys of rare-earth metals, totaling 2 pounds worth $328, were imported from West Germany. Ferrocerium and other pyrophoric alloys, from Japan, West Germany, Austria, and France totaled 7,241 pounds valued at $35,062 compared with 13,903 pounds valued at $65,407 in 1966.

WORLD REVIEW

Australia.—Proved reserves of 100,000 long tons of monazite were said to be associated with ilmenite deposits of the Geographe Bay area, Western Australia. Monazite production in this state reportedly was running at a rate of about 1,500 long tons per year.[5] Byproduct monazite production by a large Western Australia beach sand processor was 25 percent greater than that of 1966 and 77 percent greater than that of 1965. Based on first quarter production of monazite concentrate, it appeared that annual production would be about 2,250 long tons of concentrate containing about 2,050 long tons monazite.[6] For the years 1965 through 1967, the average grade of the monazite concentrates produced in Australia has been 94, 92.5 and 91 percent respectively. Reportedly, Associated Minerals Consolidated, Ltd. produced rare-earth polishing powders at Southport, Queensland.

Canada.—Preliminary Dominion Bureau of Statistics data indicated that 160,078 pounds of yttrium oxide in concentrate, valued at $1.69 million, was recovered from uranium mill effluent in 1967. A new yttrium processing facility was opened at Denison Mines Ltd. uranium concentrating plant near Elliot Lake, Ontario. The proposed output of this facility was estimated as up to 300,000 pounds annually. The Nordic plant of Rio Algom Mines Ltd., with a rated capacity of 100,000 pounds per year, has been producing yttrium oxide since 1965. Additional equipment for extracting yttrium values was said to have been installed at the thorium recovery facilities of Rio Tinto Nuclear Products, a wholly owned subsidiary of Rio Algom Mines.

Interest was shown in the possible economic extraction of rare-earth elements from phosphate rock deposits at

5 The Australian Mineral Industry. Quarterly Review. V. 19, pt. 1, No. 4, June 1967, p. 84.

6 The Australian Mineral Industry. Quarterly Statistics. V. 20, pt. 2, No. 1, September 1967, p. 7.

Table 1.—World production of monazite concentrates, by countries [1] [2]

(Short tons)

Country	1963	1964	1965	1966	1967
Australia	r 2,310	2,219	r 2,582	r 2,212	2,908
Brazil	2,448	733	658	822	NA
Ceylon	------	25	40	40	22
Congo (Kinshasa)	------	-------	22	NA	NA
India [3]	2,678	r 2,307	e 2,800	NA	NA
Indonesia	169	154	28	NA	5
Korea, South [4]	------	-------	-------	13	14
Malagasy Republic	678	1,063	1,196	937	27
Malaysia (exports)	991	340	777	970	e 1,061
Nigeria [3]	13	11	9	8	125
South Africa, Republic of	2,300	-------	-------	-------	-------
Total [5]	11,587	6,852	8,112	5,002	4,162

e Estimate. r Revised. NA Not available.
1 United States production data withheld to avoid disclosing individual company confidential data.
2 Compiled mostly from data available March 1968.
3 Year ended March 31 of year following that stated.
4 Reported as concentrates containing 45 to 55 percent REO; also reported as 30 percent cerium, which may be high.
5 Totals are of listed figures only; no undisclosed data included.

Nemegos, Ontario. The deposits, totaling 40 to 80 million tons of apatite, were said to contain about 55 pounds of rare-earth oxides per ton of apatite concentrate.

Finland.—In 1967 it was announced that the Korsnäs lead mine of Outokumpu Oy had produced 2,876 short tons of rare-earth concentrate containing 2.63 percent rare-earth oxides, worth $122,935 (Fmk 394,500). Typpi Oy, Oulu, planned to quadruple its output of rare-earth oxides, using Kola apatite as a raw material.

Two Finnish scientists, Prof. Olavi Erämetsä and Allan Johansson, conducted research on a fuel cell using a praseodymium compound as a solid electrolyte.

India.—In Madras State, the Manavalakurichi plant of Indian Rare Earths Ltd., with an annual capacity of 3,000 metric tons of monazite concentrate, was expected to come on stream in 1967. The company made such items as rare-earth chloride and fluoride in its monazite chemical processing plant at Alwaye, Kerala State. Lanthanum oxide and misch metal were produced on a pilot plant scale in anticipation of eventual commercial-scale production at Alwaye.

Japan.—At the Nippon Yttrium Co. Ltd. plant in Mitaka, Tokyo, high-purity yttrium oxide monthly output was expected to be increased from 660 to 2,205 pounds by the installation of a solvent extraction process developed by The Rio Tinto Zinc Corp., Ltd. subsidiary, Thorium Ltd. In turn, Pyrites Co., a subsidiary of Rio Tinto Zinc, acquired a one-third interest in the Japanese firm which is a joint venture of Mitsui Mining & Smelting Co. and Tohoku Metal Industries. Operation of the new plant was expected in mid-1968. Shinetsu Chemical Industry Co. used a Japanese developed ion-exchange method to produce high-purity yttrium oxide at a plant at Takefu, Fukui Prefecture.

Malagasy Republic.—In 1966, Etablissements Tricot, a French lighter flint manufacturer, ceased concentrating monazite at its Isandravinang plant in the Manantenina district. Competition from Australian monazite was the reason given for closing the plant.

Malawi.—A private company was given a concession by the Malawi Government to prospect for and determine the feasibility of extracting monazite from the Kangankunde Hill carbonatite complex near Balaka and northwest of Zomba. Laboratory tests and pilot plant treatment of the material had been demonstrated previously.

Malaysia.—A rapid method for determining yttrium in xenotime was developed at Ipoh, Perak State. It was believed that this would save valuable time and prevent discarding the more valuable xenotime in the mistaken belief that it was lower value monazite.

Mauritania.—Pechiney St. Gobain of France, one of Europe's largest producers of rare-earth oxides, explored recently discovered deposits of massive monazite at Bounaga, about 60 miles southwest of Akjoujt and about 220 miles east of Nouakchott. The material was said to contain an average of 3.8 percent yttrium oxide. Société d'Exploitation Minière et de Recherches de Mauritanie (SOMIREMA), a subsidiary of Péchiney, will mine and export the ores starting in early 1968. The ore concentrates will be processed in the Pechiney St. Gobain plant, La Rochelle, France.

Spain.—A deposit of bastnaesite was discovered at Pozoblanco near Córdoba, and it was believed to contain a useful percentage of europium.

United Kingdom.—Rio Tinto Zinc's rare-earth producing subsidiary, Thorium Ltd. opened a new laboratory at Widnes, Lancashire. The company gained a Queen's Award for Technological Innovation by developing an efficient solvent extraction process for separating and purifying rare-earth elements. The company was in the midst of an expansion program which would triple annual capacity for praseodymium oxide to 65,000 pounds by late 1968 and materially increase output of cerium, europium, lanthanum, and neodymium oxides. Subsequently, Thorium Ltd. joined with Johnson Matthey & Co. Ltd. in forming a new company, Rare Earth Products Ltd. Thorium Ltd. was scheduled to manage the plant starting on November 1, 1967.

TECHNOLOGY

Although monazite is currently secondary to bastnaesite in this country as a source of rare-earth oxides, its history as the dominant rare-earth and thorium mineral reaches back to the 19th century. A recent U.S. Geological Survey publication is of maximum importance in making known the world distribution, types of geological environments, elemental contents, and relative abundance data on monazite.[7] In the event of immensely increased demand for some of the heavy rare-earth oxides it might be possible to recover these elements as a byproduct from "wet process" phosphoric acid used in producing fertilizers from marine phosphorites. The possible extraction processes which might be used for the byproduct recovery were discussed.[8]

Mining and concentrating bastnaesite and processing the concentrates to intermediate rare-earth products and others such as high-purity europium oxide were described. Two comprehensive flowsheets, showing the ore concentrating and the europium, cerium, and lanthanum circuits, were published.[9]

Bureau of Mines investigations reflected a varied interest in rare-earth materials. Additions of small quantites of rare-earth elements were said to have little effect on the tensile properties of steel. Cerium metal was purified by solid-state electrolysis, and high-purity neodymium, praseodymium, and didymium metals were prepared by electrolysis of their oxides. Selective leaching of rare-earth values was facilitated by fusing euxenite with ammonium sulfate. Thermochemical data were published, and measurements were made of the reaction rate between yttrium metal and molten lithium fluoride. Yttrium was electrorefined and the electrical properties of yttrium compounds were discussed. Reconnaissance studies delineated an area of remote potential value as a source of

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[7] Overstreet, William C. The Geological Occurrence of Monazite. Geol. Survey Prof. Paper 530, 1967, 327 pp.

[8] Altschuler, Z. S., Sol Berman, and Frank Cuttitta. Rare Earths in Phosphorites—Geochemistry and Potential Recovery. Geol. Survey Prof. Paper 575-B, 1967, pp. B1–B9.

[9] Harrah, H. W. Rare Earth Concentration at Molybdenum Corporation of America. Part II. Solvent Extraction Plant. Deco Trefoil, v. 31, No. 5, November-December 1967, pp. 9–16.
Johnson, N. L. Rare Earth Concentration at Molybdenum Corporation of America. Deco Trefoil, v. 30, No. 4, August-September-October 1966, pp. 9–16.

yttrium and related rare-earth elements.[10]

Investigations continued on fluorescence and luminescence phenomena of rare-earth materials, generated by their outstanding success in color television phosphors.[11] Methods were studied to achieve the maximum economy in preparing phosphor coatings and in promoting maximum performance under a particular mode of excitation.[12]

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[10] Barnard, P. G. Effects of Rare-Earth Additions on Plain-Carbon Steel. BuMines Rept. of Inv. 6907, 1967, 25 pp.

Driscoll, Timothy J., Jr., and Lindsay D. Norman, Jr. Thermoelectric Properties of Yttrium-Group V and Yttrium-Group VI Binary and Ternary Compounds. BuMines Rept. of Inv. 7025, September 1967, 14 pp.

Marchant, J. D., E. S. Shedd, and T. A. Henrie. Solid-State Electromigration of Impurities in Cerium Metal. BuMines Rept. of Inv. 6894, 1967, 13pp.

Merrill, C. C., and M. M. Wong. Electrorefining Yttrium. BuMines Rept. of Inv. 7018, September 1967, 10 pp.

Morrice, E., and T. A. Henrie. Electrowinning High-Purity Neodymium, Praseodymium, and Didymium Metals From Their Oxides. BuMines Rept. of Inv. 6957, May 1967, 11 pp.

Porter, Bernard, R. E. Meaker, and T. A. Henrie. Reaction Rate of Solid Yttrium Metal With Molten Lithium Fluoride. BuMines Rept. of Inv. 7008, August 1967, 13 pp.

Shaw, Van E., and R. E. Lindstrom. Extraction of Euxenite Metal Values by Fusion With Ammonium Sulfate or Ammonium Bisulfate. BuMines Rept. of Inv. 6906, 1967, 11 pp.

Stuve, J. M. Heats of Formation of Ytterbium and Thulium Trichlorides. BuMines Rept. of Inv. 6902, 1967, 7 pp.

Stuve, J. M. Heats of Formation of Holmium and Terbium Trichlorides. BuMines Rept. of Inv. 7046. November 1967, 7 pp. Williams, Roger L. Reconnaissance of Yttrium and Rare-Earth Resources in Northern New Jersey. BuMines Rept. of Inv. 6885, 1967, 34 pp.

[11] Aia, Michael A. Structure and Luminescence of the Phosphate-Vanadates of Yttrium, Gadolinium, Lutetium, and Lanthanum. J. Electrochem. Soc., v. 114, No. 4, April 1967, pp. 367–370.

Avella, F. J., O. J. Sovers, and C. S. Wiggins. Rare Earth Cathodoluminescence in $InBO_3$ and Related Orthoborates. J. Electrochem. Soc., v. 114, No. 6, June 1967, pp. 613–616.

Blasse, G., and A. Bril. Fluorescence of Eu^{3+}-Activated Garnets Containing Pentavalent Vanadium. J. Electrochem. Soc., v. 114, No. 3, March 1967, pp. 250–252.

Brixner, L. H. Fluorescence and Cathodoluminescence of Eu^{3+} in Some Alkali and Alkaline Earths—Yttrates and Gadolinates as Hosts. J. Electrochem. Soc., v. 114, No. 3, March 1967, pp. 252–254.

[12] Wacher, P., D. J. Bracco, and F. C. Palilla. The Particle Size Distribution of Yttrium Vanadate Phosphors as a Function of Preparation Parameters. Electrochem. Tech., v. 5, Nos. 7-8, July-August 1967, pp. 358–363.

Salt

By Benjamin Petkof [1]

U. S. production of salt continued to increase to meet continued expanding requirements of the domestic heavy chemical industry. Total production in 1967, almost two-thirds of which was consumed in the production of chlorine, soda ash, and other chemicals, increased 7 percent in quantity and 9 percent in value. Exports and imports rose slightly over those of 1966.

DOMESTIC PRODUCTION

Salt was produced in 17 States during 1967, five of which Louisiana, Texas, Ohio, New York, and Michigan, supplied 86 percent of total production.

Fifty–seven companies in the United States and Puerto Rico produced salt at 102 plants. Eleven companies, with production in excess of 1 million tons each, accounted for 86 percent of total production, 15 companies whose production was less than 1 million, but greater than 100,000 tons per year operated 26 plants and supplied 14 percent of total production; and 31 companies whose individual production was under 100,000 tons per year, operated 35 plants to supply the remaining material.

Twelve plants, with an annual production over 1 million tons each, supplied 57 percent of total domestic production; and 12 plants producing 500,000 tons to 1 million tons each, annually, supplied 21 percent. The remainder was supplied by 78 plants.

International Salt Co. began operating a new refinery in Cleveland, Ohio, that was capable of producing 200,000 tons per year of high-purity evaporated salt from rock salt. The company uses its own recrystallizing process whereby salt is mixed with saturated brine and raised to a high temperature by the injection of steam. Insoluable calcium sulfate is filtered out and the clarified brine is cooled rapidly in a flash chamber where the salt is recrystallized.[2]

Lithium Corporation of America and Chemsalt were jointly building 12,000 acres of solar ponds in the Great Bear Basin near Ogden, Utah. The extraction of various chemical compounds including salt was expected to begin in 1970.[3]

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[1] Commodity specialist, Division of Mineral Studies.
[2] Chemical Engineering. v. 74, No. 19, Sept. 11, 1967, p. 232.
[3] Chemical Week. No Letup at Salt Lake. v. 100, No. 20, May 20, 1967, p. 22.

Table 1.—Salient salt statistics

(Thousand short tons and thousand dollars)

	1963	1964	1965	1966	1967
United States:					
Sold or used by producers	30,641	31,623	34,687	36,463	38,946
Value	$184,589	$200,706	$215,699	$229,985	$251,210
Exports	781	594	688	662	678
Value	$4,140	$3,373	$4,285	$4,472	$4,583
Imports for consumption	1,516	2,261	2,410	2,479	2,843
Value	$5,112	$5,677	$6,505	$6,464	$8,541
Consumption, apparent	31,376	33,290	36,409	38,280	41,111
World: Production	105,973	109,276	119,135	120,119	111,304

Table 2.—Salt sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1966		1967	
	Quantity	Value	Quantity	Value
California	1,693	W	1,732	W
Kansas [1]	969	$13,388	1,069	$14,686
Louisiana	8,736	44,189	9,585	48,483
Michigan	4,465	38,611	4,789	42,389
New Mexico	66	716	82	1,036
New York	4,980	36,203	5,320	41,568
Ohio	5,138	35,735	5,407	39,549
Oklahoma	W	W	10	76
Texas	7,724	33,797	8,344	36,435
Utah	427	3,770	403	3,525
West Virginia	1,147	5,446	1,127	5,137
Other States [2]	1,118	18,130	1,078	18,326
Total	36,463	229,985	38,946	251,210
Puerto Rico	11	183	12	195

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Quantity and value of brine included with "Other States."
[2] Includes Alabama, Colorado, Hawaii, Kansas (brine only), Nevada, North Dakota, Virginia, and States indicated by symbol W.

Table 3.—Salt sold or used by producers in the United States by methods of recovery

(Thousand short tons and thousand dollars)

Method of recovery	1966		1967	
	Quantity	Value	Quantity	Value
Evaporated:				
Bulk:				
Open pans or grainers	305	$8,220	356	$10,608
Vacuum pans	2,633	60,317	2,860	65,515
Solar	1,769	11,688	1,729	11,356
Pressed blocks	328	8,529	344	8,367
Total	5,035	88,754	5,289	95,846
Rock:				
Bulk	10,020	59,436	11,598	70,100
Pressed blocks	60	1,682	63	1,853
Total	10,080	61,118	11,661	71,953
Salt in brine (sold or used as such)	21,348	80,113	21,996	83,411
Grand total	36,463	229,985	38,946	251,210

Table 4.—Evaporated salt sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1966		1967	
	Quantity	Value	Quantity	Value
Kansas	452	$10,836	521	$12,085
Louisiana	267	6,354	301	7,619
Michigan	1,033	23,145	1,042	24,439
New York	648	15,312	729	16,512
Ohio	607	13,207	688	14,908
Oklahoma	W	W	7	67
Other States [1]	2,028	19,900	2,001	20,216
Total	5,035	88,754	5,289	95,846
Puerto Rico	11	183	12	195

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes California, Hawaii, Nevada, New Mexico, North Dakota, Texas, Utah, and States indicated by symbol W.

Table 5.—Rock salt sold by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1963	8,345	$51,648	1966	10,080	$61,118
1964	8,554	52,290	1967	11,661	71,953
1965	9,810	57,710			

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
1963	362	$7,914	60	$1,589	422	$9,503
1964	387	8,659	65	1,725	452	10,384
1965	375	8,701	68	1,767	443	10,468
1966	328	8,529	60	1,682	388	10,211
1967	344	8,367	63	1,853	407	10,220

CONSUMPTION AND USES

Of the total domestic salt output 64 percent was sold or used in the chemical manufacturing industry, 42 percent was used for production of chlorine and its byproduct caustic soda, 18 percent for sodium carbonate (soda ash), and 4 percent for other chemicals. The chemical manufacturing industry therefore consumed 64 percent of the domestic salt sold and used.

The next largest use, for ice and snow removal and road bed stabilization, accounted for 14 percent of total salt output. Salt assumed to be used as table salt represented 3 percent of the total.

Of the total salt consumed, 56 percent was sold or used as brine.

Table 7.—Salt sold or used by producers in the United States, by classes and consumers or uses

(Thousand short tons)

Consumer or use	1966				1967			
	Evaporated	Rock	Brine	Total	Evaporated	Rock	Brine	Total
Chlorine	W	W	13,196	15,410	451	1,561	14,223	16,235
Soda ash	W	W	7,207	7,208	W	W	6,823	6,825
Soap (including detergents)	23	8	23	54	23	8	----	31
All other chemicals	W	1,206	W	1,541	314	1,459	38	1,811
Textile and dyeing	W	104	W	202	W	94	W	189
Meatpackers, tanners, and casing manufacturers	W	424	W	723	297	431	----	728
Fishing	16	4	-----	20	14	5	-----	19
Dairy	40	4	-----	44	46	4	-----	50
Canning	172	36	-----	208	183	W	W	233
Baking	103	W	W	107	W	W	-----	113
Flour processors (including cereal)	60	8	-----	68	59	9	-----	68
Other food processing	140	30	-----	170	152	W	W	188
Ice manufacturers and cold storage companies	W	17	W	26	W	13	W	20
Feed dealers	654	369	-----	1,023	718	398	-----	1,116
Feed mixers	302	131	-----	433	323	W	W	464
Metals	W	106	W	236	W	121	W	249
Ceramics (including glass)	4	10	-----	14	5	10	-----	15
Rubber	W	W	93	132	W	W	13	112
Oil	61	64	52	177	63	49	126	238
Paper and pulp	W	134	W	192	16	124	13	153
Water softener manufacturers and service companies	301	286	4	591	335	W	W	683
Grocery stores [1]	639	291	-----	930	678	338	-----	1,016
Railroads	10	27	-----	37	6	27	-----	33
Bus and transit companies	W	14	W	17	W	W	-----	69
States, counties, and other political subdivision (except Federal) [2]	174	3,956	3	4,133	W	5,157	W	5,297
U.S. Government	W	29	W	55	W	31	W	66
Miscellaneous	1,118	934	660	2,712	1,081	1,183	661	2,925
Undistributed [3]	1,218	1,888	110	-----	525	639	99	-----
Total	5,035	10,080	21,348	36,463	5,289	11,661	21,996	38,946

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Includes salt assumed to be used as table salt.
[2] Includes salt used for ice and snow removal and roadbed stabilization.
[3] Includes some exports and consumption in overseas areas administered by the United States, and items indicated by symbol W.

Table 8.—Distribution (shipments) of evaporated and rock salt in the United States, by destination

(Thousand short tons)

Destination	1966 Evaporated	1966 Rock	1967 Evaporated	1967 Rock
Alabama	37	485	40	427
Alaska	W	------	W	W
Arizona	W	5	W	W
Arkansas	17	74	16	83
California	850	W	759	W
Colorado	81	28	96	35
Connecticut	18	W	19	W
Delaware	8	W	8	W
District of Columbia	4	W	3	W
Florida	29	95	31	107
Georgia	55	222	56	W
Hawaii	W	------	W	------
Idaho	43	W	43	W
Illinois	268	524	281	461
Indiana	135	306	144	380
Iowa	148	211	174	243
Kansas	70	184	86	204
Kentucky	43	274	45	343
Louisiana	33	332	34	391
Maine	12	W	13	W
Maryland	43	W	46	116
Massachusetts	70	374	57	613
Michigan	174	W	180	W
Minnesota	143	266	155	341
Mississippi	15	73	17	72
Missouri	83	304	81	353
Montana	35	1	37	1
Nebraska	86	84	90	92
Nevada	24	W	22	W
New Hampshire	5	W	9	W
New Jersey	161	405	157	465
New Mexico	13	57	14	71
New York	256	W	354	W
North Carolina	107	153	105	161
North Dakota	39	4	42	4
Ohio	283	812	303	961
Oklahoma	30	57	34	56
Oregon	55	W	33	W
Pennsylvania	187	619	203	823
Rhode Island	11	W	12	W
South Carolina	32	18	32	20
South Dakota	38	22	36	21
Tennessee	122	W	129	290
Texas	105	360	113	422
Utah	138	W	154	W
Vermont	8	W	7	W
Virginia	87	142	88	124
Washington	155	W	W	W
West Virginia	22	94	21	108
Wisconsin	146	259	154	425
Wyoming	21	W	20	W
Other [1]	490	3,236	736	3,448
Total	5,035	10,080	5,289	11,661

W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1] Includes shipments to overseas areas administered by the United States, Puerto Rico, exports, some shipments to unspecified destinations, and States indicated by symbol W.

PRICES

During the year The Oil, Paint and Drug Reporter quoted rock salt and table salt (paper bags and carlots) at $1.00 and $1.34 per hundred pounds respectively during the year.

Based on reported production data, the average, per ton values of rock and evaporated salt were $6.04 and $18.12 respectively.

FOREIGN TRADE

Exports and imports of salt remained low compared with domestic production. Exports, the bulk of which went to Japan and Canada, increased about 2 percent in quantity over those of 1966. Imports increased about 15 percent. Canada, Mexico, the Bahamas, and Tunisia supplied 95 percent of the total. Imported material was about 7 percent of domestic production.

Table 9.—Salt shipped to the Commonwealth of Puerto Rico and overseas areas administered by the United States

(Thousand short tons and thousand dollars)

Area	1966		1967	
	Quantity	Value	Quantity	Value
American Samoa	(1)	$16	(1)	$16
Guam	(1)	14	(1)	19
Puerto Rico	10	762	11	840
Virgin Islands	(1)	13	(1)	17

[1] Less than ½ unit.

Table 10.—U.S. exports of salt by countries

(Thousand short tons and thousand dollars)

Destination	1966		1967	
	Quantity	Value	Quantity	Value
Australia	1	$62	1	$56
Bahamas	(1)	30	1	36
Brazil	45	206	(1)	4
Canada	178	1,637	205	1,738
Dominican Republic	1	52	1	45
Greece	1	43	1	26
Japan	429	1,890	460	2,098
Mexico	2	62	2	52
Netherlands	(1)	3	1	21
Netherlands Antilles	2	47	1	47
Peru	(1)	15	1	49
Saudi Arabia	1	49	1	60
South Africa, Republic of	(1)	20	1	18
Spain	1	31	1	21
Trust Territory of the Pacific Islands	(1)	11	1	22
Other	1	314	(1)	290
Total	662	4,472	678	4,583

[1] Less than ½ unit.

Table 11.—U.S. imports for consumption of salt, by countries [1]

(Thousand short tons and thousand dollars)

Country	1966		1967	
	Quantity	Value	Quantity	Value
Bahamas	330	$1,234	270	$1,005
Canada	1,320	3,503	1,436	4,860
Chile	-----	-----	78	218
Mexico	636	982	830	1,724
Spain	43	305	-----	-----
Tunisia	124	371	169	542
United Arab Republic	26	66	48	159
Venezuela	-------	-----	12	32
Other	(2)	3	(2)	1
Total	2,479	6,464	2,843	8,541

[1] Includes salt brine from Canada through the Detroit Mich., customs district for 1966, 657,489 short tons valued at $203,866; 1967, 443,457 short tons valued at $128,839.
[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
1965	14	$241	2,396	$6,264
1966	10	208	2,469	6,256
1967	14	282	2,829	8,259

[1] Includes salt brine from Canada through the Detroit Mich., customs district for 1965, 645,481 short tons valued at $179,350; 1966, 657,489 short tons valued at $203,866; 1967, 443,457 short tons valued at $128,839.

Table 13.—U.S. imports for consumption of salt, by customs districts[1]

(Thousand short tons and thousand dollars)

Customs district	1966		1967	
	Quantity	Value	Quantity	Value
Baltimore, Md	85	$226	179	$490
Boston, Mass	71	370	92	369
Bridgeport, Conn	52	240	22	59
Buffalo, N.Y	97	534	52	225
Chicago, Ill	72	350	181	858
Cleveland, Ohio	52	219	190	806
Detroit, Mich	921	1,495	850	2,205
Duluth, Minn	21	104	43	161
Juneau, Alaska	(2)	2	-----	-----
Los Angeles, Calif	118	243	175	361
Milwaukee, Wis	43	197	85	392
New York City	64	263	46	162
Norfolk, Va	(2)	1	12	43
Ogdensburg, N.Y	(2)	1	(2)	4
Philadelphia, Pa	12	32	22	164
Portland, Maine	67	420	127	635
Portland, Oreg	135	231	137	171
Providence, R.I	4	19	26	77
Rochester, N.Y	(2)	(2)	-----	-----
St. Albans, Vt	3	18	13	55
San Juan, Puerto Rico	(2)	1	6	31
Savannah, Ga	168	621	157	579
Seattle, Wash	453	768	391	602
Wilmington, N.C	41	109	37	92
Total	2,479	6,464	2,843	8,541

[1] Includes salt brine from Canada through the Detroit Mich., customs district for 1966, 657,489 short tons valued at $203,866; 1967, 443,457 short tons valued at $128,839.
[2] Less than ½ unit.

WORLD REVIEW

Australia.—The industry has been in the process of developing new production facilities to meet demands by domestic industry and the Japanese chemical industry. Shark Bay Pty. Ltd. shipped salt to Japan from its first commercial harvest at Shark Bay in Western Australia. Salt was also produced by Imperial Chemical Industries of Australia and New Zealand, Ltd., at its Port Alma, Queensland, solar salt field project. The output was shipped to the company's chlorine-soda plant at Botany, New South Wales.[4]

In addition, Norseman Gold Mines N.L. and Sumitomo Shoji Kaisha Ltd. of Japan agreed to a joint venture to recover salt at Lake Lefroy, 60 miles north of Norseman, Western Australia, for export to Japan.[5]

[4] Bureau of Mines. Mineral Trade Notes. v. 65, No. 1, January 1968, p. 27–28.
[5] Bureau of Mines. Mineral Trade Notes. v. 64, No. 6, June 1967, p. 23.

Table 14.—World production of salt, by countries [1] [2]

(Thousand short tons)

Country	1963	1964	1965	1966	1967 p
North America:					
Canada	r 3,722	r 3,989	4,584	r 4,492	5,351
Caribbean Islands:					
Bahamas	r 257	370	r [3] 463	r NA	NA
Leeward Islands	7	[3] 3	8	e 8	NA
Turks and Caicos Islands	30	9	3	e 3	NA
Cuba	99	96	117	e 110	NA
Dominican Republic:					
Rock salt	r 32	2	r 1	r NA	NA
Other salt:	r 17	32	29	e 28	NA
Haiti	e 11	11	11	e 11	NA
Netherlands Antilles	([4])	([4])	e 2	e 2	NA
Costa Rica	7	22	2	2	NA
El Salvador	r ([4])	r 24	r 25	r 21	NA
Guatemala	21	20	17	r 22	NA
Honduras	e 11	e 11	e 11	e 11	25
Mexico	r 1,412	r 1,980	r 2,229	r 2,681	3,671
Nicaragua	18	19	20	21	NA
Panama	11	12	12	10	NA
United States (including Puerto Rico):					
Rock salt	8,345	8,554	9,810	10,080	11,661
Other salt:					
United States	22,296	23,069	24,877	26,383	27,285
Puerto Rico	8	5	8	11	12
South America:					
Argentina:					
Rock salt	3	2	r 3	r 2	NA
Other salt	300	431	r 807	r 854	NA
Brazil	1,315	831	1,323	1,447	NA
Chile	53	104	110	224	461
Colombia:					
Rock salt	292	319	309	r 332	342
Other salt	37	56	r 56	r 89	175
Ecuador e	39	39	39	39	NA
Peru	r 115	147	r 152	191	155
Venezuela	84	224	190	r 164	e 94
Europe:					
Austria:					
Rock salt	6	1	1	1	1
Other salt	e r 413	r 431	r 444	r 517	466
Bulgaria	116	90	138	e 138	e 165
Czechoslovakia	206	203	211	r 217	e 220
Denmark	-------	-------	-------	28	110
France:					
Rock salt and salt from springs	3,405	3,573	3,663	r 3,749	e 3,748
Other salt	667	872	1,241	r 1,173	e 1,213
Germany:					
East	2,291	2,291	2,083	e 2,200	e 2,200
West (marketable):					
Rock salt	5,769	5,957	5,627	r 5,646	e 5,622
Brine salt	400	440	483	625	NA
Greece	91	r 111	r 96	100	NA
Italy:					
Rock salt and brine salt	2,086	2,244	2,347	r 2,334	e 2,847
Other salt	1,022	928	1,221	r 1,565	e 1,653
Malta	2	2	2	3	NA
Netherlands	1,630	1,759	1,882	2,047	2,122
Poland:					
Rock salt	711	728	743	r 840	e 2,756
Other salt	1,639	1,743	1,789	r 1,816	
Portugal:					
Rock salt	87	98	99	108	e 121
Other salt	295	256	451	374	NA
Rumania	1,804	1,994	2,222	2,255	e 2,315
Spain:					
Rock salt	771	808	r 876	r NA	NA
Other salt [5]	1,101	1,313	r 1,171	r NA	NA
Switzerland	211	201	254	r 209	e 220
U.S.S.R.	10,538	11,133	e 10,500	e 10,500	e 10,500
United Kingdom:					
Rock salt	842	776	810	1,176	NA
Other salt	6,317	6,659	6,906	6,929	NA
Yugoslavia	184	203	192	182	185
Africa:					
Algeria	137	128	128	e 128	e 129
Angola	76	89	65	67	e 71
Cape Verde Islands	32	35	44	e r 44	e 44
Chad	28	8	11	11	e 11

Table 14.—World production of salt, by countries [1] [2]—Continued

(Thousand short tons)

Country	1963	1964	1965	1966	1967 [p]
Africa—Continued					
Ethiopia (including Eritrea) [6]	281	226	207	[e] [r] 353	[e] 331
Ghana	([r])	34	30	40	[e] 33
Kenya	19	30	34	35	[e] 35
Libya	21	13	13	[r] ([4])	NA
Malagasy Republic	220	320	160	503	NA
Mali	NA	NA	3	[r] 3	[e] 4
Mauritius	[r] 4	4	4	4	4
Morocco	41	67	37	43	22
Mozambique	44	-------	33	[r] 29	NA
Senegal (including Mauritania)	66	62	56	67	66
Somali Republic	2	7	6	([4])	NA
South Africa, Republic of	218	331	365	346	325
South-West Africa, Territory of:					
Rock salt	6	6	6	6	[e] 6
Other salt	66	103	103	65	[e] 83
Sudan	41	66	57	47	[e] 44
Tanzania	37	36	43	45	[e] 44
Tunisia (sales)	340	236	392	362	NA
Uganda	3	3	3	2	[e] 2
United Arab Republic	432	744	545	691	NA
Asia:					
Aden	95	89	79	79	66
Afghanistan:					
Rock salt	23	14	20	22	NA
Other salt	13	13	22	21	NA
Burma	177	140	146	[r] 130	186
Ceylon	25	57	86	71	84
China, mainland [e]	11,600	11,000	14,300	14,300	14,300
Cyprus	8	-------	6	4	8
Goa	[e] 11				
India	5,006	5,122	5,184	4,969	6,200
Indonesia	495	58	278	[e] 276	110
Iran [7]	380	243	248	[e] 248	NA
Iraq [8]	34	[e] 30	[e] 66	[e] 66	[e] 66
Israel	57	47	61	[r] 64	63
Japan	823	984	935	937	1,073
Jordan	20	22	22	14	13
Korea:					
North [e]	500	440	550	[r] 600	600
South	254	425	737	433	578
Kuwait	-------	-------	8	[r] 4	[e] 6
Laos	NA	[e] 3	[e] 3	4	3
Lebanon	21	22	26	28	[e] 28
Mongolia [e]	9	9	9	9	9
Pakistan:					
Rock salt	267	217	299	345	NA
Other salt	234	214	246	216	NA
Philippines	77	52	[r] 281	[r] 202	128
Ryukyu Islands	4	3	3	7	7
Saudi Arabia	11	NA	NA	[e] 3	[e] 3
Syrian Arab Republic	17	18	23	[e] 22	[r] 22
Taiwan	690	664	617	453	571
Thailand	293	209	207	[e] 220	[e] 120
Turkey:					
Rock salt	33	36	39	35	NA
Other salt	406	355	505	279	NA
Viet-Nam:					
North	141	[e] 165	[e] 165	[e] 165	NA
South	216	208	177	[e] 176	NA
Yemen	[e] 110	[e] 39	-------	[e] [r] 94	[e] 110
Oceania:					
Australia	651	611	733	[r] 722	NA
New Zealand	12	24	39	40	NA
Total [9]	[r] 105,973	[r] 109,276	[r] 119,135	[r] 120,119	111,304

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

[1] Salt is produced in many other countries but quantities are relatively insignificant or reliable data not available.

[2] Compiled mostly from data available May 1968.

[3] Exports.

[4] Less than ½ unit.

[5] Includes an average annual production in the Canary Islands of 15,000 metric tons of sea salt.

[6] Year ended September 10 of year stated.

[7] Year ended March 20 of year following that stated.

[8] Year ended March 31 of year following that stated.

[9] Total is of listed figures only: no undisclosed data included.

Brazil.—Union Carbide Pan-American acquired control of the Salgema Industrias Quimicas Ltda. to develop the rock salt deposits in the State of Alagoas.[6]

Bulgaria.—A salt deposit has been discovered near Provadiya at a depth of 3,000 feet. The dome-shaped deposit has been drilled to a depth of 3,000 feet and will be mined by the solution method. Production will be used to supply a calcined soda plant being developed at Devnniya.[7]

Canada.—Preliminary data indicated that Canadian salt production reached 5.4 million short tons in 1967, about 57 percent of which consisted of rock salt.[8] During 1966 rock salt was produced by two companies in three mines. The bulk of Canada's salt exports in 1966 went to the United States.[9]

Denmark.—Dansk Salt A/S, a Danish-Dutch venture and the only Danish salt producer, began production in 1966 with an output of about 28,000 tons. In 1967 the company's output was estimated between 110,000 and 165,000 short tons. Exports of salt to markets in other Scandinavian countries were anticipated.[10]

Dominican Republic.—The Pittsburgh Plate Glass Company signed an agreement with the Dominican Corp. of State Companies in October 1967 to study the feasibility of developing the salt resources of Barahona Province. If salt can be mined, a joint company will be established to develop the province's salt resources. Pittsburgh Plate Glass anticipates using any output to supply 300,000 tons of salt annually to its projected Puerto Rican chlorine and caustic soda plant.[11]

Peru.—Most Peruvian salt was produced by Estanco de la Sal from salt beds and from solar evaporation of sea water. Domestic consumption totaled almost 120,000 tons. Additional production is expected from the evaporation of brine for potassium recovery, when the Minera Bayovar plant comes into production.[12]

Portugal.—A report has been prepared describing the rock salt deposit in the Algarve province of southern Portugal. Technical and economic problems relating to rocksalt mining were discussed and recommendations were made.[13]

United Kingdom.—The only working rock salt mine in the United Kingdom is located at Winsford in Cheshire. Mining on a small scale began in 1844 and continued until 1852, production was resumed in 1928. Improvements begun and further modernization in 1960 increased productive capacity. The salt of 95 percent purity is found in two rock salt beds, each about 80 feet thick beginning at the 260-foot and 400-foot levels respectively. Only the bottom 20 feet of the lower bed is mined.[14]

TECHNOLOGY

A survey of the known salt domes in Texas, Louisiana, Mississippi, Alabama, and the associated offshore tidelands provides information, such as location, depth of cap rock and salt, liquid gas propane facilities, production of salt and other minerals, and rock related to the dome structure, for proved salt domes in the area. This information is valuable for developing economic and marketing studies of this four-State area.[15]

Japan, which is dependent on foreign sources for its salt supplies, has developed processes that utilize salt with varying impurities from different world sources for the Japanese chemical industry. A paper on the subject provided analysis of the impurities contained in salt from the various producing countries.[16]

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[6] Chemical Age (London). Brazilian Rock Salt Deposits To Be Exploited by UCC. v. 97, No. 2497, May 20, 1967, p. 31.

[7] Bureau of Mines. Mineral Trade Notes. v. 65, No. 3, March 1968, pp. 39–40.

[8] Dominion Bureau of Statistics (Ottawa, Canada). Salt. v. 22, No. 12, December 1967, 1 p.

[9] D. H. Stonehouse. Salt. Canadian Mineral Yearbook. No. 45, 1966, 6 pp.

[10] Bureau of Mines. Mineral Trade Notes. v. 65, No. 1, January 1968, p. 27–28.

[11] Bureau of Mines. Mineral Trade Notes. v. 65, No. 1, January 1968, p. 28.

[12] Bureau of Mines. Mineral Trade Notes. v. 64, No. 12, December 1967, p. 45.

[13] Fitch, F. H. Exploitation of Rocksalt Deposits at Loule. Organization for Economic Cooperation and Development, Paris. Project No. AT (67) 13, Jan. 8, 1968, 65 pp.

[14] Chemistry and Industry (London). Meadowbank Salt Mine. No. 25, June 24, 1967, p. 1061.

[15] Hawkins, M. E., and C. J. Jirik. Salt Domes In Texas, Louisiana, Mississippi, Alabama, and Offshore Tidelands: A Survey. BuMines Inf. Circ. 8313, 1966, 78 pp.

[16] Yamaha, Mashio, Hidetomo Suzuki, and Kiyoshi Tsukamoto (Ebara-Infilco Company, Tokyo, Japan). Advanced Brine Purification Process in Japan. Electrochem. Technol., v. 5, No. 5–6, May–June 1967, pp. 257–261.

Sand and Gravel

By William R. Barton [1]

DOMESTIC PRODUCTION

For the first time in almost a decade, sand and gravel production failed to post gains.

The 905 million tons of sand and gravel sold or used in 1967 was almost 30 million tons below the corresponding figure for 1966, and 3 million tons below that of 1965. While 1967 output from commercial operations declined 2 percent, that from Government and contractor operations was off 7 percent from 1966.

[1] Geologist, Knoxville Office of Mineral Resources, Bureau of Mines, Knoxville, Tenn.; formerly commodity specialist, Division of Mineral Studies.

Table 1.—Sand and gravel sold or used by producers in the United States, by classes of operations and uses

(Thousand short tons and thousand dollars)

Class of operations and use	1966 Quantity	1966 Value	1967 [1] Quantity	1967 [1] Value
Construction:				
Building:				
Sand	155,652	$163,109	147,250	$157,928
Gravel	128,692	167,138	118,690	160,335
Paving:				
Sand	134,667	125,205	133,748	129,621
Gravel	356,125	345,322	356,241	349,776
Fill:				
Sand	43,650	26,814	42,246	26,163
Gravel	63,848	44,385	50,935	36,836
Railroad ballast:				
Sand	249	226	412	382
Gravel	4,439	3,189	1,865	1,719
Other:				
Sand	7,743	6,781	10,018	9,756
Gravel	8,112	9,442	13,086	15,043
Total construction	903,177	891,611	874,491	887,537
Industrial sand:				
Unground:				
Glass	8,823	27,723	8,937	28,976
Molding	10,679	29,877	9,459	26,934
Grinding and polishing	744	1,565	639	1,482
Blast sand	987	4,826	1,147	6,442
Fire or furnace	555	1,407	496	1,127
Engine	836	1,828	816	1,751
Filtration	489	995	201	572
Oil hydrofrac	299	2,003	190	1,328
Other	1,735	5,595	1,948	6,260
Total	25,147	75,819	23,833	74,872
Ground [2]	1,213	10,803	1,490	10,983
Total industrial	26,360	86,622	25,323	85,855
Miscellaneous gravel	4,944	6,749	5,348	6,942
Grand total	934,481	984,982	905,162	980,356
Commercial:				
Sand	315,843	368,755	305,170	366,596
Gravel	363,754	408,205	362,431	411,768
Government-and-contractor: [3]				
Sand	52,478	40,002	53,827	43,109
Gravel	202,406	168,020	183,734	158,883

[1] Data may not add to totals shown because of independent rounding.
[2] See table 10 for use breakdown.
[3] Approximate figures for operations by State, counties, municipalities, and other government agencies under lease.

The immense plant has become the frequent solution in the battle against rising production and labor costs. Proper design, centralized control, and larger equipment units, have allowed production increases without adding more workers. Several operations, which give a typical cross section of modern production practices were described.[2]

Orderly planning for optimum use of available sand and gravel resources in metropolitan areas, within acceptable limits of land use, is of increasing importance. The industry, zoning officials, and other interested parties are seeking a satisfactory compromise between those interested in the cost and availability of a basic construction raw material and the preservation of the esthetic aspects of our landscape.

Results were published of two Bureau of Mines studies that analyzed aggregate producer relationships with urbanizing environments.[3]

The pressure of financing efforts in Viet-Nam affected demand for aggregates adversely as government construction spending was cut back or delayed. Relatively high mortgage rates for private construction also were attributed in part to the pressure from the dual "war and peace" economy built up during 1967.

The results of the Department of the Interior study on the environmental effects of strip and surface mining stated that sand and gravel operations were responsible for 26 percent of land disturbed annually by surface mining in the United States,[4] second only to that disturbed by coal. The nature of sand and gravel operations, however, tended to be smaller, scattered, and in more urbanized areas compared with the huge coal strip pits.

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[2] Rock Products. Aggregate Plant Design Issue. V. 70, No. 9, September 1967, pp. 70–89.

[3] Sheridan, M. J. Urbanization and Its Impact on the Mineral Aggregate Industry in the Denver, Colo., Area. BuMines Inf. Circ. 8320, 1967, 53 pp.

Williams, F. E. Urbanization and the Mineral Aggregate Industry, Tucson, Ariz., Area. BuMines Inf. Circ. 8318, 1967, 23 pp.

[4] U.S. Department of the Interior. Surface Mining and Our Environment, A Special Report to the Nation 1967, 124, pp.

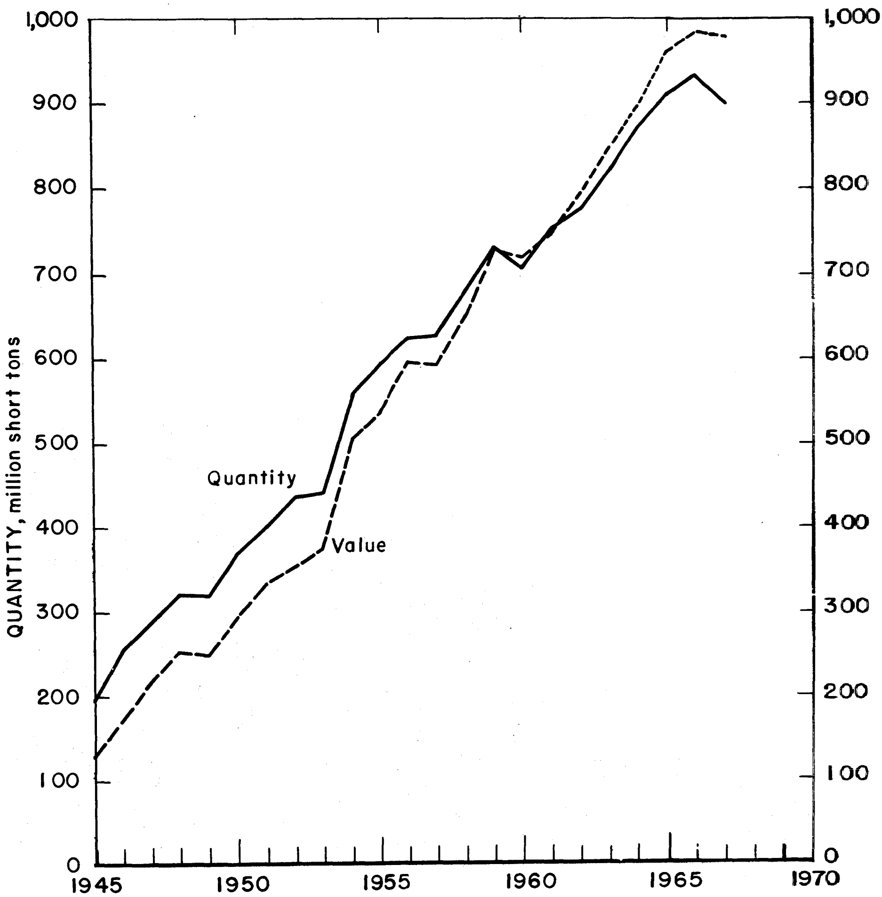

Figure 1.—Production and value of sand and gravel in the United States.

CONSUMPTION AND USES

The construction industry, the prime user of sand and gravel, consumed 97 percent of the tonnage, and 91 percent of the value of sand and gravel output in 1967. The principal consumers of higher priced industrial sands are the foundry and glass industries. A new synthetic aggregate called Sinopal was announced by Martin Marietta Corp. during the year. A highly reflective, white aggregate with skid-resistant properties, it is produced by the melting and recrystallization of a sand and limestone mixture. Visualized markets are in top coats on particularly dangerous highway and bridge segments and in traffic control and safety markings on pavements, including lane lines, dividers, direction arrows, pavement edges, crossing zones, interchanges, and intersections.

PRICES

Representative prices for construction sand and gravel in various metropolitan areas are published each month in Engineering News-Record. In December, the following base prices, per ton, were reported for typical cities.

City	Gravel		Sand
	1½-inch.	¾-inch	
Philadelphia	$1.65	$1.65	$1.35
Atlanta	2.40	2.55	3.50
Detroit	2.99	2.99	1.99
Denver	2.15	2.15	1.57
Los Angeles	4.00	4.00	3.50

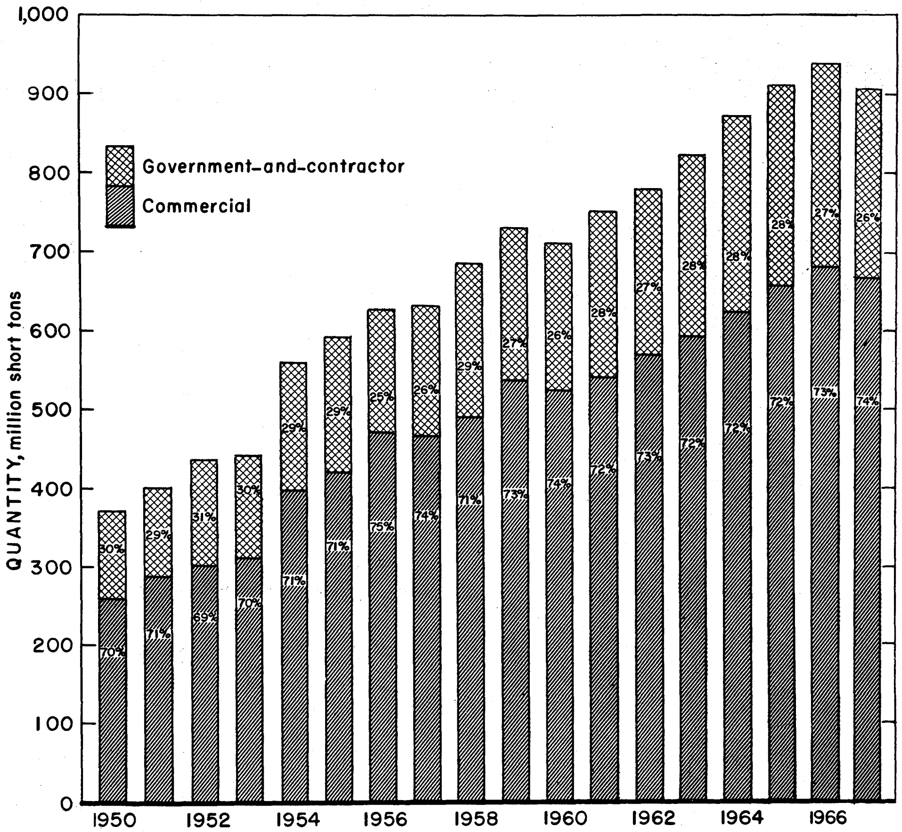

Figure 2.—Sand and gravel sold or used in the United States.

These sample cities clearly indicate the diversity of prices, which are dependent upon total local supply and demand, relation of available natural size fractions to demand for same, and abundance or suitability of competing aggregates.

FOREIGN TRADE

As in previous years the bulk of foreign trade in sand and gravel was with Canada, approximately 93 percent of U.S. imports and 80 percent of exports.

WORLD REVIEW

Australia.—A 2-million-ton deposit of silica sand, 20 miles from Fremantle, was the source of shipments to Hawaii and Japan.[5] The deposit, at Jandakot, has a reported silica content of 99.5 percent.

Germany, West.—A dredging operation at Wilmar-Kreis in Wetzlar was described.[6] The deposit was developed to fulfill an initial contract for 1 million tons of gravel for the construction of the Gieben-Dortmund autobahn. Because of heavy traffic on local village streets, coupled with their restricted load-bearing capacity, a system of conveyors and railroad transport was required to deliver the dewatered gravel to the job site.

United Kingdom.—A new sand and gravel plant at Spade Oak in the Thames Valley typified use of tree screens, landscaping, and asbestos-sheet enclosed processing equipment to reduce noise and enhance operation appearance.[7]

Seagoing dredges are a major means of producing sand and gravel for United Kingdom use. High population densities, high land values, and legal restrictions on land mining, have made the waters surrounding the British Isles an attractive area for exploitation of aggregate raw materials. Two of the larger ships, the "Pen Avon" and the "A. A. Raymond" were described in detail.[8] The "Pen Avon" has a hold capacity of 750 cubic yards and can hydraulically suction dredge gravel beds 15 feet thick at depths up to 140 feet. The "A. A. Raymond," with a 2,000-cubic-yard capacity, has been working in shallower depths of water, averaging about 60 feet.

A new range of sand-processing equipment has been marketed through Neldco Processes, Ltd. The line includes a classifier from which three accurately graded size fractions may be drawn simultaneously, a standing wave separator designed to remove coal, lignite, and other impurities, and a dewatering belt conveyor that reduces sand moisture content to 13 percent or less within 2 minutes.[9]

TECHNOLOGY

Modern technologic trends in recent years have been toward plant automation, central controls, larger equipment units, and larger plant size. To a degree, these generalities are true for both stationary and portable plants, although with portable plants the possibilities are obviously more limited. To serve large metropolitan areas, huge automated plants exploiting large deposits have provided greatest efficiencies.

Installations ranging from 1,500 to 3,000 tons per hour capacity are increasingly common, featuring trucks that will carry up to 100 tons with other equipment in proportion to match. Such facilities have been referred to as "super gravel plants." They are designed to combat the problem of dwindling profit margins by lowering unit costs by overwhelming volume.[10] Portable plants are designed primarily to extract sand and gravel from smaller, scattered, or more remote deposits, and are particularly adaptable to servicing jobs such as highway construction where the delivery site may move at frequent intervals. Larger scale portable plants have been achieved by unitization of equipment; that is, each operating unit is transported independently and then assembled into a complete plant by interconnecting the units at the selected pit site. In addition to permitting portability of higher total capacity plants, the unitized plant offers flexibility by permitting selective changes of units to vary capacity or to alter product specifications, with resulting lower costs for delivered aggregates.[11] Another noticeable trend has been the increased use of semipermanent, or as they are sometimes called, mobile plants for use in intermediate

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[5] Skillings' Mining Review. Sand Shipped to Hawaii. V. 56, No. 10, Mar. 11, 1967, p. 10.

[6] Pit and Quarry. German Dredge and Plant Make Base Gravel for Autabahn. V. 59, No. 11, May 1967, pp. 179–180.

[7] Cement, Lime and Gravel (London). A New Sand and Gravel Installation in the Thames Valley. V. 42, No. 12, December 1967, pp. 385–389.

[8] Cement, Lime and Gravel (London). A Sea-Going Dredger With an Unusual Pumping System. V. 42, No. 10, October 1967 pp. 322–325.

Mining and Minerals Engineering (London). A. A. Raymond. V. 3, No. 3, March 1967, pp. 91–97.

[9] Fisher, R. C. Improved Methods of Processing Sand. Cement, Lime and Gravel (London). v. 42, No. 2 February 1967, pp. 33–39; No. 3, March 1967, pp. 76–79.

[10] Bergstrom, John H. The Super Gravel Plant. Rock Products, v. 70, No. 9, September 1967, pp. 70–76.

[11] Matthews, C. W. Asphalt Paving Co.—Where The Action Is. Rock Products, v. 70, No. 9, September 1967, pp. 86–89.

cases where both the stationary and the portable installations appear to offer certain virtues. In general appearance the mobile plants look like a permanent plant, lacking the attached running gear of the portable plant. However, the components are readily disassembled and mounted on skids rather than concrete footings during operation at a site.[12]

The technology of pit rehabilitation and land use planning continued to develop rapidly under the pressures generated by rapid urbanization and the need for improving the quality of the human environment. The National Sand and Gravel Association has been a leader in sponsoring research in the problem, and published results of the planning and implementation methodology developed during a case study near Laurel, Md.[13] In the Los Angeles area, depleted sand and gravel pits perform a civic duty as sanitary landfill sites prior to subsequent utilization for purposes such as light industrial parks or golf courses.[14] Virtually every sand and gravel pit in the area has potential as a sanitary landfill for disposal of the 9 million tons of refuse generated annually in Los Angeles County. To permit fill below the water table level, experiments are being conducted with plastic and jute linings and impervious inorganic fill in the lower layer.

Dredge operations for aggregate raw materials have been under unique attack for despoiling natural waterways with sediment. The contributions that dredging can make to improving natural waterways is less well understood. One operation in Texas in which the work performed by a sand and gravel dredge operation improved the use and value of waterfront property in a scenic and resort area was described.[15]

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[12] Bergstrom, John H. Producing Aggregate in the Twilight Zone. Rock Products, v. 70, No. 9, September 1967, pp. 77–79.

[13] Jensen, David R. Selecting Land Use for Sand and Gravel Sites. University of Illinois Research Project No. 3. The National Sand and Gravel Association, Silver Spring, Md., 1967, 66 p.

[14] Stern, Enid W. From Gravel Pit to Golf Course. Rock Products, v. 70, No. 9, July 1967, pp. 82–83.

[15] Herod, Buren C. Capitol Aggregates Boosts Efficiency by Consolidating Processing Units. Pit and Quarry, v. 60, No. 3, September 1967, pp. 102–109.

Table 2.—Sand and gravel sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Sand		Gravel		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1963	313,978	$338,500	507,872	$508,772	821,850	$847,272
1964	326,641	358,129	541,567	535,246	868,208	893,375
1965	352,735	388,051	555,314	569,365	908,049	957,416
1966	368,321	408,757	566,160	576,225	934,481	984,982
1967	358,997	409,705	546,165	570,651	905,162	980,356

Table 3.—Sand and gravel sold or used by producers in the United States by States, and classes of operations—Continued

(Thousand short tons and thousand dollars)

State	1966						1967[1]					
	Commercial		Government-and-contractor		Total		Commercial		Government-and-contractor		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	6,971	$7,840	111	$113	7,082	$7,953	7,227	$7,966	2	$3	7,229	$7,969
Alaska	1,075	1,263	16,382	20,530	17,457	21,793	1,822	1,749	20,548	24,499	22,370	26,248
Arizona	8,024	9,737	10,706	10,711	18,730	20,448	8,232	9,281	8,348	7,734	16,580	17,017
Arkansas	11,677	15,656	4,379	5,382	16,056	21,038	10,202	13,113	4,037	2,414	14,239	15,531
California	103,184	123,374	17,508	15,783	120,692	139,157	95,694	117,182	20,431	22,028	116,125	139,212
Colorado	10,396	11,932	11,849	11,553	22,245	23,485	11,107	12,752	10,703	10,150	21,810	22,904
Connecticut	7,004	7,954	2,557	1,009	9,561	8,963	6,618	8,055	1,702	655	8,320	8,710
Delaware	1,610	1,443			1,610	1,443	1,966	1,846			1,966	1,846
Florida	6,953	6,132	450	285	7,403	6,417	6,578	6,256	334	222	6,912	6,479
Georgia	3,915	4,185			3,915	4,185	3,787	4,206			3,787	4,206
Hawaii	510	1,589	1	2	511	1,591	460	1,449	9	18	469	1,467
Idaho	2,390	2,574	5,154	4,098	7,544	6,672	2,145	2,212	9,101	9,278	11,246	11,490
Illinois	37,262	42,606	975	595	38,237	43,201	37,347	43,303	1,454	872	38,801	44,175
Indiana	24,165	23,066	827	476	24,992	23,542	25,340	25,049	925	540	26,265	25,588
Iowa	15,836	15,835	3,808	2,378	19,644	18,213	15,405	15,095	2,329	1,470	17,734	16,564
Kansas	9,316	7,193	2,311	1,181	11,627	8,374	8,510	6,727	3,556	1,922	12,066	8,650
Kentucky	7,617	7,231	447	293	8,064	7,524	7,507	7,562	474	297	7,981	7,859
Louisiana	18,171	22,459	45	45	18,216	22,504	20,216	27,346	96	96	20,312	27,442
Maine	2,165	1,644	12,871	5,383	15,036	7,027	2,076	1,858	9,551	3,509	11,627	5,368
Maryland	14,839	20,295	269	88	15,108	20,383	12,637	17,606	231	118	12,868	17,724
Massachusetts	14,732	15,818	2,589	2,028	17,321	17,846	14,727	16,552	3,154	2,950	17,881	19,504
Michigan	44,465	43,799	10,658	5,722	55,123	49,521	43,243	44,646	9,067	4,972	52,310	49,616
Minnesota	27,977	22,109	11,354	6,863	39,331	28,972	31,721	27,301	9,491	5,824	41,212	33,132
Mississippi	12,307	12,815	368	748	12,675	13,563	13,575	14,299	464	1,186	14,039	15,485
Missouri	10,454	13,283	248	257	10,702	13,540	9,651	12,488	65	68	9,716	12,556
Montana	2,369	2,696	11,447	10,827	13,816	13,523	2,794	2,985	9,545	7,669	12,339	10,655
Nebraska	11,375	12,227	2,164	1,952	13,539	14,179	10,621	9,856	1,118	1,021	11,739	10,878
Nevada	3,662	5,949	5,423	3,185	9,085	9,134	3,220	5,079	6,946	3,561	10,166	8,644
New Hampshire	3,636	3,399	3,990	1,408	7,626	4,807	3,607	3,295	4,842	1,843	8,449	5,137
New Jersey	17,762	29,311	20	11	17,782	29,322	18,610	29,969	16	6	18,626	29,975
New Mexico	3,454	3,994	12,049	9,035	15,503	13,029	3,145	4,109	11,527	10,228	14,672	14,336
New York	27,153	31,769	14,750	11,322	41,903	43,091	27,928	32,488	15,572	12,008	43,500	44,499
North Carolina	7,618	8,821	3,983	2,311	11,601	11,132	6,563	7,998	3,451	1,964	10,014	9,962
North Dakota	5,059	5,755	5,086	4,813	10,145	10,568	4,163	4,586	4,659	4,536	8,822	9,118
Ohio	43,737	52,859	114	50	43,851	52,909	42,817	52,743	379	145	43,196	52,888
Oklahoma	4,329	6,151	1,711	1,414	6,040	7,565	3,654	4,729	886	552	4,540	5,280
Oregon	10,054	12,452	25,278	22,534	35,327	34,986	10,551	12,600	9,079	12,647	19,630	25,250
Pennsylvania	17,519	29,489	48	73	17,567	29,562	17,427	29,585	52	79	17,479	29,614
Rhode Island	2,276	2,212			2,276	2,212	2,334	2,416			2,334	2,416
South Carolina	6,016	7,668			6,016	7,668	5,248	7,178			5,248	7,178
South Dakota	2,422	2,875	11,208	10,710	13,630	13,585	2,690	3,127	10,778	10,616	13,468	13,737
Tennessee	7,873	10,584	755	558	8,628	11,142	7,115	10,036	860	643	7,975	10,679

Table 3.—Sand and gravel sold or used by producers in the United States by States, and classes of operations—Continued

(Thousand short tons and thousand dollars)

State	1966						1967 [1]					
	Commercial		Government-and-contractor		Total		Commercial		Government-and-contractor		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Texas	23,089	28,947	3,133	2,366	26,222	31,313	25,397	33,630	6,001	5,539	31,398	39,170
Utah	4,587	5,194	7,781	7,743	12,368	12,937	4,092	4,028	5,320	4,605	9,412	8,631
Vermont	1,226	1,218	1,097	526	2,323	1,744	1,384	1,355	2,334	822	3,718	2,178
Virginia	17,084	16,597	107	38	17,191	16,635	9,634	12,256	229	238	9,863	12,494
Washington	18,846	18,179	10,156	8,627	29,002	26,806	17,141	17,473	11,023	10,046	28,164	27,520
West Virginia	5,448	11,569	----------	----------	5,448	11,569	5,827	12,167	----------	----------	5,827	12,167
Wisconsin	28,466	23,358	13,057	7,355	41,523	30,713	32,696	27,551	9,846	5,401	42,542	32,955
Wyoming	1,522	1,855	5,665	5,641	7,187	7,496	1,150	1,276	7,031	6,976	8,181	8,253
Total	679,597	776,960	254,884	208,022	934,481	984,982	667,601	778,364	237,561	201,970	905,162	980,356
American Samoa	-------	----------	20	18	20	18	----------	----------	7	7	7	7
Panama Canal Zone	72	91	----------	----------	72	91	56	94	----------	----------	56	94
Puerto Rico	8,844	13,561	1,035	993	9,879	14,554	12,747	20,074	1,354	1,558	14,101	21,633

[1] 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 1967, by States, uses and classes of operations

(Thousand short tons and thousand dollars)

State	Sand, construction							
	Building				Paving			
	Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	2,274	$2,233	-----	-----	643	$624	1	$1
Alaska	47	190	2	$33	15	47	491	1,653
Arizona	2,663	2,997	-----	-----	560	665	1,371	1,320
Arkansas	1,145	1,190	1	W	2,681	3,290	1,396	764
California	18,837	22,227	110	127	13,756	15,264	7,777	8,958
Colorado	2,072	2,364	25	48	385	487	955	933
Connecticut	1,707	2,063	-----	-----	1,476	1,632	194	73
Delaware	312	355	-----	-----	225	234	--------	--------
Florida	4,975	3,937	-----	-----	522	420	251	174
Georgia	2,852	2,558	-----	-----	W	W	--------	--------
Hawaii	375	1,196	-----	-----	3	5	9	18
Idaho	190	358	14	W	26	27	85	49
Illinois	6,575	6,139	-----	-----	6,374	5,464	248	144
Indiana	4,679	4,130	-----	-----	4,057	3,485	45	25
Iowa	3,030	2,966	3	1	2,828	2,852	72	40
Kansas	3,450	2,822	165	165	2,207	1,677	1,432	726
Kentucky	2,496	2,553	-----	-----	2,218	2,098	--------	--------
Louisiana	5,097	6,070	-----	-----	3,654	4,703	--------	--------
Maine	252	201	-----	-----	246	222	1,957	738
Maryland	4,130	5,306	-----	-----	1,900	2,711	41	15
Massachusetts	3,061	3,400	-----	-----	2,461	2,509	23	20
Michigan	6,508	5,990	90	49	5,565	4,550	2,291	1,121
Minnesota	3,922	3,312	-----	-----	3,679	2,340	1,449	794
Mississippi	1,021	907	-----	-----	3,349	3,311	305	763
Missouri	3,359	3,139	-----	-----	1,043	966	1	2
Montana	298	506	2	3	121	184	753	722
Nebraska	2,011	1,643	-----	-----	1,127	1,059	240	225
Nevada	594	1,229	1	1	162	296	126	124
New Hampshire	580	503	-----	-----	544	422	W	W
New Jersey	5,173	5,349	-----	-----	3,570	3,557	--------	--------
New Mexico	806	1,006	-----	-----	172	210	248	228
New York	9,960	11,823	94	141	3,260	4,189	626	440
North Carolina	2,563	2,088	-----	-----	726	750	1,930	1,109
North Dakota	349	415	-----	-----	565	621	1,595	1,577
Ohio	7,058	8,020	-----	-----	8,149	8,732	W	W
Oklahoma	1,534	1,447	-----	-----	654	625	465	247
Oregon	1,288	1,850	22	44	261	321	16	17
Pennsylvania	4,855	7,424	-----	-----	3,678	5,636	--------	--------
Rhode Island	434	424	-----	-----	290	289	--------	--------
South Carolina	2,833	1,857	-----	-----	W	W	--------	--------
South Dakota	621	677	-----	-----	56	56	1,967	1,964
Tennessee	2,346	3,144	1	1	1,007	1,672	22	35
Texas	6,073	6,059	61	33	3,726	3,597	1,107	697
Utah	951	1,105	-----	-----	203	219	485	427
Vermont	310	289	-----	-----	208	156	787	275
Virginia	2,332	2,757	-----	-----	2,233	1,862	27	10
Washington	2,486	2,744	69	136	744	681	602	609
West Virginia	1,674	2,142	-----	-----	478	782	--------	--------
Wisconsin	4,301	3,838	-----	-----	2,661	1,924	2,035	949
Wyoming	131	186	-----	-----	95	115	2,921	2,921
Undistributed	-------	---------	-----	18	503	347	2,336	829
Total	146,590	157,128	660	800	95,066	97,885	38,682	31,736
American Samoa	7	7	-----	-----	--------	--------	--------	--------
Panama Canal Zone	-------	---------	-----	-----	--------	--------	--------	--------
Puerto Rico	3,065	5,982	8	15	2,360	3,249	413	604

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

Table 4.—Sand and gravel sold or used by producers in the United States in 1967, by States, uses and classes of operations—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	---	---	53	$22	---	---	W	W	---	---
Alaska	---	---	31	30	4,821	$5,176	3	$11	---	---
Arizona	W	W	455	175	355	283	W	W	---	---
Arkansas	---	---	W	W	---	---	69	68	---	---
California	16	W	3,609	2,314	504	498	2,701	3,278	3	$5
Colorado	W	(1)	329	328	---	---	9	5	1	1
Connecticut	---	---	393	236	---	---	304	322	40	25
Delaware	---	---	W	W	---	---	---	---	---	---
Florida	---	---	399	250	83	49	W	W	---	---
Georgia	---	---	W	W	---	---	---	---	---	---
Hawaii	---	---	1	1	---	---	---	---	---	---
Idaho	W	W	55	36	---	---	58	41	31	34
Illinois	W	W	W	W	484	262	W	W	---	---
Indiana	14	$14	2,052	1,157	---	---	68	52	---	---
Iowa	W	W	1,147	736	3	1	W	W	2	1
Kansas	27	19	1,049	546	5	3	34	39	---	---
Kentucky	---	---	741	415	---	---	---	---	---	---
Louisiana	---	---	45	39	---	---	W	W	---	---
Maine	W	W	259	125	---	---	W	W	268	109
Maryland	---	---	W	W	---	---	W	W	---	---
Massachusetts	---	---	678	276	---	---	595	511	9	8
Michigan	---	---	3,401	1,601	919	373	W	W	102	44
Minnesota	---	---	1,038	491	103	48	W	W	49	27
Mississippi	---	---	15	6	---	---	154	154	---	---
Missouri	W	W	366	324	---	---	W	W	---	---
Montana	1	1	14	27	254	118	7	11	5	12
Nebraska	---	---	847	682	---	---	W	W	---	---
Nevada	(1)	1	111	116	10	11	135	72	10	10
New Hampshire	---	---	551	268	20	7	60	42	---	---
New Jersey	---	---	1,358	578	---	---	38	42	---	---
New Mexico	---	---	W	W	---	---	---	---	5	7
New York	---	---	1,406	746	2,975	1,238	524	482	637	320
North Carolina	W	W	127	92	553	342	26	29	477	157
North Dakota	---	---	142	138	---	---	1	1	---	---
Ohio	---	---	1,413	929	---	---	361	365	---	---
Oklahoma	W	W	365	133	---	---	194	145	---	---
Oregon	W	W	359	279	3	2	39	W	450	366
Pennsylvania	---	---	24	20	---	---	W	W	52	79
Rhode Island	---	---	W	W	---	---	W	W	---	---
South Carolina	---	---	135	W	---	---	W	W	---	---
South Dakota	---	---	43	21	11	11	---	---	10	5
Tennessee	---	---	W	W	---	---	---	---	---	---
Texas	---	---	865	514	---	---	452	630	---	---
Utah	24	20	128	64	129	111	W	W	---	---
Vermont	---	---	W	W	---	---	W	W	35	14
Virginia	---	---	634	305	34	13	53	55	---	---
Washington	1	1	821	456	---	---	276	443	423	558
West Virginia	---	---	W	W	---	---	W	W	---	---
Wisconsin	W	W	1,860	1,005	472	189	W	W	129	54
Wyoming	---	---	48	52	9	2	---	---	---	---
Undistributed	329	326	3,132	1,893	---	---	1,119	1,122	---	---
Total	412	382	30,499	17,426	11,747	8,737	7,280	7,920	2,738	1,836
American Samoa	---	---	---	---	---	---	---	---	---	---
Panama Canal Zone	---	---	---	---	---	---	54	87	---	---
Puerto Rico	---	---	960	817	485	410	---	---	---	---

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Less than ½ unit.
[2] Includes unspecified.

Table 4.—Sand and gravel sold or used by producers in the United States in 1967, by States, uses and classes of operations—Continued

(Thousand short tons and thousand dollars)

State	Sand, industrial (commercial)—Continued									
	Glass		Molding		Grinding and polishing		Blast		Fire or furnace	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	---	---	W	W	---	---	---	---	---	---
Alaska	---	---	---	---	---	---	---	---	---	---
Arizona	---	---	---	---	---	---	W	W	---	---
Arkansas	W	W	W	W	W	W	---	---	---	---
California	W	W	W	W	---	---	262	$1,152	W	W
Colorado	---	---	---	---	---	---	3	11	W	W
Connecticut	---	---	1	$1	W	W	---	---	---	---
Delaware	---	---	---	---	---	---	---	---	---	---
Florida	W	W	W	W	---	---	54	403	---	---
Georgia	W	W	W	W	---	---	W	W	---	---
Hawaii	---	---	---	---	---	---	8	23	---	---
Idaho	W	W	---	---	---	---	W	W	---	---
Illinois	1,999	$4,313	1,036	3,571	W	W	W	W	---	---
Indiana	W	W	W	W	---	---	W	W	W	W
Iowa	---	---	W	W	---	---	W	W	---	---
Kansas	---	---	---	---	---	---	8	W	---	---
Kentucky	---	---	---	---	---	---	---	---	---	---
Louisiana	---	---	---	---	---	---	W	W	---	---
Maine	W	W	---	---	W	W	---	---	---	---
Maryland	---	---	---	---	---	---	---	---	---	---
Massachusetts	---	---	118	578	---	---	7	68	---	---
Michigan	W	W	3,231	6,198	---	---	W	W	---	---
Minnesota	W	W	W	W	---	---	W	W	---	---
Mississippi	---	---	W	W	---	---	---	---	---	---
Missouri	W	W	W	W	W	W	W	W	---	---
Montana	---	---	---	---	---	---	1	2	---	---
Nebraska	---	---	---	---	---	---	---	---	---	---
Nevada	W	W	W	W	---	---	---	---	W	W
New Hampshire	---	---	---	---	---	---	---	---	---	---
New Jersey	1,031	4,136	1,672	5,269	---	---	150	705	W	W
New Mexico	---	---	---	---	---	---	(1)	W	---	---
New York	---	---	W	W	---	---	---	---	---	---
North Carolina	---	---	---	---	---	---	W	W	---	---
North Dakota	---	---	---	---	---	---	---	---	---	---
Ohio	W	W	475	2,093	---	---	W	W	138	$423
Oklahoma	W	W	W	W	---	---	W	W	---	---
Oregon	---	---	1	4	---	---	---	---	---	---
Pennsylvania	W	W	157	461	W	W	W	W	71	223
Rhode Island	---	---	W	W	---	---	---	---	---	---
South Carolina	W	W	W	W	---	---	10	50	W	W
South Dakota	---	---	---	---	---	---	---	---	---	---
Tennessee	W	W	319	992	W	W	---	---	---	---
Texas	W	W	148	436	---	---	269	1,998	W	W
Utah	---	---	W	W	---	---	W	W	W	W
Vermont	---	---	---	---	---	---	---	---	---	---
Virginia	W	W	---	---	---	---	---	---	---	---
Washington	---	---	(1)	W	---	---	W	W	---	---
West Virginia	W	W	W	W	---	---	W	W	W	W
Wisconsin	W	W	995	2,859	---	---	37	131	---	---
Wyoming	---	---	---	---	---	---	---	---	---	---
Undistributed	5,907	20,527	1,306	4,472	639	1,482	338	1,899	287	481
Total	8,937	28,976	9,459	26,934	639	1,482	1,147	6,442	496	1,127
American Samoa	---	---	---	---	---	---	---	---	---	---
Panama Canal Zone	---	---	---	---	---	---	---	---	---	---
Puerto Rico	---	---	---	---	---	---	---	---	---	---

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Less than ½ unit.

Table 4.—Sand and gravel sold or used by producers in the United States in 1967, by States, uses, and classes of operations—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	------	-------
Alaska	---	------	----	----	----	------	------	------	------	-------
Arizona	1	$9	----	----	W	W	------	------	------	-------
Arkansas	---	------	----	----	----	------	W	W	W	W
California	54	153	W	W	----	------	55	$230	W	W
Colorado	8	30	----	----	----	------	------	------	------	-----
Connecticut	---	------	W	W	----	------	------	------	------	-------
Delaware	W	W	----	----	----	------	------	------	------	-------
Florida	W	W	W	W	----	------	W	W	W	W
Georgia	W	W	W	W	----	------	W	W	5	$48
Hawaii	---	------	----	----	----	------	4	19	------	-------
Idaho	---	------	W	W	----	------	------	------	W	W
Illinois	W	W	W	W	W	W	W	W	W	W
Indiana	W	W	----	----	----	------	W	W	W	W
Iowa	---	------	W	W	----	------	------	------	------	-------
Kansas	27	35	3	W	----	------	W	W	124	W
Kentucky	10	10	----	----	----	------	2	5	------	-------
Louisiana	W	W	W	W	----	------	------	------	W	W
Maine	W	W	----	----	----	------	W	W	------	-------
Maryland	---	------	----	----	----	------	W	W	------	-------
Massachusetts	---	------	7	$18	----	------	------	------	------	-------
Michigan	W	W	----	----	----	------	W	W	W	W
Minnesota	W	W	----	----	W	W	------	------	W	W
Mississippi	---	------	----	----	----	------	------	------	------	-------
Missouri	W	W	W	W	----	------	W	W	261	W
Montana	---	------	----	----	----	------	------	------	------	-------
Nebraska	---	------	----	----	----	------	1	1	------	-------
Nevada	---	------	----	----	----	------	W	W	------	-------
New Hampshire	W	W	----	----	----	------	W	W	------	-------
New Jersey	W	W	W	W	W	W	212	895	W	W
New Mexico	---	------	----	----	----	------	------	------	------	-------
New York	W	W	W	W	----	------	------	------	W	W
North Carolina	---	------	W	W	----	------	------	------	------	-------
North Dakota	---	------	----	----	----	------	------	------	------	-------
Ohio	W	W	W	W	----	------	268	686	W	W
Oklahoma	W	W	----	----	(1)	W	W	W	W	W
Oregon	18	21	----	----	----	------	W	W	------	-------
Pennsylvania	W	W	----	----	----	------	207	486	W	W
Rhode Island	---	------	----	----	----	------	------	------	------	-------
South Carolina	W	W	W	W	----	------	W	W	W	W
South Dakota	---	------	----	----	----	------	------	------	------	-------
Tennessee	W	W	----	----	----	------	W	W	------	-------
Texas	W	W	----	----	W	W	W	W	135	530
Utah	W	W	----	----	----	------	------	------	------	-------
Vermont	W	W	----	----	----	------	------	------	------	-------
Virginia	W	W	----	----	----	------	W	W	W	W
Washington	---	------	----	----	----	------	------	------	------	-------
West Virginia	W	W	(1)	W	----	------	W	W	W	W
Wisconsin	W	W	W	W	W	W	------	------	------	-------
Wyoming	---	------	----	----	----	------	------	------	------	-------
Undistributed	698	1,493	191	554	190	$1,328	1,199	3,938	965	10,405
Total	816	1,751	201	572	190	1,328	1,948	6,260	1,490	10,983
American Samoa	---	------	----	----	----	------	------	------	------	-------
Panama Canal Zone	---	------	----	----	----	------	------	------	------	-------
Puerto Rico	---	------	----	----	----	------	------	------	------	-------

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Less than ½ percent.

Table 4.—Sand and gravel sold or used by producers in the United States in 1967, by States, uses, and classes of operations—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	2,286	$2,929	-----	-----	747	$862	1	$2
Alaska	54	234	-----	-----	192	496	1,207	3,658
Arizona	1,775	2,569	-----	-----	1,892	2,075	6,539	6,071
Arkansas	1,431	2,217	-----	-----	4,214	5,275	2,640	1,653
California	20,739	25,596	129	$219	28,757	34,939	10,151	10,856
Colorado	2,353	3,132	36	45	5,144	5,640	8,727	8,356
Connecticut	1,288	2,316	-----	-----	794	981	1,374	499
Delaware	248	409	-----	-----	1,084	799	-------	-------
Florida	W	W	-----	-----	-------	-------	-------	-------
Georgia	W	W	-----	-----	W	W	-------	-------
Hawaii	28	83	-----	-----	41	121	-------	-------
Idaho	244	310	20	27	1,276	1,143	7,880	8,588
Illinois	6,936	6,519	-----	-----	9,500	9,707	722	466
Indiana	3,263	3,983	-----	-----	8,154	8,597	873	510
Iowa	1,361	2,289	-----	-----	6,699	5,778	2,249	1,426
Kansas	309	337	-----	-----	1,180	1,014	1,954	1,029
Kentucky	755	942	62	65	1,082	1,370	412	232
Louisiana	6,174	8,799	-----	-----	4,848	7,073	96	96
Maine	211	215	-----	-----	672	807	7,320	2,661
Maryland	2,724	4,971	-----	-----	2,267	2,931	130	61
Massachusetts	2,973	4,461	-----	-----	3,098	3,416	3,115	2,918
Michigan	6,585	9,198	-----	-----	16,604	14,514	5,301	3,225
Minnesota	3,254	5,387	3	2	17,943	13,802	7,708	4,882
Mississippi	1,416	1,525	-----	-----	7,227	7,759	159	423
Missouri	1,808	2,269	-----	-----	1,737	1,883	64	66
Montana	512	686	4	5	1,437	1,134	7,650	6,405
Nebraska	1,174	1,158	15	8	5,230	5,073	863	789
Nevada	380	752	1	1	1,084	1,104	6,633	3,257
New Hampshire	646	833	-----	-----	820	914	2,661	1,068
New Jersey	2,862	5,196	-----	-----	1,532	1,938	14	5
New Mexico	864	1,354	-----	-----	1,133	1,415	11,048	9,878
New York	4,969	7,395	-----	-----	4,217	4,804	6,483	6,885
North Carolina	901	1,652	-----	-----	1,498	1,784	491	356
North Dakota	333	647	-----	-----	2,520	2,600	3,064	2,955
Ohio	7,357	8,882	-----	-----	12,959	16,478	127	46
Oklahoma	126	222	26	29	77	86	395	275
Oregon	2,348	2,856	204	292	5,670	6,857	5,728	9,965
Pennsylvania	2,562	4,141	-----	-----	4,147	6,639	-------	-------
Rhode Island	580	775	-----	-----	475	574	-------	-------
South Carolina	1,392	W	-----	-----	W	W	-------	-------
South Dakota	472	672	-----	-----	1,384	1,596	8,774	8,620
Tennessee	876	1,084	-----	-----	1,813	1,796	747	557
Texas	7,726	11,462	10	14	5,084	6,212	4,817	4,793
Utah	1,241	1,216	86	43	1,138	1,089	4,147	3,707
Vermont	319	446	-----	-----	356	383	1,512	534
Virginia	1,433	2,739	-----	-----	2,307	3,157	162	204
Washington	3,756	4,662	260	319	5,842	5,687	7,621	6,213
West Virginia	1,500	1,880	-----	-----	909	1,411	-------	-------
Wisconsin	4,742	4,180	4	2	16,115	12,502	6,707	4,015
Wyoming	156	221	3	3	627	633	4,086	4,042
Undistributed	385	3,460	-----	-----	363	681	-------	-------
Total	117,827	159,261	863	1,074	203,889	217,529	152,352	132,247
American Samoa	-------	-------	-----	-----	-------	-------	-------	-------
Panama Canal Zone	-------	-------	-----	-----	2	7	-------	-------
Puerto Rico	2,779	5,108	9	13	3,006	4,428	265	371

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

Table 4.—Sand and gravel sold or used by producers in the United States in 1967, by States, uses, and classes of operations

(Thousand short tons and thousand dollars)

State	Gravel, construction—Continued										Gravel miscellaneous (commercial)	
	Railroad ballast (commercial)		Fill				Other					
			Commercial		Government-and-contractor		Commercial		Government-and-contractor			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	-----	-----	W	W	------	------	W	W	-----	-----	207	$256
Alaska	6	$14	1,472	$721	14,027	$13,979	2	$6	-----	-----	-----	-----
Arizona	W	W	737	421	83	62	W	W	-----	-----	30	49
Arkansas	-----	-----	21	12	------	------	70	73	-----	-----	-----	-----
California	251	279	1,458	1,542	1,634	1,235	3,674	4,486	123	$132	470	644
Colorado	24	22	452	298	955	767	-----	-----	4	2	318	416
Connecticut	W	W	407	210	94	58	W	W	-----	-----	133	164
Delaware	-----	-----	W	W	------	------	W	W	-----	-----	-----	-----
Florida	-----	-----	W	W	------	------	-----	-----	-----	-----	-----	-----
Georgia	-----	-----	W	W	------	------	W	W	-----	-----	-----	-----
Hawaii	-----	-----	(1)	1	------	------	-----	-----	-----	-----	-----	-----
Idaho	-----	-----	93	62	1,006	526	144	129	65	37	3	4
Illinois	250	252	1,260	713	------	------	-----	-----	-----	-----	-----	-----
Indiana	19	18	2,388	1,469	7	4	7	10	-----	-----	-----	-----
Iowa	44	36	164	103	------	------	18	15	-----	-----	-----	-----
Kansas	W	W	28	31	------	------	24	36	-----	-----	35	41
Kentucky	W	W	W	W	------	------	-----	-----	-----	-----	3	1
Louisiana	-----	-----	W	W	------	------	W	W	-----	-----	-----	-----
Maine	W	W	126	69	3	1	W	W	3	1	W	W
Maryland	-----	-----	823	509	60	42	W	W	-----	-----	W	W
Massachusetts	-----	-----	1,093	699	5	3	132	196	2	3	504	420
Michigan	W	W	419	300	364	158	W	W	-----	-----	-----	-----
Minnesota	180	114	1,174	486	179	78	15	16	-----	-----	-----	-----
Mississippi	W	W	36	31	------	------	172	329	-----	-----	79	110
Missouri	8	4	116	67	------	------	W	W	-----	-----	102	83
Montana	131	173	181	139	848	374	91	122	29	31	-----	-----
Nebraska	W	W	34	29	------	------	1	1	-----	-----	177	186
Nevada	1	2	222	225	132	130	2	2	33	31	357	532
New Hampshire	-----	-----	204	100	------	------	47	58	-----	-----	112	98
New Jersey	-----	-----	558	501	2	1	W	W	-----	-----	W	W
New Mexico	-----	-----	89	45	226	114	-----	-----	-----	-----	48	56
New York	W	W	2,704	1,656	4,636	2,936	W	W	121	51	372	311
North Carolina	W	W	W	W	------	------	-----	-----	-----	-----	604	1,488
North Dakota	111	46	101	72	------	------	-----	-----	-----	-----	41	46
Ohio	W	W	2,035	1,182	77	37	W	W	-----	-----	574	686
Oklahoma	-----	-----	------	------	------	------	2	1	-----	-----	-----	-----
Oregon	W	W	445	251	158	114	52	58	2,498	1,850	29	18
Pennsylvania	W	W	343	214	------	------	85	120	-----	-----	W	W
Rhode Island	-----	-----	283	150	------	------	W	W	-----	-----	W	W
South Carolina	1	W	------	------	------	------	-----	-----	-----	-----	25	W
South Dakota	4	3	78	64	10	9	1	1	1	1	31	37
Tennessee	W	W	27	29	90	50	W	W	-----	-----	W	W
Texas	1	1	302	186	6	3	256	488	-----	-----	86	190
Utah	18	15	260	136	473	315	-----	-----	-----	-----	84	88
Vermont	-----	-----	W	W	------	------	W	W	-----	-----	W	W
Virginia	-----	-----	W	W	6	11	W	W	-----	-----	W	W
Washington	150	103	1,807	1,090	553	289	1,255	1,600	1,495	1,923	W	W
West Virginia	W	W	W	W	------	------	-----	-----	-----	-----	-----	-----
Wisconsin	169	101	1,655	808	499	195	1	1	-----	-----	-----	-----
Wyoming	-----	-----	41	25	12	9	-----	-----	-----	-----	52	44
Undistributed	497	536	1,154	690	------	------	2,661	3,233	-----	-----	872	974
Total	1,865	1,719	24,790	15,336	26,145	21,500	8,712	10,981	4,374	4,062	5,348	6,942
American Samoa	-----	-----	------	------	------	------	-----	-----	-----	-----	-----	-----
Panama Canal Zone	-----	-----	------	------	------	------	-----	-----	-----	-----	-----	-----
Puerto Rico	-----	-----	577	490	174	146	-----	-----	-----	-----	-----	-----

W Withheld to avoid disclosing individual confidential data; included with "Undistributed."
[1] Less than ½ unit.

Table 5.—Sand and gravel sold or used by Government-and-contractor producers in the United States, by uses

(Thousand short tons and thousand dollars)

Year	Sand							
	Building		Paving		Fill		Other	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1963	728	$882	33,285	$23,840	7,076	$3,124	1,433	$668
1964	950	1,401	34,262	26,999	6,335	2,935	1,811	882
1965	316	328	37,460	29,695	14,824	7,112	2,722	2,038
1966	808	943	37,087	29,702	12,920	8,430	1,663	927
1967	660	800	38,682	31,736	11,747	8,737	2,738	1,836

Year	Gravel								Total government-and-contractor sand and gravel[1]	
	Building		Paving		Fill		Other			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1963	4,110	$4,091	157,671	$132,829	26,379	$21,476	497	$366	231,179	$187,276
1964	3,515	3,946	163,872	139,297	35,870	18,030	772	551	247,387	194,041
1965	1,297	1,028	149,111	133,800	45,143	35,410	1,292	1,347	252,165	210,758
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	152,352	132,247	26,145	21,500	4,374	4,062	237,561	201,970

[1] 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 producer

(Thousand short tons and thousand dollars)

Type of producer	1963		1964		1965		1966		1967[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction and maintenance crews	57,546	$35,945	64,820	$41,451	62,822	$39,611	67,163	$43,821	68,655	$44,903
Contractor	173,633	151,331	182,567	152,590	189,343	171,147	187,721	164,201	168,906	157,085
Total	231,179	187,276	247,387	194,041	252,165	210,758	254,884	208,022	237,561	201,970
State	146,053	124,138	157,136	130,651	159,758	144,287	150,304	131,921	147,960	133,980
Counties	57,493	39,728	60,764	41,151	59,730	40,987	60,966	41,973	60,004	41,390
Municipalities	3,928	3,436	3,363	2,500	3,278	2,343	2,916	2,576	3,001	2,202
Federal agencies	23,705	19,974	26,124	19,739	29,399	23,141	40,698	31,552	26,596	24,398
Total	231,179	187,276	247,387	194,041	252,165	210,758	254,884	208,022	237,561	201,970

[1] 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 degrees of preparation

(Thousand short tons and thousand dollars)

	1966		1967 [1]	
	Quanity	Value	Quantity	Value
Commercial operations:				
Prepared	617,180	$738,858	609,039	$743,462
Unprepared	62,417	38,102	58,562	34,902
Total	679,597	776,960	667,601	778,364
Government-and-contractor operations:				
Prepared	187,348	162,442	180,556	160,108
Unprepared	67,536	45,580	57,005	41,880
Total	254,884	208,022	237,561	201,970
Grand total	934,481	984,982	905,162	980,356

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

Table 8.—Number and production of domestic commercial sand and gravel plants by size of operation

Annual production (short tons)	1966				1967			
	Plants [1]		Production		Plants [1]		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	2,544	40.8	26,162	3.8	2,609	41.3	26,032	3.9
25,000 to 50,000	970	15.6	35,259	5.2	949	15.0	35,164	5.3
50,000 to 100,000	957	15.3	69,457	10.2	1,016	16.1	74,142	11.1
100,000 to 200,000	841	13.5	120,711	17.8	804	12.7	115,065	17.2
200,000 to 300,000	382	6.1	94,052	13.3	400	6.3	96,901	14.5
300,000 to 400,000	190	3.0	65,048	10.1	201	3.2	69,570	10.4
400,000 to 500,000	116	1.9	52,737	7.8	101	1.6	45,129	6.8
500,000 to 600,000	62	1.0	32,929	4.8	67	1.1	36,928	5.5
600,000 to 700,000	41	.7	26,945	4.0	32	.5	21,053	3.2
700,000 to 800,000	25	.4	18,979	2.8	36	.6	26,852	4.0
800,000 to 900,000	24	.4	20,658	3.0	25	.4	21,300	3.2
900,000 to 1,000,000	15	.2	14,187	2.1	20	.3	19,056	2.9
1,000,000 and over	69	1.1	102,473	15.1	55	.9	80,409	12.0
Total	6,236	100.0	679,597	100.0	6,315	100.0	667,601	100.0

[1] Includes a few companies operating more than 1 plant but not submitting separate returns for individual plants.

Table 9.—Sand and gravel sold or used in the United States, by classes of operation and method of transportation

	1966		1967	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Commercial:				
Truck	590,197	63	573,765	63
Rail	54,240	6	57,799	7
Waterway	32,596	4	32,979	4
Unspecified	2,564	(1)	3,058	(1)
Total commercial	679,597	73	667,601	74
Government-and-contractor: Truck: [2]	254,884	27	237,561	26
Grand total	934,481	100	905,162	100

[1] Less than 0.5 percent.
[2] 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] by uses

(Thousand short tons and thousand dollars)

Use	1966 Quantity	1966 Value	1967 Quantity	1967 Value
Abrasives	238	$2,222	302	$1,844
Chemicals	33	326	39	377
Enamel	14	162	12	132
Filler	123	1,230	120	1,061
Foundry uses	181	1,534	140	1,115
Glass	225	1,183	334	1,337
Pottery, porcelain, and tile	219	2,320	256	2,580
Unspecified	180	1,826	287	2,537
Total	1,213	10,803	1,490	10,983

[1] Arkansas, California, Florida (1967 only), Georgia, Idaho (1967 only), Illinois, Indiana, Kansas, Louisiana, Maryland (1967 only), Michigan, Minnesota, Missouri, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota (1966 only), Texas, Utah (1966 only), Virginia, Washington (1966 only), and West Virginia.

Table 11.—U.S. imports for consumption of sand and gravel by classes

(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
1965	11	$39	678	$840	689	$879
1966	18	95	631	811	649	906
1967	44	159	588	753	632	912

[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 Gilbert L. Dehuff [1]

Several producers of ferrosilicon and metallurgical silicon metal were engaged in plant modernization and/or expansion, or were reaping the benefits of recently completed undertakings of this type. The same was true for two large producers of high-purity silicon for electronic applications. Sales of silicon transistors increased and silicon was in greater demand than germanium for this use in both 1966 and 1967.

DOMESTIC PRODUCTION

Producers of either polycrystal or monocrystal high-purity silicon, or both, included the following: Dow Corning Corp.; Fairchild Semiconductor, Division of Fairchild Camera & Instrument Corp.; Mallinckrodt Chemical Works; Monsanto Chemical Co.; Motorola, Inc.; and Texas Instruments, Inc. Both Dow Corning and Monsanto continued to expand their production facilities.

On August 31, 1967, Vanadium Corporation of America merged with Foote Mineral Co. to become the latter's Vancoram Operations with its Keokuk Electro-Metals Co. Division becoming Foote's Kemco Division. About October 1, National Metallurgical Corp. became an operating subsidiary of Kawecki Chemical Co. Immediately prior to that time it had been a division of Apex Smelting Co., a unit of Amax Aluminum Co. Division, American Metal Climax, Inc. Pittsburgh Metallurgical Co., a division of Air Reduction Co., changed its name to Airco Alloys in order to better identify with the parent company.

In June 1967 at Beverly, Ohio, the Globe Metallurgical Division, Interlake Steel Corp., doubled its capacity to produce silicon metal by putting into production its large new No. 7 furnace. Late in the year, Foote Mineral Co.'s Vancoram Operations brought into production a new 54,700-kilovolt-ampere ferrosilicon furnace at Graham, W. Va. Ohio Ferro-Alloys Corp. was another producer of silicon alloys and metal to increase capacity and obtain cost benefits from new furnace additions at its plants. The

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Production, shipments, and stocks of silvery pig iron, ferrosilicon, and silicon metal in 1967 [1]

(Short tons, gross weight)

Alloy Type	Silicon content (percent)	Producers' stocks as of Dec. 31, 1966	Production	Shipments	Producers' stocks as of Dec. 31, 1967
Silvery pig iron	5–20	r 40,281	219,945	210,342	49,907
Ferrosilicon	21–55	28,056	346,366	327,808	48,172
Do	56–70	2,790	43,824	37,996	9,054
Do	71–80	8,308	84,664	76,989	17,127
Do	81–89	2,217	36,012	34,223	4,283
Do	90–95	262	753	623	391
Silicon metal	96–99	2,811	88,748	85,703	5,856
Ferrosilicon briquets	40–50	1,773	60,930	58,093	4,610
Miscellaneous silicon alloys	------	3,566	27,601	26,372	4,795

r Revised.
[1] Excludes ferrosilicon used to make other silicon alloys.

largest was a 60,000-kilovolt-ampere rotating-hearth furnace at Philo, Ohio.

Airco Alloys and Union Carbide Corp. each announced new ferroalloy casting processes designed to improve density, minimize fines, and facilitate sizing with resultant lower costs for the consumer. Ferrosilicon appeared to be a particular beneficiary.

Producers of metallurgical silicon metal were Airco Alloys; Kemco Division, and Vancoram Operations, Foote Mineral Co.; Globe Metallurgical Division, Interlake Steel Corp.; National Metallurgical Corp.; Ohio Ferro-Alloys Corp.; Reynolds Metals Co.; and Mining and Metals Division, Union Carbide Corp.

CONSUMPTION AND USES

For the second consecutive year, sales of silicon transistors exceeded those of germanium, the spread between the two almost doubling in 1967 in spite of the fact that high-purity silicon transistor sales increased only slightly that year. The trend toward integrated circuits continued. The principal use of metallurgical silicon metal (96 to 99 percent silicon) continued to be for additions to aluminum and for production of silicon chemicals from which silicones and high-purity silicon metal were derived. Steel, high-temperature and super alloys, copper base alloys, and electrical contact materials were other uses. Ferrosilicon was used primarily for deoxidizing steel, to produce silicon alloy steels, and for iron castings. However, it also served in the thermic reduction of nickel and of magnesium. The greater part of silvery pig iron was consumed by the iron foundries, but a sizable quantity was also used in the manufacture of steel. Use of silicon carbide as an auxiliary fuel in basic oxygen steel furnaces was said to permit a higher percentage of scrap in the feed for these furnaces. The carbide continued to be used otherwise as a deoxidizer in production of steel.

Table 2.—Consumption and consumer stocks of silicon alloys and metal in the United States in 1967

(Short tons, gross weight)

Material	Silicon content (percent)	Stocks Dec. 31, 1966	Consumption	Stocks Dec. 31, 1967
Silvery pig iron	5–20	32,877	181,560	20,470
Ferrosilicon	[1] 21–55	24,660	286,132	21,563
Do	56–70	1,681	24,314	1,236
Do	71–80	6,360	68,196	5,708
Do	81–90	1,195	7,925	1,094
Do	91–95	669	2,746	415
Silicon metal	96–99	4,746	56,156	4,338
Ferrosilicon briquets	40–50	5,021	34,409	6,905
Miscellaneous silicon alloys [2]	------	4,701	44,525	4,076

[1] Mainly from 40 to 55 percent silicon.
[2] Includes calcium-silicon, calcium-manganese-silicon, silicon-manganese-zirconium, Ferrocarbo (including briquets), Alsifer, silicon carbide, magnesium-ferrosilicon, and other miscellaneous silicon alloys.

PRICES

The price for the 50-percent grade of ferrosilicon remained unchanged throughout 1967 at 13.1 cents per pound of contained silicon, f.o.b. shipping point, freight equalized to nearest main producer, carload lots, lump, bulk. This price was set at the beginning of the second quarter of 1966 when it was increased from 12.7 cents, same basis. At this same time, the price of metallurgical-grade silicon metal of 0.35 percent maximum iron content dropped 0.2 cent to 18.05 cents per pound of contained silicon, at which price it remained to the end of 1967.

FOREIGN TRADE

Of the 11,774 short tons of ferrosilicon exported in 1967, West Germany took 6,822 tons, Canada 1,602 tons, and Mexico 1,357 tons. The remainder was divided among 18 other countries.

Table 3.—U.S. exports of ferrosilicon

Year	Short tons	Value (thousands)
1965	4,585	$1,755
1966	5,812	2,004
1967	11,774	3,228

Imports for consumption of high-purity silicon in 1967 totaled 19,213 kilograms valued at $2,126,359, or $111 per kilogram. Percentage contributions on a weight basis were from West Germany, 84; Japan, 9; Canada, 4; Switzerland, 2; and the remainder from Italy, France, United Kingdom, Denmark, and Belgium-Luxembourg, in that order. The total imported in 1966 was 21,144 kilograms, valued at $3,035,607, or $144 per kilogram, with West Germany supplying 78 percent and Japan 21 percent of the total weight.

Table 4.—U.S. imports for consumption of ferrosilicon and silicon metal, by grades and countries

	1965			1966			1967		
	Short tons		Value (thousands)	Short tons		Value (thousands)	Short tons		Value (thousands)
	Gross weight	Silicon content		Gross weight	Silicon content		Gross weight	Silicon content	
Ferrosilicon:									
8 percent and less than 60 percent silicon:									
Canada	12,281	2,022	$744	14,121	2,469	$811	10,673	1,846	$621
France	11	6	3	483	259	149	215	116	67
Germany, West	523	78	87	949	432	258	502	242	144
Japan	1,203	556	397	2,321	1,089	631	2,621	1,265	698
Norway	-----	------	------	------	------	------	552	247	180
Total	14,018	2,662	1,231	17,874	4,249	1,849	14,563	3,716	1,710
60 percent and not more than 80 percent silicon:									
France	1,379	1,054	220	3,867	2,573	1,011	5,493	3,922	1,093
Germany, West	-----	------	------	2,416	1,480	797	887	545	306
India	-----	------	------	------	------	------	110	87	14
Norway	916	697	125	5,013	3,852	743	6,601	5,018	941
Portugal	-----	------	------	------	------	------	27	21	4
South Africa, Republic of	112	87	15	901	697	133	549	420	84
Sweden	-----	------	------	------	------	------	1,918	1,450	263
Total	2,407	1,838	360	12,197	8,602	2,684	15,585	11,463	2,705
Over 80 percent but not over 90 percent silicon:									
Canada	-----	------	------	55	46	15	------	------	------
Italy	68	58	15	224	192	53	185	158	41
Norway	-----	------	------	55	44	9	------	------	------
Total	68	58	15	334	282	77	185	158	41
Grand total	16,493	4,558	1,606	30,405	13,133	4,610	30,333	15,337	4,456
Silicon metal:									
Canada	-----	------	------	1,439	1,337	128	------	------	------
Germany, West	(1)	(1)	(1)	------	------	------	------	------	------
Italy	-----	------	------	(1)	(1)	1	39	38	15
Japan	-----	------	------	------	------	------	5	5	1
Norway	-----	------	------	86	79	25	------	------	------
Sweden	-----	------	------	55	54	15	------	------	------
Total	(1)	(1)	(1)	1,580	1,470	169	44	43	16

[1] Less than ½ unit.

Tariff.—Presidential Proclamation 3822, signed December 16, 1967, authorized tariff reductions proposed by the Kennedy Round of negotiations earlier in the year. "Column 1" or "favored nation" rates of duty (applicable to most countries) for the calendar year 1968 for various grades of ferrosilicon and silicon metal became effective January 1 as follows:

TSUS No.	*Item*	*1967 rate*	*1968 rate*
607.50	Ferrosilicon, 8 to 60 percent silicon	0.72 cent per lb. Si content	0.5 cent per lb. Si content
607.51	Ferrosilicon, 60 to 80 percent silicon	0.84 cent per lb. Si content	0.75 cent per lb. Si content
607.52	Ferrosilicon, 80 to 90 percent silicon	2 cents per lb. Si content	1.8 cent per lb. Si content
607.53	Ferrosilicon, over 90 percent silicon	4 cents per lb. Si content	3.6 cents per lb. Si content
632.42	Silicon metal, not over 99.7 percent silicon.	4 cents per lb. Si content	3.6 cents per lb. Si content
632.43	Silicon metal, over 99.7 percent silicon.	10.5 percent ad valorem	9 percent ad valorem

These will be stepped down annually until January 1, 1972, when the 8- to 60-percent grade of ferrosilicon will be free of duty and the duty on the other items will be half or roughly half that effective in 1967.

WORLD REVIEW

Canada.—Plans for a 7,000-ton-per-year silicon metal smelter to be erected at Chicoutimi, Quebec, by Chicoutimi Silicon Ltd. were changed to provide for a 25,000- to 35,000-ton-per-year ferrosilicon smelter instead. Union Carbide Canada Ltd. replaced Metal Mines Ltd. as one of the four owners, and assumed responsibility for manufacture and sales. Quartzite or sandstone from its quarry at Melocheville, Quebec, will provide the necessary silicon, and plans called for export of much of the ferrosilicon product. Aluminum Company of Canada Ltd., one of the four partners, will continue to purchase its silicon metal requirements from Union Carbide's Beauharnois, Quebec, plant and elsewhere.

Japan.—Fuji Iron and Steel's subsidiary, Nippon Denko KK, was reported to be increasing its capacity to produce silicon metal by 4,000 to 5,000 tons per year by installation of an 8,000-to 9,000-kilovolt-ampere furnace at its Fukushima works. The company's production for the 1967 fiscal year was estimated to be 10,000 tons; that of Showa Denko and Shin-Etsu Chemical Industry Co., each 4,500 tons; and Tekkosha, 2,000 tons. Consumption for the same period was expected to be 22,000 to 23,000 tons, an increase of 10 percent due largely to increased demand from the Japanese aluminum industry.[2]

Dow Corning International Ltd. joined with Toyo Rayon Co., Ltd., in 1966 on an equal participation basis to form Toray Silicone Co., Ltd., for the purpose of producing and selling silicone products. The two established Japanese producers, Shin-Etsu Chemical Industry and Tokyo Shibaura Electric (Toshiba), both held Dow Corning and General Electric patent licenses. Dow Corning International also was reported as seeking the approval of the Japanese Government for a joint venture with Shin-Etsu to produce and sell high-purity silicon of semiconductor grade. Shin-Etsu was to have a 55-percent interest and Dow Corning 45 percent.[3]

Korea, South.—Korean Electric Ferro-Alloy Co., a quasi-government concern producing ferromanganese at Seoul, placed a contract with a Japanese firm for an electric furnace that will produce ferrosilicon at a 5,000-ton-per-year rate.[4]

Norway.—A/S Hafslund was reported to be doubling its production capacity of ferrosilicon by installation of a new 30,000-kilovolt-ampere furnace at its Sarpsborg plant. Elektrokemish A/S was reported to

[2] Metal Bulletin (London). No. 5248, Nov. 14, 1967, p. 27.
[3] Chemical & Engineering News. V. 44, No. 53, Dec. 26, 1966, pp. 10–11.
[4] Metal Bulletin (London). No. 5086, Apr. 1, 1966, p. 20.

have placed its new Salten Verk smelter, at Fauske in the northern part of the country, in operation in the first half of 1967. The furnace, claimed to be the largest of its kind in Europe, had capacity to produce 24,000 tons of ferrosilicon per year. In 1966, the company took over control of Porsgrunn Elektrometallurgiske A/S which has been in operation since 1915 and is a producer of ferrosilicon, silicomanganese, and ferromanganese. Because of air pollution problems in the densely populated area at Porsgrunn, ferrosilicon production will be shifted to the large modern furnaces of Elektrokemish A/S at its Fiskaa Verk and Salten Verk plants. Plans for Porsgrunn called for installation of a large new closed silicomanganese furnace.

United Kingdom.—At its Ruabon (Denbighshire) plant, Monsanto Chemicals Ltd. planned an increase of 1,000 kilograms in annual capacity to produce high-purity silicon rods up to 40 millimeters in diameter by the float-zone method. The plant output includes other high-purity silicon products.[5]

[5] Metal Bulletin (London). No. 5246, Nov. 7, 1967, p. 24.

Silver

By J. Patrick Ryan [1]

The domestic silver situation in 1967 featured a sharp falloff in mine and refinery production attributed to the copper strikes, and a rise in the New York price of silver to a record high following the termination of Treasury sales at $1.29 per ounce.

Domestic industrial consumption of silver dropped appreciably from its 1966 peak, and coinage consumption continued its downward trend from the record level of 1965. Heavy withdrawals for commercial use and coinage reduced the Treasury bullion stock to 348.3 million ounces at yearend. The New York Commodity Exchange showed record highs for trading volume, price levels, and bullion stocks.

The United States for the second consecutive year was a net exporter of silver, as outflow to foreign countries exceeded inflow.

World silver production declined owing largely to the falloff of output in the United States and Mexico. Free-world consumption of silver for industrial use and coinage dropped appreciably. Speculative holdings and inventory accumulation rose to a record high.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient silver statistics

	1963	1964	1965	1966	1967
United States:					
Mine production ------- thousand troy ounces --	35,243	36,334	39,806	43,669	32,119
Value ------------------------ thousands --	$45,076	$46,980	$51,469	$56,464	$49,784
Ore (dry and siliceous) produced:					
Gold ore ----------- thousand short tons --	2,460	2,631	3,113	2,580	2,315
Gold-silver ore -------------------- do ----	223	224	205	248	157
Silver ore ------------------------ do ----	587	644	902	1,069	904
Percentage derived from—					
Dry and siliceous ores -------------------	33	32	35	33	39
Base-metal ores -----------------------	67	68	65	67	61
Refinery production ---- thousand troy ounces --	[6] 35,000	[6] 37,000	[6] 39,000	48,358	30,268
Exports [1] ---------------------------- do ----	31,485	109,395	39,665	85,538	70,769
Imports, general [1] -------------------- do ----	59,062	51,674	54,709	63,032	55,520
Stocks Dec. 31: Treasury [2] million troy ounces --	1,583	[r] 1,218	[r] 804	594	351
Consumption—industry and the arts thousand troy ounces --	110,000	123,000	137,000	183,696	171,031
Coinage ---------------------------- do ----	111,493	203,000	320,321	53,852	43,851
Price [3] ------------------- per troy ounce --	$1.279	$1.293	$1.293	$1.293	$1.550
World:					
Production ----------- thousand troy ounces --	249,982	248,551	256,362	266,564	260,820
Consumption [4]—industry and the arts thousand troy ounces --	[r] 260,700	[r] 304,200	[r] 346,600	390,200	377,400
Coinage [5] ---------------------------- do ----	167,000	264,500	[r] 380,600	[r] 106,400	78,200

[r] Revised.
[1] Excludes coinage.
[2] Includes silver in silver dollars.
[3] Average New York price.
[4] Free world only. Source: Handy & Harman, The Silver Market In 1963–65; Handy & Harman and U.S. Bureau of Mines 1966–67.
[5] Free world only.
[6] U. S. Bureau of the Mint.

Source: Handy & Harman, The Silver Market in 1963–67.

Legislation and Government Programs.—Treasury-sponsored legislation (H.R. 7476, S. 1352), enacted as Public Law 90–29 on June 24, 1967, authorized the Secretary of the Treasury to write off up to $200 million in silver certificates that were judged to have been destroyed or lost. The legislation also restricted the time in which silver certificates could be redeemed in silver to one year, ending June 24, 1968. The new law also directed the Secretary of the Treasury to hold 165 million ounces of silver in reserve for the strategic stockpile, and authorized the sale of any remaining silver at not less than $1.29 per ounce.

On recommendation of the newly-created Coinage Commission, which held its first meeting on May 18, and in response to the extraordinarily heavy demand for silver which threatened to exhaust the Treasury's remaining free stocks, the Treasury restricted future sales of silver to domestic users. The melting and export of silver coins was prohibited to assure a continual, orderly transition to the new coins.

On July 14, again on recommendations of the Coinage Commission, sales of silver at $1.29 per ounce were halted and future sales were limited to 2 million ounces per week on an auction basis.

A bill (H.R. 11386) prohibiting the further use of silver for coinage was introduced in Congress on July 12 and referred to the Banking and Currency Committee. No further action was taken.

Thirteen contracts for silver exploration totaling $1,235,620 were executed during the year under the financial assistance program administered by the Office of Minerals Exploration, U.S. Geological Survey. The Government provided about 75 percent of the exploration costs. The following exploration contracts for silver or silver-gold were active or in force at yearend:

Operator	*Location*	*Total Cost*
B.L.M.W. Mining Co	Madison County, Mont	$20,550
Resource Americas Corp	San Bernardino County, Calif	32,088
Spokane National Mines, Inc	Beaverhead County, Mont	33,880
P. W. Beckley	Culberson County, Tex	16,800
Betty O'Neal Silver, Inc	Lander County, Nev	90,240
Cardiff Industries, Inc	Salt Lake County, Utah	10,500
Mascot Mines, Inc	Jefferson County, Mont	28,200
Great Basin Exploration Co	Mineral County, Nev	33,000
Donald C. Gilbert	Santa Cruz, Ariz	14,000
Don H. Clair, et al	Esmeralda, Nev	44,200
Thomas F. Miller	Box Elder, Utah	78,800
Beardsley Gulch Mining Co	Custer, Mont	44,680
Busty Belle Mines, Inc	Fourth District, Alaska	34,200
Silver Cloud, Inc	Humboldt, Nev	32,000
Tempiute Mining Co	Lincoln, Nev	40,000
C. R. Bennett	Cascade, Mont	66,220
Big Treasure Mining & Development Co.	Pinal, Ariz	112,000
Congdon & Carey	Custer, Colo	54,660
Exploration Limited	Nye County, Nev	40,000
Double Rainbow Mines, Inc	Lawrence County, S. Dak	312,180
Great Eastern Mines	San Juan County, Colo	81,200
Oxley Petroleum Co	Clear Creek County, Colo	194,400
Roy Pray & Assoc	Hinddale County, Colo	64,640
Ventura Oil Co	Ouray County, Colo	81,600
Development Operating Corp	Jefferson County, Mont	90,000
Janus Mining Co	Madison County, Mont	87,600
Silver Queen Explorations	Beaverhead County, Mont	51,600
A & B Silver Mines	Lincoln County, Nev	72,000
Robt. C. Hanford	Yavapai County, Ariz	30,000
Inca Mining Co	Pershing County, Nev	81,600
Total		1,972,838

The Bureau of Mines continued its survey of the Nation's silver production potential and made an economic appraisal of domestic primary silver resources that were minable at current cost-price levels and technologic conditions.

DOMESTIC PRODUCTION

Mine output of recoverable silver dropped sharply in 1967 because strikes against major copper mining and smelting companies cut off most production of byproduct silver during the second half of the year. The strikes, which began in mid-July, reduced the output of silver-lead-zinc ores as well as silver-bearing copper ores, and cut overall production of silver to about 40 percent of normal during the last quarter.

Idaho's silver production, largely from silver-lead ores, was down about 14 percent owing principally to the shutdown of operations at the Galena mine, the State's second largest silver mine, and to a lesser extent to the shutdown of the Lucky Friday mine in mid-October. In Montana, a 60-percent drop in production resulted from closing Anaconda's copper mining operations, which yield byproduct silver. Similarly, silver production in Utah and Arizona dropped 36 and 27 percent, respectively, owing to closure of copper mines, from which most of the silver is recovered. These four States, however, furnished nearly 90 percent of total domestic production.

Affected by the long copper strike, ores mined chiefly for copper, lead, and zinc, which normally produce two-thirds of total domestic silver, furnished only 60 percent in 1967; the remaining 40 percent was recovered from ores in which silver is the principal metal. Of the 25 leading silver-producing mines, which contributed 85 percent of total domestic output, only four in Idaho depended chiefly on the value of silver in the ore. Eight of the mines produced over 1 million ounces each, supplying 58 percent of total domestic output. Domestic mines contributed about 19 percent of the total silver used in the Nation's arts and industries.

Sunshine Mining Co., the leading silver producer, reported that it recovered 7.7 million ounces of silver from treating 239,915 tons of ore averaging 32 ounces of silver per ton, about 300,000 ounces more than in 1966. Ore reserves at yearend totaled 842,480 tons averaging 40 ounces of silver per ton. Lead, copper, and antimony are also recovered from the ore.[2]

Hecla Mining Co. reported a total silver output of 6.15 million ounces, compared with 7.07 million ounces in 1966, from five operating mines, including a one-third interest in the Sunshine unit area and a 30-percent interest in the Star-Morning unit. The Lucky Friday mine in the Coeur d'Alene district, Idaho, treated 145,470 tons of ore assaying 16.9 ounces of silver per ton, 10.8 percent lead, and 1.1 percent zinc, yielding 2,414,191 ounces of silver. The reduction in tonnage from the previous year reflected the shutdown of operations on October 15 by a labor strike. Development on the 3,450-foot level disclosed favorable ore characteristics. Ore reserves at yearend increased from 658,000 to 677,000 tons. The company reported plans for extensive deep-level exploration of adjoining properties. At the Mayflower mine in the Park City district, Utah, Hecla mined and treated 127,180 tons of ore assaying 0.57 ounce of gold per ton, 4.7 ounces of silver, 4.5 percent lead, 4.0 percent zinc and 0.9 percent copper, yielding 535,130 ounces of silver. Estimated ore reserves dropped 54,000 tons, to 331,000 tons at yearend. At the Silver Summit mine the company milled 26,870 tons of ore assaying 20.1 ounces of silver per ton and 0.6 percent copper, yielding 528,590 ounces of silver. Estimated ore reserves increased 3,000 tons, to 34,000 tons at yearend. The Star-Morning mines produced 228,021 tons of ore assaying 2.6 ounces of silver per ton, 5.1 percent lead, and 8.8 percent zinc. Ore reserves totaled 1.12 million tons.[3]

The Bunker Hill Co. reported mine production of 3.2 million ounces of silver, 0.5 million ounces more than in 1966, from its three operating units, including a 70-percent interest in the Star-Morning mine. The grade of ore at the Crescent mine rose to 56 ounces of silver per ton and silver output rose 71 percent, to 1.4 million

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[2] Sunshine Mining Co. 1967 Annual Report. P. 12.

[3] Hecla Mining Co. 1967 Annual Report. Pp. 8–10, 13.

ounces, more than offsetting declines at the Bunker Hill and Star-Morning mines. The three mines aggregated ore reserves of 5.4 million tons compared with 5.6 million tons at the end of 1966.[4]

Data reported by smelters and refiners indicate that about 33 million ounces of silver was recovered from old scrap materials and returned to industrial use. Most of this secondary silver was reclaimed from the treatment of photographic wastes, discarded electrical and electronic equipment, sterling ware, and jewelry.

In a survey by the Bureau of Mines, domestic primary resources of silver were estimated at 4,900 million ounces, of which about 1,300 million ounces was classified as reserves in operating mines recoverable under current economic and technologic conditions. The remaining 3,600 million ounces could be mined at prices up to $3 per ounce. About 62 percent of total resources is contained in precious metal ores and 38 percent in base metal ores.

[4] The 1967 Annual Report of the Bunker Hill Co. Pp. 2,3,12.

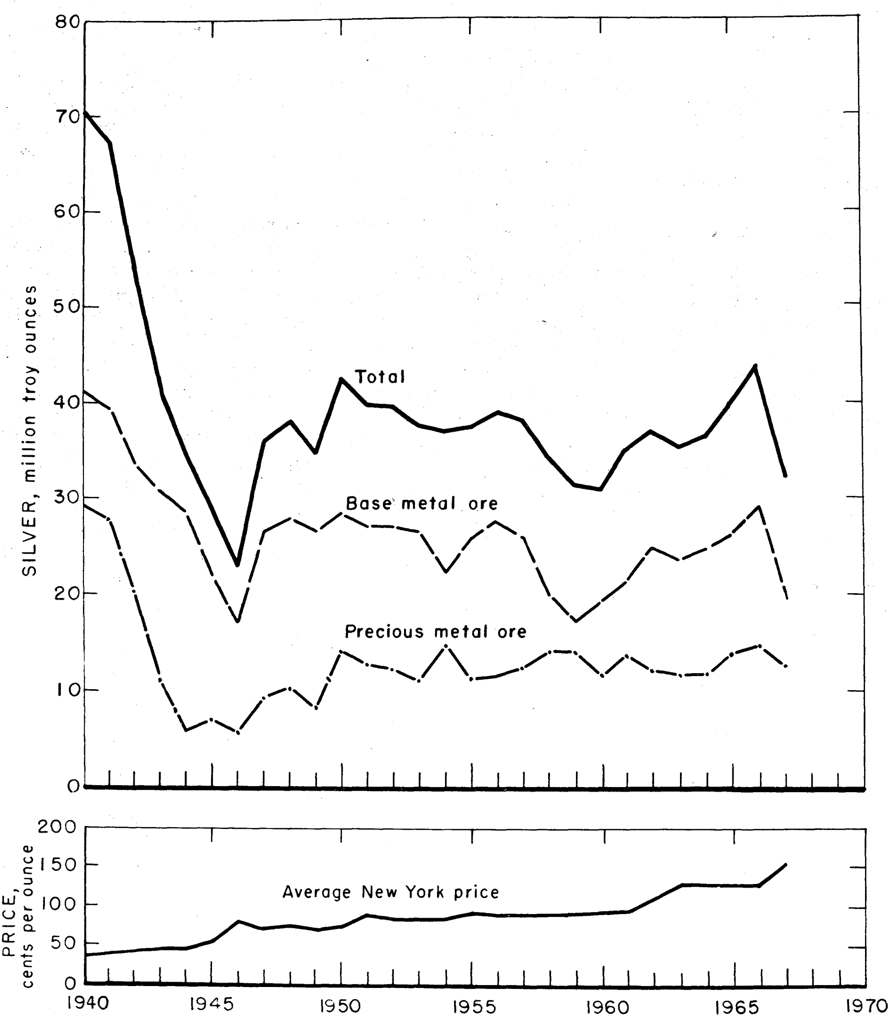

Figure 1.—Silver production in the United States and price per ounce.

CONSUMPTION AND USES

According to data compiled by the Bureau of Mines, industrial consumption of silver dropped about 7 percent compared with 1966, the first such decline in domestic silver consumption since 1963. Although consumption declined in most major categories, particularly electrical and electronic and brazing alloys, appreciable increases were noted in photographic and catalytic uses. The expanding use of bimetals in place of solid alloys largely accounted for reduced consumption of silver in the electrical field even though the number and variety of electrical applications has increased. The more efficient use of silver in photographic film emulsions has reduced the unit quantities required, but this economy was more than offset by greater volume.

A silver-palladium electrode paste, developed for use in printing microminiature circuits, provided better conductivity, more ease in handling, and greater adaptability to mass production techniques compared with other precious metal pastes.

Silver plating improved diffusion bonds between dissimilar metals, according to results of Boeing Co. tests for joining titanium alloys to aluminum, stainless steel, and Inconel. Minimum temperatures ranging from 1,100° to 1,300° F and pressures ranging from 5,500 to 30,000 pounds per square inch (psi) were used.

A water-cooled silver boat, developed for growing high-purity crystals, may find increased use in moderately high-temperature processing to achieve high-purity castings. Silver is used as the crucible or boat material because of its high electrical and thermal conductivity coupled with good reflectivity. When the silver boat is surrounded by an induction coil, it acts as a single turned secondary coil and large currents are induced to flow. Because of the shape of the boat, electromagnetic repulsion occurs between the boat and the charge. The resulting levitation of the melt prevents contamination by the crucible.

Silver-impregnated graphite improved the life of spherical bearings on helicopter rotors by more than 470 hours. Subject to high centrifugal forces and exposed to sand, dust, and salt water corrosion, previously-used bearings lasted no longer than 30 hours and required frequent lubrication. The new bearings, grade P-5AG TC, have a compressive strength of 45,000 psi and high resistance to chemical and electrolytic corrosion, and can operate without lubrication both in an oxidizing atmosphere and in a neutral atmosphere up to 500° F.

A silver-zinc battery pack in the front and rear compartments of a 1966 Corvair chassis provided the power for the General Motors Corp. test vehicle, Electrovair II. Silver-zinc batteries were used because of their ability to develop high peak power and good energy storage. Electrovair accelerated from 0 to 60 miles per hour in 16 seconds and can attain speeds as high as 80 miles per hour. It can travel 40 to 80 miles before recharge.

Silver and gold electroplated contacts were used in wedge action relays for advanced electronic systems in aircraft, missiles, space vehicles, and computers. The precious metals enable extremely low contact resistance, 0.012 to 0.015 ohm constant within 15 million ohms, for more than 100,000 operations. As a result, the device provides the highest confidence level ever achieved in an electromechanical relay—a failure rate of 0.001 percent in 10,000 operations.

Silver and platinum electrodes were used in a sensing device developed by Diamond Alkali to control the use of chlorine in the pulp bleaching process. The instrument senses the oxidation-reduction potential of the solution and transmits a millivolt signal to a control unit, which regulates the rate of chlorine flow.

A new conductive coating made of very fine silver particles dispersed in a rapid air-drying resin was marketed by Acheson Colloids Co. The new coating provides excellent electrical conductivity with a volume resistivity of 0.01 ohm-centimeter. It adheres readily to a variety of surfaces, including metal, plastic, glass, ceramic, paper, and rubber, and is heat resistant to 250° F. Typical applications include electroforming, sensing inks, electrostatic screening, potentiometer tracks, capacitors, electrodes, Mylar tape, and printed circuits.

A silver dressing, applied to the rotating component in aircraft engines by Universal Machines Co., enables an accurate fit between mating parts, promotes anti-seizure characteristics, and provides a tight seal to minimize air leakage and thus increase engine efficiency. The flame-spraying technique, by which the silver alloy coating is applied has also proved effective for economical maintenance operations during engine overhauls.

The Army Institute for Exploratory Research designed a solid-state silver battery for use as a sensing device. The battery is essentially a small pellet of compressed silver-iodide powder carrying vacuum-deposited thin films of silver and platinum on opposite faces. The battery is rechargeable for at least 50 cycles, and the open-circuit voltage (about 0.6 volt per cell) is a function of the state of charge. When the deposited films are very thin, the battery is so sensitive to even a minute current drain that it will act as a sensing device. When the films are relatively thick, the device acts much like an ordinary power source. These features are expected to lead to radically new circuit designs.

STOCKS

Although the withdrawal of silver for coinage from the Treasury bullion stock dropped sharply, sales and redemptions for commercial use increased substantially. The total outflow of 243.6 million ounces reduced the Treasury stock to 348.3 million ounces. An additional 2.3 million ounces was contained in silver dollars. The outflow included 43.8 million ounces for minting 40-percent-silver half-dollars, 42.0 million ounces auctioned in General Services Administration (GSA) weekly sales, and 157.8 million ounces sold otherwise or redeemed by silver certificate for commercial use.

Most of the 157.8 million ounces withdrawn for commercial use was absorbed into industry and private stocks or was exported. Stocks of silver held by refiners, dealers, and fabricators totaled 54.1 million ounces at yearend, slightly less than at the end of 1966. About 31.2 million ounces of silver was held in Commodity Exchange warehouses at yearend, compared with 2.2 million ounces at the end of 1966.

PRICES

After nearly 4 years of relative price stability, the termination of Treasury sales of silver at 129.3 cents per ounce in mid-July brought a sharp rise in the New York price which, with wide fluctuations, reached a record high of $2.17 per ounce in November.

Early in the year the heavy rate of withdrawal for commercial use threatened to exhaust the available free stock of silver and bring a sharp rise in price. In March, to prevent the possible widespread withdrawal of silver coins from circulation, which might result if the price rose much above 129.3 cents, the Treasury sought Congressional authority to write off additional silver certificates to release more silver into free stocks and maintain price stability.

The Treasury's action on May 18, limiting sales of silver at 129.3 cents per ounce to domestic users, and prohibiting the melting and export of silver coin, immediately created a dual-price situation. Prices jumped sharply on the London market and the New York Commodity Exhange. At the same time the New York prompt price, published by Handy & Harman, increased slightly to 130.1 cents per ounce, and to 130.5 cents per ounce on July 5, reflecting additional transportation, handling, and testing costs. As the price of unrestricted silver soared to 170 cents per ounce, non-Treasury silver, including newly mined silver and some secondary silver, tended to flow to premium markets.

The dual-price situation was eliminated when, on July 14, the Treasury halted further sales at 129.3 cents per ounce and announced that future sales would be made by auction. The New York price, quoted by Handy & Harman, reflecting the change in the Treasury sales policy and the impact of the commencement of the strike against major nonferrous metal refining companies, jumped 43 percent, to 187.0 cents per ounce, comparable with other major world markets. Weekly auctions by GSA beginning on August 4 brought temporary price stability. However, speculative demand, following the devaluation of the pound Sterling, increased the New York price to a high of

217 cents near the end of November after which it declined to 210 cents per ounce as the year closed.

Since Treasury silver sold by GSA was limited to domestic industrial consumers and not available for speculation, premium prices developed on the London market and on the New York Commodity Exchange. The volume of trading on the Commodity Exchange (COMEX) established a new record of 1,500 million ounces, compared with about 100 million ounces in 1966. COMEX prices ranged from 128.7 cents on January 26 for February 1967 delivery to 247.0 cents on December 29 for May 1969 delivery. At yearend open contracts for 257.4 million ounces were outstanding, compared with 24.2 million at the end of 1966.

In the London market, silver quotations for prompt delivery ranged from a low of 11.5d in April to a high of 221d in mid-December, equivalent to 130.1 cents and 221.3 cents, respectively, at the prevailing exchange rate of the pound. The average price for the year was 141.7d (approximately 142.5 cents). The London forward quotation was changed in January from a 2-month to a 3-month delivery basis.

FOREIGN TRADE

As a result of the May 18 embargo on the export of silver from the Treasury stock, foreign trade changed during the second half of the year from a net export to a net import pattern. Total exports and imports were substantially below those of 1966. Net exports were 15.3 million ounces compared with net exports of 23.4 million ounces in the corresponding period of 1966. Two-thirds of the imports of silver came from Canada, Mexico, and South Africa. More than three-fourths of total exported silver went to West European countries, chiefly the United Kingdom and Switzerland.

New tariff rates on silver in plated, semifabricated, and compound forms were announced in accordance with the Kennedy Round trade negotiations. The new and lower rates effective January 1, 1968, follow:

TSUS[1] *No.*	*Item*	*Rate, percent*[2]
605.46	Platinum-plated silver	29
605.47	Gold-plated silver	45
605.60	Plates and sheets	21.5
605.65	Rolled silver	18.5
605.66	Other semimanufactured silver	36
420.60 427.28	Silver compounds	9

[1] Tariff Schedules of the United States.
[2] Ad valorem.

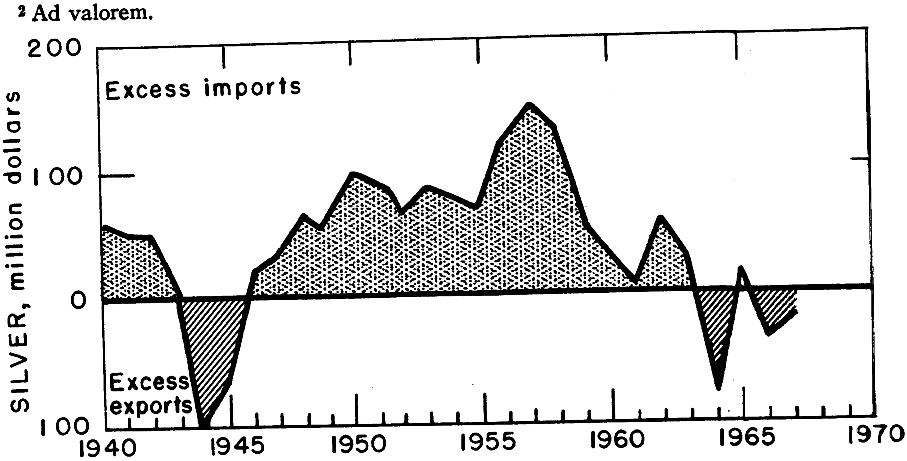

Figure 2.—Net imports or exports of silver.

WORLD REVIEW

World silver production was estimated at 261.6 million ounces, approximately 4.4 million ounces less than in 1966. Production gains in Canada, Peru, Australia, Japan, and the U.S.S.R. failed to offset losses in the United States, Mexico, Bolivia, Yugoslavia, and Sweden. Western Hemisphere countries contributed about 60 percent of total world output.

Consumption of silver in the arts and industries, and in coinage of the free world was estimated at 455.6 million ounces, a continuation of the declining trend from the peak of 1965 and a drop of about 8 percent from the 1966 level. Industrial consumption declined about 3 percent, to 377.4 million ounces, and coinage uses dropped about 26 percent. The United States accounted for most of the drop in industrial consumption. Most of the falloff in consumption of silver for coinage was attributed to reductions in the United States and Canada.

Free world consumption of silver exceeded new production by approximately 194 million ounces. The production deficit continued to be balanced by withdrawals chiefly from the U.S. Treasury bullion stock, from foreign government stocks, including sales from the U.S.S.R. demonetized coin, and from other secondary sources. Inventory accumulations and speculative holdings increased sharply and were estimated to exceed 120 million ounces at yearend.

Australia.—Output of silver, recovered mainly as a byproduct of lead production, increased nearly 5 percent to a record high. Developed reserves of lead-zinc-silver ores are large and exploration for additional reserves continued on a large scale.

Mt. Isa Mines reported that it treated a record 4.2 million tons of silver-lead-zinc and copper ore. Recovery of silver, however, dropped to 5.8 million ounces compared with 6.1 million ounces last year. Operations were adversely affected by a shortage of skilled miners. The com-

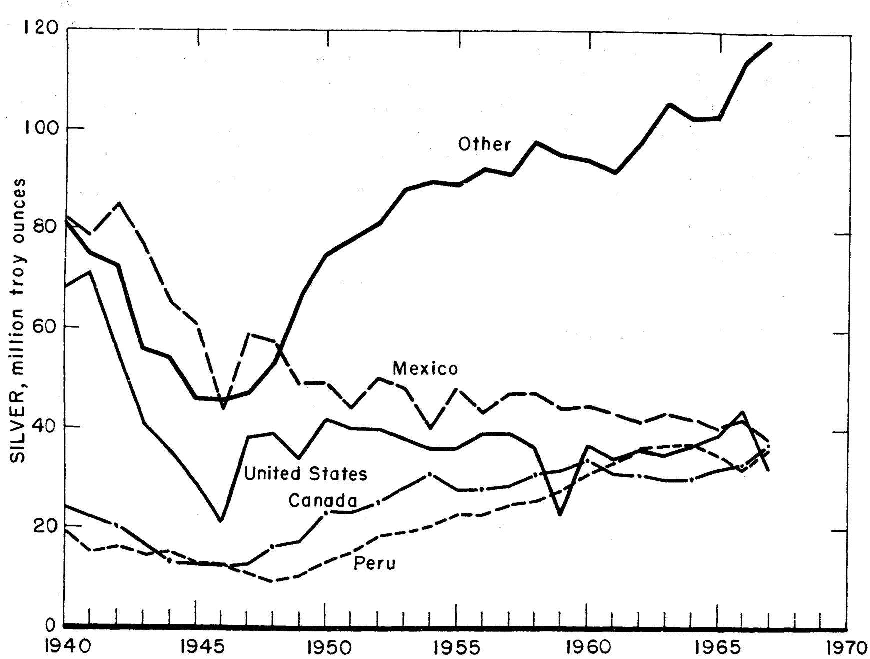

Figure 3. World production of silver.

pany continued its major program to expand ore production to 16,000 tons per day. Silver-lead-zinc ore reserves increased 1 million tons, to 32.6 million tons averaging 5.4 ounces silver per ton, 7.4 percent lead, and 5.6 percent zinc.[5]

Canada.—Output of silver increased 3 million ounces, to 36.4 million ounces, the fourth consecutive annual gain and an alltime record. The production gain was largely due to the expansion of metal output at the Kidd Creek mine of Texas Gulf Sulphur Co. near Timmins, Ontario, following the first full year of operation. Silver is recovered at Kidd Creek as a coproduct of zinc, lead, and copper. Canada advanced to second rank among silver-producing countries in 1967, exceeded only by Mexico. Of the total production about 80 percent was recovered from ores mined essentially for base metals, about 16 percent from silver-cobalt and silver ores, and the remaining 4 percent from lode gold ores.

Two mines in British Columbia began operations in 1967; Western Mines commenced treating zinc-copper-lead ore yielding 2 ounces of silver per ton in its 750-ton mill, and Utica Mines began production of silver-gold-lead-zinc ore in October in its 300-ton mill. Utica ore reserves of 275,000 tons averaged about 20 ounces of silver and 0.05 ounce of gold per ton. The Par mine in Saskatchewan began production of silver-bearing zinc-lead-copper ore at mid-year. Ore reserves of 250,000 tons grading 4.7 ounces of silver per ton were reported. Two silver mines in the Cobalt district, Deer Horn and Silver Towns, resumed operations after long shutdowns.

Consumption of silver in the arts and industries was about 5.8 million ounces, about the same as in 1966, and coinage requirements accounted for about 8.2 million ounces, a sharp drop from 1966. In the first half of 1967 Canada suspended fabrication of silver dollars and half-dollars. As a result of the sharp rise in the price of silver in mid-May, the intrinsic value of the 80-percent-silver coins became greater than their face value, and in August the silver content of the coins was reduced to 50 percent pending the changeover to nickel coins planned for 1968. Exports of refined and unrefined silver to the United States increased about 2 million ounces, to 23.4 million ounces. Imports of silver, virtually all from the United States, were about 5.2 million ounces.

United Keno Hill Mines Ltd. reported that silver output dropped to 3.8 million ounces, from 4.2 million ounces in 1966, marking the sixth successive annual decline. The company curtailed development at its producing mines in the Yukon territory during the second half of the year, and reduced mining and milling operations because of a depletion of ore reserves and a critical shortage of skilled miners. The company treated 106,189 tons averaging 37.7 ounces of silver per ton, 8.0 percent lead, and 5.9 percent zinc. Silver recovery was 95 percent. Ore reserves at yearend were estimated at 124,500 tons averaging 38.6 ounces of silver per ton, 7.5 percent lead, and 6.5 percent zinc.[6]

Cominco Ltd. reported an aggregate production of 5.2 million ounces of silver, of which 67 percent came from company mines, principally the Sullivan and Bluebell, compared with 6.6 million ounces in 1966. The 1967 silver output was the smallest in more than 10 years.

The Texas Gulf Sulphur Co. Kidd Creek mine, Canada's leading silver producer, mined and milled 3,039,000 tons of zinc-copper-silver-lead ore and produced 7.8 million ounces of silver. Metallurgical recovery was 75 percent. Silver is recovered primarily from the copper and lead concentrates.

Germany, West.—Industrial consumption of silver was about 48.2 million ounces, approximately the same as in 1966. Imports totaled about 51.4 million ounces, of which 16.1 million ounces came from Mexico, 9 million from Peru, 5.6 million from the United States, 4.2 million from the Middle East, 3.2 million from Belgium, and 13.3 million from other countries. About 15.1 million ounces was exported, chiefly to Italy, Switzerland, and Norway.

Mexico.—Silver output in Mexico dropped nearly 10 percent, but the country regained its rank as the leading silver producer. Industrial consumption was about 5.0 million ounces. About 0.5 million ounces of silver was used in minting

[5] Mount Isa Mines Ltd. Annual Report. 1967, pp. 18–19.
[6] United Keno Hill Mines Ltd. Annual Report. 1967, p. 12.

the 10-percent-silver 1-peso coins. In addition, about 1.5 million ounces of silver was used in minting the newly authorized 25-peso silver coins commemorating the 1968 Olympics. A total of 30 million coins requiring about 15.6 million ounces of silver was authorized. The Olympic coin, equivalent to $2, weighs 22.5 grams 720 fine and contains 0.52 ounce of silver. Exports of silver totaled 30.6 million ounces, about 5.5 million of which went to the United States; nearly all of the remainder went to European countries. Government stocks were estimated at 27 million ounces.

Fresnillo Co. reported that, during the year ending June 30, 1967, its Fresnillo Naica and Zimapán units treated 1.2 million tons of ore yielding 4.9 million ounces of silver, slightly less than in 1966. Average working costs at these units was $8.15 per ton compared with $8.30 per ton in 1966. The ore reserves at mid-year at the three major units were 4.6 million tons averaging 5.13 ounces of silver and 0.01 ounce gold per ton, 4.9 percent lead, 4.7 percent zinc, and 0.31 percent copper. The company was developing the El Monte silver-lead-zinc-copper ore body in Zimapán and nearly completed a 200-ton mill at the Amaltea mine in Jalisco in preparation for production in 1968.[7]

Asarco Mexicana treated 1.9 million tons of silver-bearing ores and recovered 16.5 million ounces of silver, about the same as in 1966.

Peru.—Silver production in Peru, recovered principally as a coproduct or byproduct of copper, lead, and zinc, increased about 9 percent, to 35.9 million ounces valued at $50 million. Peru ranked as the third largest silver-producing country in 1967, exceeded only by Mexico and Canada.

Cerro de Pasco Corp. reported a slight drop in silver production to 19.5 million ounces, representing about 54 percent of Peru's total output. Cerro's 1967 metal production was adversely affected by a 1-week strike by mine workers and a 2-week strike by metallurgical workers. About 49 percent of the corporation's silver output came from purchased ores.

United Kingdom.—Industrial consumption of silver was about 24.0 million ounces, a slight reduction from that of 1966. Imports of silver totaled 63.8 million ounces, a gain of 16 percent over that of 1966. About 28.9 million ounces was received from the United States, 9.6 million from the U.S.S.R., 11.3 million from the Trucial States, and nearly all of the remaining 14 million from 26 other countries. United Kingdom exports of silver dropped 3.7 million ounces to 31.7 million. The principal countries to which silver was shipped included Italy, 11.8 million ounces; Belgium, 5.7 million; West Germany, 4.6 million; and France, 2.6 million. Virtually all of the remainder, about 7 million ounces, was shipped to Switzerland, Poland, and 24 other countries.

About 1.9 million ounces of silver was recovered from demonetized United Kingdom coins in 1967 compared with 0.5 million ounces during 1966.

TECHNOLOGY

The growth of industrial demand for silver and the continuation of a worldwide production deficit, coupled with a substantial rise in price, has encouraged research to develop improved techniques for discovering new silver-bearing deposits and evaluating the economic feasibility of production from known marginal or submarginal deposits. A rapid and precise atomic-absorption, spectrophotometric method for determining silver in mineralized rocks was developed by the U.S. Geological Survey.[8] The procedure consists of digesting the sample with nitric acid, centrifuging the diluted solution, and atomizing it into an atomic absorption spectrophotometer to measure silver at the wave length of 3,284 angstroms. Silver ranging in concentration from about 0.03 to 250 troy ounces per ton can be determined without preliminary separations even in the presence of high concentrations of other diverse elements.

Intensified exploration for silver deposits made greater use of newer scientific techniques such as mercury detection, infrared sensors, radar imaging techniques, and airborne magnetometers. The adoption of new types of analytical and process

[7] Fresnillo Co. Annual Report. 1967, pp. 8–9.

[8] Huffman, Claude, Jr., J. D. Mensik, and L. F. Rader. Determination of Silver in Mineralized Rocks by Atomic Absorption Spectrophotometry. U.S. Geol. Survey Prof. Paper 550–B, 1966, pp. B189–B191.

control instrumentation improved refinery operations and increased silver recovery from scrap by expediting analyses of the large number and variety of materials at lower cost.

A rapid field test for silver having a sensitivity of about 2 parts per million was developed. Silver quantitatively displaces copper from a hexane solution of copper dithizonate in the presence of 0.5 molar H_2SO_4. Colorimetric measurement of the hexane layer determines the silver content.[9]

The geological study of the silver deposits near Miller Lake, Gowganda, Ontario, revealed native silver and cobalt arsenide deposits in narrow vein fractures in and around diabase intrusions, a structural environment similar to that at Cobalt, Ontario. The silver is found in association with calcite and quartz.[10]

The discovery of the Gortdrum copper-silver deposit near Tipperary, Ireland, was due to reconnaissance and geological and geochemical exploration followed by target delineation from induced polarization surveys. The Gortdrum deposit was detected by anomalous metal in stream sediments 3,000 feet downstream. Soil sampling indicated an area 2,000 feet by 700 feet containing 2½ to 20 times the normal background metal content. An induced polarization survey defined the dimensions and attitude of the ore body, and subsequent drilling indicated the quantity and grade of the ore and the geological environment.[11]

Bureau of Mines assays of fly ash samples collected from seven incinerators in the Washington, D.C. area revealed quantities of silver ranging from 2 to 9 ounces per ton and gold ranging from 0.02 to 0.05 ounce per ton. About 500,000 tons of incinerator fly ash are produced annually, representing a potential source of gold and silver that might ultimately supply a significant part of industrial demand for these metals if economical extraction methods can be developed.

The Bureau of Mines designed and tested an efficient metallic displacement process, utilizing steel wool or steel window screen, for recovery of silver from waste photographic fixing solutions. A melting process for recovering pure silver from precipitated sludge containing 27 to 80 percent silver was devised. The process is particularly suitable for small-scale operations applicable to small commercial photographic laboratories and amateur photographers who process their own films and papers.[12]

A comprehensive and authoritative treatise was published to commemorate the centennial of the founding of the firm Handy & Harman, leading fabricators of silver and silver alloys.[13]

Table 2.—Mine production of recoverable silver in the United States, by months

(Thousand troy ounces)

Month	1966	1967
January	3,385	3,333
February	3,310	3,347
March	3,924	3,653
April	3,565	3,439
May	3,670	3,551
June	3,846	3,475
July	3,351	2,841
August	3,711	1,873
September	3,650	1,689
October	3,702	1,644
November	3,764	1,638
December	3,791	1,636
Total	43,669	32,119

[9] Bloom, H. A. Field Method for the Determination of Silver in Soils and Rocks Using Dithizone. Econ. Geol., v. 61, No. 1, January-February 1966, pp. 189–197.

[10] Hester, B. W. Geology of the Silver Deposits Near Miller Lake, Gowganda. The Canadian Mining and Metallurgical Bulletin, v. 60, No. 667, November 1967, pp. 1277–1286.

[11] Thompson, I. S. The Discovery of the Gortdrum Copper Deposit Co. Tipperary, Ireland. Paper presented at 68th Annual Meeting CIM & M. April 1966.

[12] Dannenberg, R. O., and G. M. Potter. Silver Recovery from Waste Photographic Solutions by Metallic Displacement. BuMines Rept. of Inv. 7117, 1968, 22 pp.

[13] Butts, Allison (ed.). Silver, Economics, Metallurgy, and Use, 1967, 488 pp.

Table 3.—Twenty-five leading silver-producing mines in the United States in 1967 in order of output

Rank	Mine	State	County	Operator	Source of silver
1	Sunshine	Idaho	Shoshone	Sunshine Mining Co	Silver ore.
2	Lucky Friday	do	do	Hecla Mining Co	Lead ore.
3	Galena	do	do	American Smelting and Refining Company	Silver ore.
4	Utah Copper	Utah	Salt Lake	Kennecott Copper Corp	Copper, gold-silver ores.
5	Bunker Hill	Idaho	Shoshone	The Bunker Hill Co	Lead-zinc ore.
6	Crescent	do	do	do	Silver ore.
7	U.S. and Lark	Utah	Salt Lake	United States Smelting Refining and Mining Co	Lead-zinc ore.
8	Berkeley Pit	Montana	Silver Bow	The Anaconda Company	Copper ore.
9	Idarado	Colorado	Ouray and San Miguel	Idarado Mining Co	Copper-lead-zinc ore.
10	Burgin	Utah	Utah	Kennecott Copper Corp	Lead-zinc ore.
11	Butte Hill Copper Mines	Montana	Silver Bow	The Anaconda Company	Copper ore.
12	Mission	Arizona	Pima	American Smelting and Refining Company	Do.
13	Star-Morning	Idaho	Shoshone	Hecla Mining Co	Lead-Zinc ore.
14	Pima, Northeast	Arizona	Pima	Pima Mining Co	Copper ore.
15	Mayflower	Utah	Wasatch	Hecla Mining Co	Copper-lead-zinc ore.
16	Silver Summit	Idaho	Shoshone	do	Silver ore.
17	Mineral Park	Arizona	Mohave	Duval Corp	Copper ore.
18	Iron King	do	Yavapai	Shattuck Denn Mining Corp	Lead-zinc ore.
19	Copper Queen-Lavender Pit	do	Cochise	Phelps Dodge Corp	Copper ore.
20	Morenci	do	Greenlee	do	Copper, gold-silver ores.
21	New Cornelia	do	Pima	do	Do.
22	Pan American	Nevada	Lincoln	Grand Deposit Mining Co. & Combined Metals Reduction Co., joint venture.	Lead-zinc ore.
23	White Pine	Michigan	Ontonagon	White Pine Copper Co	Copper ore.
24	United Park City	Utah	Summit and Wasatch	United Park City Mines Co	Lead-zinc ore.
25	Silver Star-Queens	Idaho	Blaine	Federal Resources Corp	Lead ore.

Table 4.—Production of silver in the United States in 1967, by States and by source

(Troy ounces)

State	By type of mine production							Refinery production [1]
	Placer	Dry ore	Copper ore	Lead and zinc ores	Complex base metal ores	Other sources [2]	Total	
Alaska	2,795	---	2,992	---	---	---	5,787	3,000
Arizona	---	41,526	3,996,587	34,290	501,002	14,676	4,588,081	4,000,000
California	1,990	4,038	63	67,474	49,796	21,154	144,515	125,000
Colorado	329	40,743	45,608	191,438	1,538,908	673	1,817,699	1,600,000
Idaho	1	11,919,561	3,532	2,881,721	1,965,752	262,763	17,033,330	15,000,000
Kentucky	---	---	---	---	---	568	568	650
Michigan	---	---	301,992	---	---	---	301,992	275,000
Missouri	---	---	---	---	---	---	---	272,800
Montana	26	66,920	1,817,009	158,035	1,655	22,819	2,066,464	3,000,000
Nevada	129	12,641	236,441	7,544	307,841	1,159	565,755	529,000
New Mexico	---	24,213	47,354	74,990	10,938	---	157,495	171,400
New York	---	---	---	---	31,103	---	31,103	35,900
North Carolina	---	---	---	---	---	---	---	---
South Dakota	---	121,258	---	---	---	---	121,258	121,300
Tennessee	---	---	---	---	130,078	---	130,078	150,400
Utah	1	28,814	1,762,264	2,863	3,043,108	37,590	4,874,640	5,550,300
Wyoming	---	---	---	---	---	---	---	---
Other States [3]	4	244,636	7,503	9,365	9,831	8,590	279,929	165,250
Total	5,275	12,504,350	8,221,345	3,427,720	7,590,012	369,992	32,118,694	31,000,000
Percent	([4])	39	25	11	24	1	100	---

[1] U.S. Bureau of the Mint.
[2] Silver recovered from mill and smelter cleanup, slag, tailings, and as a byproduct of calcium fluorite, magnetite-pyrite, tungsten, and uranium ores.
[3] Includes Oklahoma, Oregon, Pennsylvania, Texas, Washington, and Wisconsin.
[4] Less than 0.5 percent.

Table 5.—Mine production of recoverable silver in the United States in 1965–67, by States

(Troy ounces)

State	1965	1966	1967
Alaska	7,673	7,193	5,787
Arizona	6,095,285	6,338,696	4,588,081
California	196,787	189,989	144,515
Colorado	2,051,105	2,085,534	1,817,699
Idaho	18,456,809	19,776,785	17,033,330
Kentucky	1,931	1,086	568
Michigan	457,851	483,000	301,992
Missouri	299,522	----	----
Montana	5,207,031	5,319,785	2,066,464
Nevada	507,113	867,567	565,755
New Mexico	287,472	242,620	157,495
New York	11,441	21,590	31,103
Oklahoma [1]	358,477	368,788	279,898
Oregon	8,801	343	31
Pennsylvania	(1)	(1)	(1)
South Dakota	128,971	109,885	121,258
Tennessee	94,142	100,716	130,078
Utah	5,635,570	7,755,411	4,874,640
Washington	(1)	(1)	(1)
Wyoming	52	----	----
Total	39,806,033	43,668,988	32,118,694

[1] Production of Oklahoma, Pennsylvania, and Washington combined to avoid disclosing individual company confidential data.

Table 6.—Ore, old tailings, etc., yielding silver produced in the United States and average recoverable content in 1967, in troy ounces of silver per ton

State	Gold		Gold-silver		Silver		Copper	
	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton	Short tons	Average ounces of silver per ton
Alaska	--------	------	---------	-------	---------	------	7,604	0.393
Arizona	474	0.222	74,516	0.192	13,551	2.804	72,034,837	.055
California	408	.642	1,660	2.180	8	20.750	15	4.200
Colorado	2,520	1.036	1,000	5.611	150,478	.216	2,109	21.625
Idaho	254	.307	(1)	100.000	704,741	17.224	60,887	.058
Kentucky	--------	------	---------	-------	---------	------	-----------	------
Michigan	--------	------	---------	-------	---------	------	4,979,585	.061
Montana	239	.766	3,641	2.995	17,857	4.257	9,014,687	.202
Nevada	325,339	.018	---------	-------	1,460	5.329	6,425,161	.037
New Mexico	--------	------	37,343	.648	472	.051	4,446,994	.011
New York	--------	------	---------	-------	---------	------	-----------	------
South Dakota	1,896,311	.064	---------	-------	---------	------	-----------	------
Tennessee	--------	------	---------	-------	---------	------	-----------	------
Utah	--------	------	39,060	1.239	15,806	.878	20,864,484	.084
Other States [2]	88,995	2.746	---------	-------	15	20.133	178,040	.042
Total	2,314,540	.162	157,220	.681	904,388	13.608	118,014,403	.070

State	Lead		Zinc		Lead-zinc, copper-zinc, and copper-lead-zinc		Total material	
	Short tons	Average ounces of silver	Short tons	Average ounces of silver	Short tons	Average ounces of silver	Short tons	Average ounces of silver
Alaska	--------	------	---------	-------	---------	------	7,604	0.393
Arizona	1,451	3.474	69,686	0.462	291,927	1.716	72,486,442	.063
California	3,620	18.771	---------	-------	7,860	6.335	13,571	[3] 10.502
Colorado	1,302	4.690	223,057	.834	792,227	1.942	1,172,693	1.550
Idaho	239,424	11.917	91,537	.753	676,589	2.910	1,773,432	9.605
Kentucky	--------	------	---------	-------	---------	------	[4] 83,575	.007
Michigan	--------	------	---------	-------	---------	------	4,979,585	.061
Montana	4,107	5.582	51,852	2.656	211	7.844	9,092,594	.227
Nevada	252	26.639	904	.919	228,509	1.347	6,981,625	.081
New Mexico	5	2.400	272,058	.276	44,042	.248	4,800,914	.033
New York	--------	------	---------	-------	629,901	.049	629,901	.049
South Dakota	--------	------	---------	-------	---------	------	1,896,311	.064
Tennessee	--------	------	---------	-------	1,605,590	.081	1,605,590	.081
Utah	253	11.316	16,176	.197	570,960	5.330	21,506,739	[5] .227
Other States [2]	--------	------	583,809	.016	292,628	.034	[6] 1,680,067	.167
Total	250,414	11.839	1,309,079	.392	5,140,444	1.477	128,710,643	.250

[1] Less than ½ unit.
[2] Includes Oklahoma, Oregon, Pennsylvania, and Washington.
[3] Includes byproduct silver recovered from tungsten ore.
[4] Calcium fluorite ore.
[5] Includes byproduct silver recovered from uranium ore.
[6] Includes magnetite-pyrite ore from Pennsylvania.

Table 7.—Silver produced in the United States from ore and old tailings in 1967, by States and methods of recovery, in terms of recoverable metal

State	Total ore, old tailings, etc., treated (thousand short tons)[1]	Ore and old tailings to mills					Crude ore, old tailings, etc., to smelters	
		Thousand short tons	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	8	8	-------	-------	176	2,992	-----	---------
Arizona	72,556	72,262	1	-------	1,920,399	4,418,383	294	169,697
California	15	11	73	-------	3,896	70,316	4	72,136
Colorado	1,173	1,170	838	-------	150,598	1,764,849	3	51,683
Idaho	1,773	1,707	51	-------	200,919	16,986,157	66	47,121
Kentucky	152	152	-------	-------	12,683	568	-----	---------
Michigan	7,398	7,398	-------	-------	180,310	301,992	-----	---------
Montana	9,092	9,044	-------	-------	235,189	1,946,091	48	120,347
Nevada	7,741	7,686	3,275	3,969	190,594	544,452	55	13,930
New Mexico	4,801	4,728	-------	-------	191,252	132,669	73	24,826
New York	809	809	-------	-------	134,617	31,103	-----	---------
South Dakota	1,896	1,896	80,051	41,207	---------	---------	-----	---------
Tennessee	5,468	5,468	-------	-------	280,882	130,078	-----	---------
Utah	21,511	21,397	-------	-------	639,395	4,168,752	114	705,887
Other States[2]	2,326	2,326	1	1,878	131,776	277,805	(3)	241
Total	136,719	136,062	84,290	47,054	4,272,686	30,776,207	657	1,205,868

[1] Includes some non-silver-bearing ores not separable.
[2] Includes Oklahoma, Oregon, Pennsylvania, and Washington.
[3] Less than ½ unit.

Table 8.—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
1963	89,777	99,289	0.26	0.28	99.41	0.05
1964	91,401	120,894	.25	.33	99.39	.03
1965	167,331	48,632	.42	.12	99.44	.02
1966	80,033	41,098	.18	.09	99.71	.02
1967	84,290	47,054	.26	.15	99.57	.02

[1] Crude ores and concentrates.

Table 9.—Silver produced at refineries in the United States, by source

(Troy ounces)

	1966	1967
From concentrates and ores:		
Domestic	48,357,969	30,267,987
Foreign	31,079,530	23,776,710
Total	79,437,499	54,044,697
From old scrap	36,628,567	33,534,078
From new scrap	17,033,476	25,361,399
Total production	133,099,542	112,940,174

Table 10.—U.S. consumption of silver, by end use

(Troy ounces)

	1966	1967
Electroplated ware	21,486,041	17,896,938
Sterling ware	30,894,444	30,268,955
Jewelry	6,349,050	5,750,824
Photographic materials	48,435,390	50,306,175
Dental and medical supplies	2,457,181	2,690,154
Mirrors	2,945,503	2,173,929
Brazing alloys and solders	18,419,421	15,390,493
Electrical and electronic products:		
Batteries	12,517,251	11,404,489
Contacts and conductors	33,676,352	26,777,169
Rocket nozzles	699,446	---------
Catalysts	2,682,765	5,847,278
Bearings	569,174	600,228
Miscellaneous [1]	2,564,112	1,925,183
Total net industrial consumption	183,696,130	171,031,815
Coinage	53,852,227	43,850,866
Total consumption	237,548,357	214,882,681

[1] Includes silver-bearing copper, silver-bearing lead anodes, ceramic paints, etc.

Table 11.—U.S. monetary silver

(Million troy ounces)

	1963	1964	1965	1966	1967
In the Treasury:					
Silver bullion	1,557.7	1,208.0	793.8	591.9	348.3
Silver dollars	22.1	2.3	2.3	2.3	2.3
Subsidiary coin	2.7	3.4	(1)	(1)	(1)
Total	1,582.5	1,213.7	[2] 796.1	[2] 594.2	[2] 350.6
Outside the Treasury:					
Silver dollars	352.9	372.6	372.6	372.6	372.6
Subsidiary coin	1,365.2	1,563.4	1,883.0	[3] 1,911.0	[3] 1,960.0
Total	1,718.1	1,936.0	2,255.6	2,283.6	2,332.6
Grand total	3,300.6	3,149.7	3,051.7	2,877.8	2,683.2

[1] No breakdown is available between silver and nonsilver coins.
[2] Excludes silver in subsidiary coin.
[3] Estimated.

Table 12.—U.S. exports of silver in 1967, by countries

(Thousand troy ounces and thousand dollars)

Country	Ore and base bullion		Refined bullion		U.S. coin value	Foreign coin value
	Quantity	Value	Quantity	Value		
Argentina	------	--------	--------	--------	$2	--------
Australia	------	--------	--------	--------	1	--------
Austria	------	--------	984	$1,272	--------	--------
Bahamas	------	--------	--------	--------	67	--------
Belgium-Luxembourg	424	$817	202	429	--------	(1)
Bermuda	------	--------	--------	--------	13	--------
Brazil	------	--------	33	54	--------	--------
Canada	218	287	5,015	6,895	7	$1,034
Colombia	------	--------	50	65	--------	--------
France	------	--------	7,681	10,296	20	--------
Germany, West	1,124	2,073	4,491	6,444	74	1
Hong Kong	------	--------	--------	--------	4	--------
Ireland	------	--------	--------	--------	2	--------
Italy	------	--------	322	415	1	2,773
Japan	------	--------	3,023	4,079	--------	1
Mexico	------	--------	--------	--------	4	--------
Netherlands	4	8	3,018	3,914	--------	(1)
Netherlands Antilles	------	--------	--------	--------	11	--------
Norway	------	--------	--------	--------	--------	5
Panama	------	--------	--------	--------	--------	275
Philippines	------	--------	--------	--------	--------	240
Portugal	------	--------	--------	--------	--------	2
Singapore	------	--------	--------	--------	--------	1
Spain	36	45	--------	--------	--------	--------
Sweden	------	--------	--------	--------	--------	(1)
Switzerland	3	7	13,436	17,365	87	55
United Kingdom	556	1,005	30,149	40,490	17	52
Total	2,365	4,242	68,404	91,718	310	4,439

[1] Less than ½ unit.

Table 13.—U.S. imports of silver in 1967, by countries

(Thousand troy ounces and thousand dollars)

Country	Ore and base bullion		Refined bullion		U.S. coin value	Foreign coin value
	Quantity	Value	Quantity	Value		
Argentina	92	$131	--------	--------	--------	--------
Australia	1,390	1,795	--------	--------	--------	--------
Austria	------	--------	--------	--------	--------	(1)
Belgium-Luxembourg	------	--------	201	$340	--------	$4
Bermuda	------	--------	--------	--------	--------	(1)
Bolivia	2,750	3,397	--------	--------	--------	--------
Bulgaria	------	--------	--------	--------	--------	(1)
Canada	8,289	10,825	14,344	22,231	$20	132
Chile	1,709	2,022	--------	--------	--------	--------
Colombia	81	125	--------	--------	--------	--------
Ecuador	29	33	--------	--------	--------	--------
El Salvador	------	--------	5	7	--------	--------
Germany, West	113	146	1	1	--------	--------
Guatemala	9	12	--------	--------	--------	(1)
Honduras	2,113	2,610	53	73	--------	--------
Hong Kong	------	--------	--------	--------	--------	1
India	------	--------	--------	--------	--------	1
Japan	------	--------	5	7	--------	--------
Malaysia	------	--------	--------	--------	--------	(1)
Mexico	581	807	3,068	4,022	--------	2,592
Mozambique	3	4	--------	--------	--------	(1)
Nicaragua	90	114	6	7	--------	--------
Norway	10	12	--------	--------	--------	--------
Panama	------	--------	8	9	--------	63
Peru	7,278	9,853	2,497	3,575	--------	15
Philippines	317	423	38	50	--------	--------
South Africa, Republic of	785	1,122	9,122	12,342	--------	1
Spain	------	--------	--------	--------	--------	(1)
Switzerland	------	--------	(1)	1	--------	1
Thailand	------	--------	--------	--------	--------	1
United Arab Republic	------	--------	--------	--------	--------	6
United Kingdom	3	6	530	985	--------	254
Total	25,642	33,437	29,878	43,650	20	3,071

[1] Less than ½ unit.

Table 14.—Value of silver imported into and exported from the United States

(Thousand dollars)

Year	Imports	Exports
1965	$62,903	$51,424
1966	76,187	110,533
1967	77,087	95,960

Table 15.—World production of silver, by countries [1 2 3 4]

(Troy ounces)

Country [1]	1963	1964	1965	1966	1967 [p]
North America:					
Canada	29,839,756	29,902,611	[r] 31,917,243	[r] 33,417,874	36,426,079
Central America and West Indies:					
Guatemala	64,173	[e] 10,000	[e] 18,000	[e] 3,000	NA
Haiti	107,022	92,057	77,488	50,690	NA
Honduras	[e] 3,164,000	3,220,371	3,670,659	3,734,290	4,009,418
Nicaragua	405,252	332,370	380,377	446,706	372,371
Mexico	[r] 42,760,367	[r] 41,716,208	[r] 40,332,024	[r] 41,983,477	37,939,498
United States	35,241,503	36,333,861	39,806,033	43,668,988	32,118,694
South America:					
Argentina	[r] 1,943,188	[r] 1,943,124	[r] 2,285,850	[r] 2,207,178	NA
Bolivia (exports)	[r] 4,869,031	4,810,973	[r] 4,114,422	[r] 5,124,307	4,275,368
Brazil	[r] 281,447	[r] 313,727	[r] 227,788	[r] 222,354	NA
Chile	[r] 2,768,332	[r] 3,096,594	[r] 2,972,264	[r] 3,609,962	3,065,504
Colombia	106,279	[r] 130,666	[r] 115,866	[r] 109,065	110,442
Ecuador	121,784	117,126	69,966	76,710	NA
Peru (recoverable)	[r] 35,203,184	34,419,459	[r] 36,470,307	[r] 32,841,201	35,869,829
Europe:					
Austria	68,803	73,947	76,519	93,237	NA
Czechoslovakia [5]	2,400,000	2,400,000	2,400,000	2,400,000	2,400,000
Finland	579,967	607,906	582,186	520,103	623,000
France	730,111	969,441	1,401,226	[r] 2,008,325	2,000,000
Germany:					
East [5]	4,800,000	4,800,000	4,800,000	4,800,000	4,800,000
West	2,067,068	2,062,599	2,021,896	[r] 2,018,391	[e] 2,000,000
Greece	123,009	[r] 153,970	[r] 139,052	[r] 138,200	237,900
Hungary [5]	64,300	64,300	64,300	64,300	64,300
Ireland	----------	----------	----------	1,219,000	NA
Italy	1,006,318	1,073,770	1,103,446	1,131,770	1,382,448
Poland [5]	128,600	128,600	128,600	[r] 161,000	161,000
Portugal	48,419	48,773	63,015	[r] 354,558	356,800
Rumania [5]	643,000	643,000	643,000	643,000	643,000
Spain [6]	4,955,201	2,314,853	[r] 1,961,195	NA	NA
Sweden [7]	[r] 2,874,000	[r] 3,061,000	[r] 3,884,000	4,495,000	[e] 4,000,000
U.S.S.R.[e]	[r] 28,000,000	[r] 29,000,000	[r] 31,000,000	[r] 33,000,000	35,000,000
Yugoslavia	3,791,923	4,036,879	4,148,057	3,651,424	3,075,472
Africa:					
Algeria [8]	255,000	295,000	295,000	[r] 420,000	420,000
Botswana	21	1	----------	----------	----------
Congo (Kinshasa)	1,097,176	1,480,252	1,538,413	1,851,400	1,839,777
Ghana (exports)	4,827	----------	----------	----------	----------
Kenya	52,422	47,702	21,247	19,003	3,038
Morocco	772,743	604,080	599,258	707,413	772,807
Rhodesia, Southern	83,742	88,463	[e] 95,470	[e] 95,000	NA
South Africa, Republic of	2,736,868	2,916,660	3,131,580	3,134,093	3,063,505
South-West Africa, Territory of [9]	1,142,864	1,436,136	1,540,851	1,516,539	1,449,763
Sudan	----------	40	----------	NA	NA
Swaziland	120	130	130	29	----------
Tanzania (exports)	22,669	25,329	22,865	10,572	2,294
Tunisia	9,581	12,635	33,758	38,002	44,722
Uganda (exports)	9	----------	----------	----------	NA
Zambia [10]	846,317	1,445,934	848,819	[e] 750,000	[e] 750,000

See footnotes at end of table.

Table 15.—World production of silver, by countries [1] [2] [3] [4]—Continued

(Troy ounces)

Country [1]	1963	1964	1965	1966	1967 p
Asia:					
Burma	2,075,282	1,866,752	1,638,000	1,096,000	917,000
China, mainland [5]	800,000	800,000	800,000	800,000	600,000
India	128,314	152,234	168,308	39,223	93,108
Indonesia	279,840	252,930	298,777	220,779	309,000
Japan	8,812,068	8,714,748	8,988,801	r 10,318,703	10,833,532
Korea:					
North e	r 650,000	r 650,000	r 650,000	r 650,000	700,000
South	443,987	404,468	434,000	499,269	588,000
Philippines	838,304	907,504	933,938	1,162,889	1,396,268
Taiwan	61,440	60,633	87,315	79,473	115,794
Oceania:					
Australia	19,641,925	18,426,990	r 17,280,839	r 18,875,511	19,765,000
Fiji	46,870	60,564	60,470	67,499	61,335
New Guinea and Papua	23,696	23,206	19,664	18,052	17,176
New Zealand	286	141	55	2	----------
Total	11r 249,982,408	11 r 248,550,717	11 r 256,362,337	11 r 266,563,561	e 260,820,000

e Estimate. p Preliminary. r Revised. NA Not available, estimate included in 1967 total.
[1] A small amount of silver is produced in Bulgaria, Mozambique, Panama, Thailand, and Turkey.
[2] Content of ores and concentrates produced unless otherwise noted.
[3] Data derived in part from Yearbook of the American Bureau of Metal Statistics, annual issues of Metallgesellschaft, (Germany), and the Minerais et Metaux (France).
[4] Compiled mostly from data available June 1968.
[5] Estimate, according to annual issues of Metallgesellschaft (Germany) except 1967 which is an extension of the 1966 estimate.
[6] Smelter and/or refinery production from domestic and imported material.
[7] Production reported by Bolidens Gruvaktiebolag.
[8] Estimate according to annual issues of Minerais et Metaux (France) except 1967 which is an extension of the 1966 estimate.
[9] Recoverable silver in Tsumeb Corporation Ltd. concentrates as reported for year ended June 30 of year stated.
[10] Includes recovery from refinery sludges and blister copper.
[11] Total is of listed figures only; no undisclosed data included.

Table 16.—Canada: Geographical distribution of silver production

(Troy ounces)

Province or Territory	1966	1967 p
Alberta	17	12
British Columbia	5,548,823	5,492,062
Manitoba	547,797	647,824
New Brunswick	3,108,669	2,785,198
Newfoundland	1,097,425	1,056,734
Northwest Territories	1,662,192	1,439,124
Nova Scotia	540,663	89,238
Ontario	10,900,204	15,582,832
Quebec	5,214,146	4,921,250
Saskatchewan	603,358	642,272
Yukon Territory	4,194,580	3,769,533
Total	r 33,417,874	36,426,079

p Preliminary. r Revised.

Slag-Iron and Steel

By William R. Barton [1]

Demand for iron-blast-furnace slag products in 1967 equaled available supplies. Because of this, and continued prospects of increasing demand, open-hearth steel slags were increasingly used as a supplementary or substitute material.

An unusually high interest in slag processing and usage has been generated by the increased accent placed upon utilization of solid wastes and secondary raw materials and as part of the general desire to conserve resources and use available low-cost byproduct materials for the benefit of the economy.

DOMESTIC PRODUCTION

The 29.6 million tons of iron-blast-furnace slag processed during 1967 was the byproduct of pig iron production. Slag availability was reduced somewhat while several large furnaces were out of use for repair or modernization. A total of 61 air-cooled, 14 expanded, and 14 granulated blast-furnace slag processing plants were operated by 39 companies in 1967. Slag-encrusted iron, reclaimed magnetically by slag processors for remelting, amounted to 613,109 tons compared with 526,169 tons in 1966. The industry's 1,760 plant and yard employees worked a total of 3.9 million man-hours in 1967. Production was 7.6 tons per man-hour compared with 7.2 tons in 1966. Operations at one blast-furnace slag plant at Daingerfield, Tex., were described.[2]

The amount of steel slag, especially open-hearth slag, processed continued to increase, particularly in areas where blast-furnace slag supplies were not sufficient to meet demands. It is estimated that at least 10 million tons of steel slag were marketed in 1967, including 4.9 million tons by members of the National Slag Association.

[1] Commodity specialist, Division of Mineral Studies.

[2] Rock Products. Lone Star Plant Processes Slag. V. 70, No. 10, October 1967, p. 70.

Table 1.—Iron-blast-furnace slag processed in the United States, by types

(Thousand short tons and thousand dollars)

Year	Air-cooled				Granulated		Expanded		Total	
	Screened		Unscreened							
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1963	18,290	$32,408	689	$624	2,461	$1,663	2,251	$6,703	23,691	$41,398
1964	20,969	36,458	621	599	2,840	2,170	2,426	7,273	26,856	46,500
1965	22,531	39,624	1,402	1,270	3,550	[1] 2,674	2,596	7,879	30,079	51,447
1966	19,925	35,348	551	588	3,749	[1] 3,026	2,525	7,860	26,750	46,822
1967	22,326	39,204	1,053	800	3,760	[1] 2,834	2,456	7,262	29,593	50,101

[1] Excludes value of slag used for manufacturing hydraulic cement 1965–67; and granulated aggregate for concrete block manufacturing 1966–67.

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
1966:				
Ohio	4,326	$7,960	6,089	$11,687
Pennsylvania	5,181	9,737	6,821	12,172
Illinois, Indiana, Michigan	3,860	6,363	5,983	9,198
Other States [1]	6,558	11,288	7,857	13,765
Total	19,925	35,348	26,750	46,822
1967:				
Ohio	4,029	7,684	5,868	10,211
Pennsylvania	7,134	13,051	9,082	15,412
Illinois, Indiana, Michigan	4,642	7,391	6,519	11,001
Other States [1]	6,521	11,078	8,124	13,477
Total	22,326	39,204	29,593	50,101

[1] Alabama, California, Colorado, Kentucky, Maryland, Minnesota, New York, Texas, Utah, and West Virginia.

Source: National Slag Association.

Table 3.—Shipments of iron-blast-furnace slag in the United States, by methods of transportation

Method of transportation	1966		1967	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Rail	7,234	27	6,798	23
Truck	18,734	70	22,070	74
Waterway	782	3	725	3
Total	26,750	100	29,593	100

Source: National Slag Association.

CONSUMPTION AND USES

Of all blast-furnace slag sold or used, more than 87 percent went to products used in construction or maintenance of roads, buildings, railroads, or airports, or into construction accessories such as mineral wool. The balance was used in glass manufacture, as a sewage trickling filter medium, or agricultural slag. Several papers became available which discussed blast-furnace slag utilization.[3]

The exceptionally high skid resistance of slag resulted in considerably more use in highway surface courses during 1967. This trend is expected to continue strong in the future. The use of blast-furnace slag in roofing also increased significantly during the year.

Steel slags were used, either alone or blended with blast-furnace slag, for roadway base and fill, in bituminous mixtures, as railroad ballast, for agriculture, or miscellaneous uses. While steel slags do not have the universal application of blast-furnace slags, their antiskid properties and ability to provide good color contrast with light-colored shoulder materials suit them particularly well for bituminous mixtures. Agricultural use is also growing due to the relatively high P_2O_5 content of some steel slags and the presence of several trace elements important to agriculture.

[3] Bauman, E. W., and W. R. Barton. Utilization of Blast Furnace Slag as an All-Purpose Construction Aggregate. Soc. of Min. Eng. Preprint 67H48, AIME, New York, 1967, 7 pp.

National Slag Association. Slag, The All-Purpose Construction Aggregate. Washington, D.C., 1967, 28 pp.

Van der Vlist, A. A. Robur Makes 330,000 t.p.y. of Slag Cement. Miner. Processing, v. 8, No. 5, May 1967, pp. 20–23.

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	Screened			
	1966		1967	
	Quantity	Value	Quantity	Value
Aggregate in—				
Portland-cement concrete construction	3,105	$5,782	[1] 2,394	[1] $5,587
Bituminous construction (all types)	3,904	6,956	3,462	6,387
Highway and airport construction [2 3]	7,378	13,375	10,013	16,647
Manufacture of concrete block	426	715	426	739
Railroad ballast	3,512	4,796	4,103	5,908
Mineral wool	258	442	389	613
Roofing slag:				
Cover material	396	1,227	425	1,262
Granules	64	379	48	224
Sewage trickling filter medium	15	28	7	13
Agricultural slag, liming	3	6	2	3
Other uses [4]	864	1,642	1,057	1,821
Total	19,925	35,348	22,326	39,204

[1] In 1967 included 1,461,200 tons valued at $2,959,100 for use in structures and 933,000 tons valued at $2,628,100 for use in pavements.
[2] Other than in portland-cement concrete and bituminous construction.
[3] In addition 479,000 tons valued at $524,000 in 1966; 275,100 tons valued at $337,000 in 1967, unscreened.
[4] In addition 72,000 tons valued at $64,000 in 1966; 777,400 tons valued at $463,300 in 1967, unscreened.
Source: National Slag Association.

Table 5.—Granulated and expanded iron-blast-furnace slag sold or used by processors in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1966				1967			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Highway construction	1,721	$2,380	-----	-----	1,952	$2,440	-----	-----
Fill (road, etc.)	258	220	-----	-----			-----	-----
Agricultural slag, liming	79	121	-----	-----	69	115	-----	-----
Manufacture of hydraulic cement	1,101	NA	-----	-----	1,210	NA	-----	-----
Aggregate for concrete-block manufacture	208	NA	2,449	$7,593	267	NA	2,061	$6,030
Other uses	382	305	76	267	261	279	[1] 395	[1] 1,232
Total	3,749	[2] 3,026	2,525	7,860	3,760	[2] 2,834	2,456	7,262

NA Not available.
[1] Includes 320,000 tons valued at $967,500 for use in lightweight concrete.
[2] Excludes value for manufacture of hydraulic cement and granulated aggregate for concrete-block manufacture 1966–67.
Source: National Slag Association.

Table 6.—Steel slag sold or used by processors in the United States, in 1967 by uses [1]

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Railroad ballast	534	$498
Highway base or shoulders	897	720
Paved area base	1,412	995
Miscellaneous base or fill	883	654
Bituminous mixes	578	675
Agriculture	68	61
Other uses	564	385
Total	4,936	3,988

[1] Data represents steel slag processed as reported to the National Slag Association. Does not include tonnage returned to furnaces for charge material.
Source: National Slag Association.

PRICES

Prices for crushed slag (air-cooled, screened) used as aggregate were published monthly for major U.S. market areas in Engineering News-Record. In December 1967, quoted prices ranged from $1.16 to $2.50 per ton for both 1½-inch and ¾-inch crushed slag.

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: Screened 1966	Air-cooled: Screened 1967	Air-cooled: Unscreened 1966	Air-cooled: Unscreened 1967	Granulated 1966	Granulated 1967	Expanded 1966	Expanded 1967
Aggregate in—								
Portland-cement concrete construction	$1.86	$2.33	----	----	----	----	----	----
Bituminous construction (all types)	1.78	1.84	----	----	----	----	----	----
Highway and airport construction [1]	1.81	1.65	$1.10	$1.23	$1.38	$1.25	----	----
Manufacture of concrete block	1.68	1.73	----	----	----	1.41	$3.10	$2.92
Railroad ballast	1.37	1.44	----	----	----	----	----	----
Mineral wool	1.71	1.58	----	----	----	----	----	----
Roofing slag:								
Cover material	3.10	3.00	----	----	----	----	----	----
Granules	5.94	4.65	----	----	----	----	----	----
Sewage trickling filter medium	1.93	1.97	----	----	----	----	----	----
Agricultural slag, liming	1.67	1.87	----	----	1.53	1.57	----	----
Other uses	1.90	1.73	.88	.60	.80	1.06	3.49	[2] 3.53

[1] Other than in portland cement and bituminous construction.
[2] Does not include slag valued at $3.04 a ton for use in lightweight concrete.

Source: National Slag Association.

TECHNOLOGY

A new crusher, specially designed to reduce slag in order to facilitate reclamation of contained metal, has been introduced by Hammermills, Inc., of Cedar Rapids, Iowa. Called the Bulldog Exploder, the new machine utilized impact plus autogenous grinding in air suspension to reduce the more friable slag while contained metal particles remain essentially unreduced in size.

Use technology for several important areas were reviewed in several important papers.[4]

Results of Bureau of Mines research on heat content of slags and recovery of germanium and gallium from slags were published.[5]

[4] Klieger, Paul, and A. W. Isberver. Laboratory Studies of Blended Cements-Portland Blast-Furnace Slag Cements. J. of the Portland Cement Asso., v. 9, No. 3, September 1967, pp. 2–22.
National Slag Association. Slag for Use in Bituminous Concrete. NSA Bull. 167–2, 1967, 9 pp.
National Slag Association. Building Safer Highways With Slag. NSA Bull. 167–3, 1967, 17 pp.

[5] Foerster, E. F., and P. L. Weston, Jr. Heat Content of Some Blast-Furnace and Synthetic Slags. BuMines Rept. of Inv. 6886, 1967, 21 pp.
Waters, R. F., and H. Kenworthy. Extraction of Germanium and Gallium From Coal Fly Ash and Phosphorus Furnace Flue Dust. BuMines Rept. of Inv. 6940, 1967, 33 pp.

Sodium and Sodium Compounds

By Benjamin Petkof [1]

The domestic production of natural sodium carbonates (soda ash) and sulfates remained strong in 1967.

The underground trona deposits in the Green River, Wyo., area continued to be the center of activity for the expanding natural soda ash industry. To meet growing demands, major chemical companies were expanding and constructing plant facilities, and acquiring or exploring trona deposits in the Green River area rather than enlarging or building new plants to manufacture soda ash from salt.

DOMESTIC PRODUCTION

Total output in 1967 of natural and manufactured sodium carbonate (soda ash) decreased 5 percent in quantity from that of the previous year.

Manufactured soda ash, produced at 10 plants in six States, supplied 74 percent of the total available domestic supply. These plants were distributed geographically as follows: Two each in Louisiana, Michigan, Ohio, and Texas; and one each in New York and Virginia.

Natural soda ash, which was produced by American Potash and Chemical Corp., and Pittsburgh Plate Glass Co. from natural lake brines in California, and by FMC Corp. and Stauffer Chemical Co. near Green River, Wyo., from underground bedded trona supplied the remaining 26 percent of the total sodium carbonate market.

The FMC Corp. continued to be the largest domestic producer of natural soda ash and by the end of 1967 had reached annual plant capacity of about 1.25 million tons. The other active producers in the Green River area, Stauffer Chemical Co. and Allied Chemical Corp., were also increasing their plant capacities during the year.

Several firms were prospecting the area for future operations. Texas Gulf Sulphur Co. began shaft-sinking operations to develop its trona mine.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Manufactured sodium carbonate produced and natural sodium carbonates sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Manufactured soda ash (ammonia-soda process) [1]	Natural sodium carbonates [2]	
	Quantity	Quantity	Value
1963	4,682	1,119	$27,616
1964	4,948	1,275	30,451
1965	r 4,926	1,494	34,717
1966	r 5,090	1,738	40,674
1967	p 4,828	1,728	40,539

r Revised. p Preliminary.
[1] Bureau of the Census. Includes quantities used to manufacture caustic soda, sodium bicarbonate, and finished light and dense soda ash.
[2] Soda ash and trona (sesquicarbonate).

Table 2.—Sodium sulfate produced and sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Production (manufactured and natural)[1]		Sold or used by producers (natural only)	
	Salt cake [2] (crude)	Anhydrous refined (100 percent Na_2SO_4)	Quantity	Value
1963	837	396	435	$8,392
1964	926	389	575	10,989
1965	r 976	r 428	620	11,024
1966	r 1,009	r 436	640	11,271
1967	p 968	p 418	637	10,710

r Revised. p Preliminary.
[1] Bureau of the Census.
[2] Includes glauber salt converted to 100 percent Na_2SO_4.

Total production in 1967 of manufactured and natural sodium sulfate declined 4 percent from that of 1966. About 46 percent of the total output was produced from natural sources at four operations in Texas, three in California, and one in Wyoming. The remainder was recovered as byproducts of chemical processes.

In California, American Potash and Chemical Corp., and Stauffer Chemical Co. recovered sodium sulfate from dry lake brines at the Trona and Westend plants, respectively, and United States Borax and Chemical Co. recovered sodium sulfate at plants in Wilmington and San Francisco.

The Ozark-Mahoning Mining Company recovered salt cake from subterranean brines at its Brownfield, Monahans, and Seagraves operations in Texas. American Cyanamid Company operated a unit to recover sodium sulfate from waste water at its Fort Worth plant.

In Wyoming, William E. Pratt, recovered a small quantity of sodium sulfate from dry lake beds near Casper.

Production of sodium metal increased 8 percent from 151,588 tons in 1965 to 163,368 tons in 1966. In 1967, production increased slightly to 163,448 tons. Sodium and its coproduct chlorine was produced by electrolysis of molten salt by three companies at five plants: E. I. du Pont de Nemours & Co., Inc., at Niagara Falls, N. Y., and Memphis, Tenn.; Ethyl Corp., at Baton Rouge, La., and Houston, Tex., and Reactive Metals, Inc., owned jointly by U.S. Steel Corp., and National Distillers and Chemical Corp. at Ashtabula, Ohio.

CONSUMPTION AND USES

The consumption and use pattern of sodium carbonate, sodium sulfate, and sodium metal remained relatively unchanged from previous years. About two-fifths of total sodium carbonate production was used in the production of glass, about one-fourth in chemicals, and about one-tenth in pulp and paper. The remainder was used for miscellaneous purposes such as soap and detergents, aluminum production, and water treatment.

Kraft paper production continued to require the major portion of sodium sulfate production. Sodium sulfate was used also in the manufacture of glass, ceramic glazers, detergents, stockfeeds, dyes, textiles, medicines, and miscellaneous chemicals.

Metallic sodium was used primarily in the production of tetraethyl and tetramethyl lead compounds which are used as additives to motor fuels to improve their antiknock qualities. Possible areas for future increased consumption of sodium metal are in the reduction of titanium tetrachloride to titanium with sodium; the sodium-sulfate battery for electric cars; polyethylene-clad sodium-cored electrical conduction cable and sodium-cooled breeder-type nuclear reactors.

PRICES

Prices of sodium compounds showed some variation during the year. Prices quoted during the year in the **Oil, Paint** and Drug Reporter were as follows:

Commodity		Price
Sodium carbonate (soda ash 58 percent Na_2O):		
Light, paper bags, carlots, works	per hundred weight	$1.95
Light, bulk, carlots, works	do	1.55
Dense, paper bags, carlots, works	do	2.00
Dense, bulk, carlots, works	do	1.60
Sodium sulfate (100 percent Na_2SO_4):		
Technical, anhydrous, bags, carlots [1]	per ton	56.00
Technical detergent, rayon grade, bags, carlots, works	do	38.00
Technical detergent, rayon grade, bulk, works	do	34.00
Domestic salt cake, bulk, works [1]	do	28.00
National Formulary (N.F. VII), drums	per pound	.23
Metallic sodium:		
Bricks, carlots, works	do	.23
Fused, lots of 18,000 pounds and more, works	do	.21
Bulk, tank, works	do	.18

[1] Delivered east of the Mississippi River.

FOREIGN TRADE

Exports of sodium sulfate remained unchanged from 1966 with over 90 percent of the material shipped to Canada. About 2 percent of the total sodium sulfate output was exported.

Sodium carbonate exports represented about 5 percent of the U.S. total production of manufactured and natural sodium carbonate. About 80 percent of exported material was shipped to Canada, Mexico and Argentina.

Imports of sodium sulfate increased 22 percent over those of the previous year with all of the material coming from Canada, Belgium-Luxembourg, and West Germany.

At yearend new tariff rates were established for imports of sodium compounds effective January 1, 1968 as follows:

	Tariff rate per short ton
Sodium Carbonate:	
Calcined (soda ash)	$4.40
Hydrated and sesquicarbonate	4.00
Sodium sulfate:	
Crude (salt cake)	Free
Anhydrous	.40
Crystallized (glauber salt)	.90

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
1965	277	$9,030	13	$415
1966	346	12,249	28	779
1967	304	9,914	28	856

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
1965	261	$4,521	12	$242	273	$4,763
1966	223	3,769	13	205	237	3,981
1967	273	4,312	15	190	288	4,506

[1] Includes glauber salt, as follows: 1965, 1 ton ($262); 1966, 602 tons ($6,981); 1967, tons NA ($4,069).

WORLD REVIEW

Canada.—During 1966, four companies operating five plants in Saskatchewan produced almost all of the 401,940 tons of sodium sulfate which was primarily used by the kraft paper industry. A small quantity of material was produced in Ontario. Production from two additional plants was expected in 1967 increasing capacity by 200,000 tons.

Chile.—The Cia. Salitrera Anglo Lautaro of Chile, announced that 200,000 tons of sodium sulfate would be produced annually.[2]

Korea, South.—A soda ash plant with a capacity of 200 tons per day will be built at Inchon. The Oriental Chemical Industry of the Republic of Korea has placed an order with a Japanese manufacturer for the production of the necessary facilities.[3]

TECHNOLOGY

Results were published describing a barium cation-exchange resin method for sulfate removal from brines and bitterns of the Great Salt Lake and sea water. The process allows the recovery of other compounds, such as sodium carbonate, as coproducts. Preliminary studies indicate that this process is economically feasible.[4]

Cable for the conduction of electricity has been made by filling tough polyethylene tubing with sodium metal. Test installations of this cable have been made by electric utilities in various parts of the country. If accepted for power distribution, sodium can displace more expensive copper for this use.

Research was continued to develop a sodium sulfur battery primarily to power an up-to-date model of the old-time electric automobile.[5]

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[2] Mining Journal (London). The Industry In Action. Cut in Chilean Nitrate Output. V. 268, No. 6856, Jan. 13, 1967, p. 31.

[3] Oil, Paint and Drug Reporter. Soda Ash Unit for Korea To Be Built by Japanese. V. 191, No. 12, Mar. 20, 1967, p. 36.

[4] D'Arcy R., George., J. M. Riley, and Laird Crocker. Preliminary Process Development Studies for Desulfating Great Salt Lake Brines and Sea Water. BuMines Rept. of Inv., 6928, 1967, 34 pp.

[5] American Metal Market. New Markets Brighten Future of Metal Sodium. V. 74, No. 93, May 16, 1967, pp. 1,-7.

Stone

By William R. Barton [1]

Domestic production of stone in 1967 was 786 million tons valued at $1.2 billion, compared with 813 million tons valued at $1.3 billion in 1966. Factors adversely influencing demand for stone during the year included high interest rates on construction loans and mortgages, revised Government construction allocations due to other budgetary priorities, and unfavorable weather that slowed construction. The environmental effects of surface mining operations were of great concern. Stone operations accounted for 8 percent of the land affected by surface mining in the United States, a share exceeded only by coal, sand, and gravel.

Table 1.—Salient stone statistics in the United States [1]

(Thousand short tons and thousand dollars)

	1963	1964	1965	1966	1967
Sold or used by producers:					
Dimension stone	2,616	2,545	2,403	2,327	2,011
Value	$96,318	$96,970	$92,235	$89,814	$95,472
Crushed stone	685,750	723,038	777,839	811,047	783,581
Value	$971,790	$1,037,594	$1,111,596	$1,170,901	$1,144,772
Total stone	688,366	725,583	780,242	813,374	785,592
Value	$1,068,108	$1,134,564	$1,203,831	$1,260,715	$1,240,244
Exports (value)	$6,102	$6,796	$7,599	$9,442	$9,400
Imports for consumption (value) [2]	$18,978	[3] $23,753	[3] $20,414	[3] $20,739	$19,823

[1] Includes slate.
[2] Includes whiting.
[3] Data not comparable with other years.

Legislation and Government Programs.—The results of the Kennedy Round of the General Agreement on Tariff and Trade (GATT) were published in "Tariff Schedule of the United States" (TSUS).[2] Almost all tariff reductions on stone items were to accrue in five approximately equal annual steps. In most cases, the ultimate effect on stone imports will be to cut 1967 rates in half by 1972. Public Law 90–14, 90th Congress, removed the import tariff on TSUS item 513.34, limestone to be used in the manufacture of cement.

Depletion rate changes on clam and oystershells became effective in 1967 as a result of Public Law 89–809. For shell extracted and used for riprap, road material, rubble, etc., the depletion allowance remained at 5 percent. For other uses, however, the rate was raised to 15 percent.

The results of the Department of Interior study of the environmental effects of strip and surface mining were published.[3] The study reviewed current surface mining, environmental impact, problems, goals, present law, and recommended future action to minimize environmental problems. The report stated that stone mining operations were responsible for 8 percent of the land disturbed by surface mining in the United States. The problem, as specifically related to stone quarries, was discussed further in a magazine article.[4]

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[1] Geologist, Knoxville Office of Mineral Resources, Bureau of Mines, Knoxville, Tenn.; formerly commodity specialist, Division of Mineral Studies.
[2] U.S. Tariff Commission. Tariff Schedule of The United States Annotated 1968. Pub. 222, 1967, pp. 280–281.
[3] U.S. Department of the Interior. Surface Mining and Our Environment, A Special Report to the Nation. Washington, D.C., 1967, 124 pp.
[4] Barton, William R. Prescription for Stone Quarries: Planning, Research and LSD (Logical Sequential Development). Rock Products, v. 70, No. 12, December 1967, pp. 67–70.

DIMENSION STONE

Trends and Developments.—Diversity was the keynote for dimension stone in 1967. An increased range of colors, sizes, fabrics, forms, and finishes became available for aesthetic expression in architecture. Lighter and more effective sandwich panels and veneers and more efficient handling and anchorage also contributed to product success. Architects took increasing advantage of the available materials by devising new ways to avoid the sterile concrete-and-glass-box approach to buildings that has contributed to the drabness of many cities. Precasting of stone-faced sandwich panels permits fabrication of facing for the panels in more than one piece. Desired angles, curves, or bevels are cut; then the facing is fabricated by bonding with epoxy resin.

Increasing use of two or more types of stone in one building was a notable trend. Limestone, granite, marble, and slate were effectively combined by architects Jeter and Cook in a new home office addition for the Hartford Steam Boiler Inspection and Insurance Co. in Hartford, Conn. The American Savings Association headquarters in Wichita, Kans., was designed by Schaefer, Schirmer, and Eflin in marble, slate, and glass to combine function and appearance. A unique feature is the "coursed random pattern" used in designing the marble veneer, achieving diagonal joints in place of the standard rectangular jointing of most building fronts.

DOMESTIC PRODUCTION

Dimension stone production was marked by the abundant assortment of stone varieties, finishes, and forms available. In 1967, of the total quantity of dimension stone sold or used by producers 31 percent was granite, 27 percent limestone, 17 percent sandstone, 11 percent miscellaneous stone, 7 percent slate, 4 percent marble, and 3 percent basalt.

Marble production began in Nevada at the White Pine County quarries of Western Marble Co. Initial shipments of blocks to the cutting plant at Gene, Nev., were reported.[5]

While modernization and innovation were general industry axioms, in some instances older equipment and methods were put to good use. One producer uses old-time steam-channeling machines in his quarry, although now gas-fired burners supply the needed heat.[6] Local lore states that certain of the machines date back to the construction of the Panama Canal.

CONSUMPTION AND USES

The total value of dimension stone sold or used during the year comprised 64 percent building stone, 25 percent monumental stone, and 11 percent other stone. If all uses of dimension stone are considered, popularity by variety was granite, limestone, sandstone, slate, marble, and basalt. For monumental purposes granite represented 83 percent and marble 17 percent.

Two noteworthy uses of stone were described. One was the use of translucent marble panels in a new Atlanta department store.[7] This introduced to large commercial buildings a type of stone used previously limited almost exclusively to institutional and educational type buildings. Another article described the blending of more than 80 types of stone in a mural in the Notre Dame Memorial Library.[8]

PRICES

Delivered prices for dimension stone are of almost infinite range depending upon stone variety, finish, form, and locations. Values reported to the Bureau of Mines will, however, give some insight into average relative costs by stone variety and end use (value in dollars per ton):

	Building		*Monumental*
	Rough	Dressed	Rough and dressed
Granite	$3.45	$14.80	$7.20
Marble	3.25	24.00	18.00
Limestone	1.60	3.40	....
Sandstone	3.00	3.10	....

[5] Mining Congress Journal. Western Marble Co. V. 53, No. 4, April 1967, p. 10.
[6] Bottge, R. G., A Look At the Largest Dimension Stone Producer. Rock Products, v. 70, No. 4, April 1967, pp. 90–93.
[7] Stone Magazine. Lighting Accentuates Translucent Marble. V. 87, No. 2, February 1967, p. 20.
[8] Winkler, E. M. Word of Life Stone Mural Dominates Notre Dame Library. Stone Magazine, v. 87, No. 10, October 1967, pp. 17–19.

FOREIGN TRADE

In 1967, Canada was the destination of 57 percent of U.S. building and monumental stone exports.

Fancy marbles continued to be the most highly valued import items. The leading source nations were Italy and Portugal.

WORLD REVIEW

South Africa, Republic of.—Jet channeling was used in South Africa for the first time by Marikana Granite Quarries at Belfast, Eastern Transvaal.[9]

United Arab Republic.—The use of resin to facilitate lifting of stone blocks at Abu Simbel was described.[10] Resins were used both as mortar to cement anchor rods in the stone and as reinforcing injections and coatings to strengthen porous or friable stone, or to fill hairline cracks. Techniques developed and compounds formulated may be useful for fortifying and handling delicate building stones.

United Kingdom.—Some of the causes and mechanisms of decay in building stone were discussed.[11] In particular, the relationship of microorganisms to accelerated weathering was considered. The presence of sulfur-oxidizing organisms was found to be widespread and it was stated they will produce sulfuric acid to attack stone even in nonindustrial environments.

TECHNOLOGY

A quiet revolution in stone processing technology continued during the year. Advances in equipment automation, new machine designs, and increased use of diamonds in cutting and grinding operations were prime factors in facilitating the cheaper, quicker, and more effective handling and finishing of stone. Flame-jet channeling for primary quarry cuts, improved wire saws in both quarries and plants, and automated production line grinding and polishing equipment had increasing impact. The widening use of diamond abrasives has had the broadest effect on the stone industry. Diamond core drills are employed in prospecting. Diamond-set gang saws and circular saws cut the stone blocks to approximate size and shape with a several-fold increase in speed. Diamond grinding heads bring the stone to close tolerances. In addition to speed, the new tools are precise and waste little stock. At the same time, the need for abrasive grain inventories is reduced.

CRUSHED STONE

Trends and Developments.—Increased size of individual equipment items and total plant capacity key noted industry trends in 1967. Design, labor, and maintenance costs were proportionately less with king-sized equipment and plants. To serve large metropolitan areas, huge plants that feature centralized control provided great efficiency. Portable aggregate plants are particularly adaptable for servicing jobs such as highway construction where the delivery site may move away from the plant or where only a limited market in time is foreseen, and for exploiting smaller deposits where resource depletion is an early prospect. Larger scale portable plants have been achieved by unitization of equipment; that is, each operating unit is transported independently and assembled into a complete plant by interconnecting the units at the selected quarry site. In addition to providing portability for larger plants, the unitized plant concept offers flexibility by permitting selective changes of equipment to vary capacity or alter product specifications. A trend in an early stage of development is the application of automated circuit control to take full advantage of central plant control installations.

Although the accelerating development of metropolitan areas has resulted in rapidly increasing markets for crushed stone, it carries with it problems involving zoning regulations, air and water

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[9] The South African Mining & Engineering Journal (Johannessburg). Rocket Jet Cuts S. A. Granite. V. 78, pt. 1, No. 3864, Feb. 24, 1967, p. 439.

[10] Stone Magazine. Epoxy Resins In Restoration of Abu Simbel. V. 87, No. 3, March 1967, pp. 11–13.

[11] Pochon, J., and C. Jaton. Causes of the Deterioration of Building Materials. Part II, The Role of Microbiological Agencies in the Deterioration of Stone. Chem. and Ind. (London), No. 38, Sept. 23, 1967, pp. 1587–1589.

Schaffer, R. J. Causes of the Deterioration of Building Materials. Part I, Chemical and Physical Causes. Chem. and Ind. (London), No. 38, Sept. 23, 1967, pp. 1584–1586.

pollution, and strict land rehabilitation requirements. The industry has adopted many measures to be a better neighbor. Green screens, landscaping, and plant and equipment enclosures suppress noise and dust and provide a more attractive appearance. Dust collectors and settling ponds reduce air and water pollution to acceptable levels. Blasting practices are controlled with noise and ground shock suppression in mind, and full advantage is taken of possibilities for improved community relations. A necessary part of quarry planning is the post-mineral-extraction use of the land. The quarry site can be developed so that it will provide a more beneficial service to the community than was possible prior to quarrying activity. One other solution is quarrying stone underground in metropolitan areas. The social desirability and the economic feasibility of such a course were discussed in a journal article.[12]

DOMESTIC PRODUCTION

Crushed stone production failed to post sizable gains for the first time in many years. The quantity produced declined from 811 million tons in 1966 to 784 million in 1967.

The effect of rising costs on profits, product quality control, and environmental problems were of continued concern. The control of dust to avoid air pollution, was a major operating problem encountered in the production of crushed stone. The problem, as far as the crushed stone producer is concerned, is simply to suppress, collect, or avoid generation of airborne dust during his operations. The means are at hand to do this; it is only a matter of their wise utilization.[13]

The deepest underground stone production facility was described.[14] The mine, at Barberton, Ohio was of special interest since it is typical of underground stone mines producing over 1 million tons per year. It features the largest loaders used underground anywhere in the world.

CONSUMPTION AND USES

A new synthetic white mineral aggregate called "Sinopal" was marketed by Martin Marietta Corp. It was produced by fusing a mixture of sand, limestone, and dolomite in a kiln. The product combines skid resistance properties with high reflectivity.

Much material that the stone producer considers waste can be used by blending borderline or substandard aggregates with a few percent lime. Articles were published on techniques and case histories.[15]

The use of limestone to combat air pollution or neutralize acid stream waters was increasingly recognized as offering the advantage of potentially low costs. Bureau of Mines research conducted on acid mine waters showed that coarse limestone, one of the cheapest neutralizing agents known, had potential use when contacting acid water during abrasive agitation.[16] The use of limestone to reduce sulfur dioxide in stack gases from burning coal showed promise as one means of combating that serious air pollutant. Contacting hot flue gases with powdered limestone or dolomite has been suggested as probably superior to premixing the limestone with the coal to be burned.[17]

PRICES

Aggregate prices for various United States cities are regularly quoted in Engineering News-Record. In December 1967, typical prices, per ton of crushed stone, were as follows:

	1½ inch	*¾ inch*
Boston	$1.85	$1.88
Dallas	2.57	2.77
San Francisco	2.80	2.80

[12] Dunn, J. R., W. A. Wallace, and A. Baisuck. Underground Stone Production: The Answer to Many Problems? Pit and Quarry, v. 59, No. 10, April 1967, p. 183–186, 202.

[13] Hankin, Montagu, Jr, Is Dust The Stone Industry's Next Major Problem? Rock Products, v. 70, No. 4, April 1967, pp. 80–84, 110.

Metzger, C. L. Dust Suppression and Drilling With Foaming Agents. Limestone, v. 4, No. 11, Spring 1967, pp. 24–25, 43.

[14] Bergstrom, J. H. The Monsters at 2,200 Feet. Rock Products, v. 70, No. 3, March 1967, pp. 80–82, 110.

[15] Roads and Streets. Lime Helps Pave Durably With Substandard Hotmix Stone. V. 110, No. 7, July 1967, pp. 34–40.

Rock Products. How To Spike Marginal Aggregates. V. 69, No. 7, July 1966, pp. 82–84, 121.

[16] Deul, Maurice, and E. A. Mihok. Mine Water Research. Bur. of Mines Rept. of Inv. 6987, 1967, 24 pp.

[17] Minerals Processing. Limestone as an Aid in Air Pollution Control. V. 8, No. 2, February 1967, pp. 6, 8.

For industrial uses, ground stone was much higher in price. Typical price ranges for fillers and extenders per ton, quoted in the American Paint Journal, follow:

Silica, crystalline	$20.50–$45.40
Silica, amorphous, 325-mesh	28.00–55.10
Silica, amorphous, ultra-fine-ground	65.00
Whiting, natural water ground	37.00
Whiting, dry ground, 325-mesh	14.00–19.00

Typical prices for special roofing or facing granules were $7 to $15 per ton, and special sizes or types and terrazzo aggregates were quoted as high as $30 to $70.

FOREIGN TRADE

Canada continued to be the major destination for crushed stone exports from the United States, receiving in 1967, 86 percent of the total.

Crushed stone imports included stone chips from Canada and Europe, oolitic aragonite from the Bahamas, and whiting from Europe. Imported crushed limestone from Canada is a principal raw material for cement and lime manufacture in the Pacific Northwest.

WORLD REVIEW

Canada.—Industrial Minerals of Canada purchased the St. Donat, Quebec silica (quartzite) operation of Simsil Mines.

France.—A digital computer system installed near Lyon performs a quarry scheduling function by selecting limestone from various blocks to blend a proper cement plant feed.[18]

Israel.—The technical aspects of quarrying in the principal stone quarries were described.[19]

New Zealand.—Scoria, basalt, and graywacke quarries on North Island were described.[20]

United Kingdom.—Extraction and processing of chalk in Lincolnshire was described.[21] A modern crushing and screening plant was erected at Dene quarry, Derbyshire, the site of an earlier dimension stone operation. Special features include an asphalt coating plant.[22]

TECHNOLOGY

The first comprehensive book in 30 years on the chemistry and technology of lime and limestone was published.[23] A catalog of information for scientists and engineers and an expert insight into the economics and structure of the industry are provided by the volume.

Modern crushed stone plants being built today show no radical departures from convention. Each may have a few novel features, and certainly there is a trend toward larger equipment units, but technologic change in this industry is not dramatic. In addition to larger equipment units, efficient production scheduling was recognized as a means of avoiding costly overtime pay and plant shutdowns. A description of a linear programing technique to solve production scheduling problems was presented.[24] Complete computerization offers possibilities in product specification and blending control and in balancing plant operation for optimum efficiencies. The importance of quality control involving size gradation and distributions for construction aggregates was described.[25]

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18 Lebel, Francois, A. M. Guy, and D. E. Hamilton. Computer Direction of Quarry Operations. Pit and Quarry, v. 59, No. 9, March 1967, pp. 106–112.

19. Fish, B. G. Quarry in Israel. The Quarry Managers' J. (London), v. 51, No. 4, April 1967, pp. 133–142.

20 Fish, B. G. Quarry in New Zealand. The Quarry Managers' J. (London), v. 51, No. 3, March 1967, pp. 77–84.

21 Cement, Lime and Gravel (London) Feeding and Screening Chalk. V. 42, No. 7, July 1967, pp. 217–219.

22 The Quarry Managers' Journal (London). New Outlets for a Derbyshire Limestone Operation. V. 51, No. 9 September 1967, pp. 325–330.

23 Boynton, R. S. Chemistry and Technology of Lime and Limestone. Interscience Publishers, New York, 1966, 520 pp.

24Manula, C. B., and Y. C. Kim. Optimum Production Planning. Preprint 67 AR 34, pres. at the ann. meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers, Los Angeles, Calif., Feb. 19–23, 1967, 25 pp. available from AIME, New York.

25 Copas, T. L. Crushed Stone. Limestone, v. 4, No. 13, Fall 1967, pp. 14–15, 35, 37, 39.

The cost of breaking rock, from quarry blasting to fine crushing and grinding, is one of the principal components determining crushed stone prices and profits. Potential savings from even modestly improved technology therefore are substantial. This has led to a considerable amount of in depth research. Fundamentally, rock breakage is achieved through mechanically or thermally induced stresses or combinations of the two. Most research has been done in, and most stone is broken by, mechanical stress.[26] Rock breakage while tunneling beneath urban areas is of special concern. A major factor in reducing costs and avoiding deleterious side effects, such as noise and vibration from blasting, has been the continued development of tunneling machines.[27]

Loading and transportation innovations feature large, rubber-tired equipment—not only bigger trucks, but huge articulated loaders. Some of these, such as the Michigan Model 475, are called "articulated rock shovels" and are equipped with 12-cubic-yard buckets. Such a machine can fill an 85-ton hauler in five passes. Other interesting developments include the vari-flow bin gate developed by General Tire and Rubber Co. to closely control quantity or permit measured discharge rate of granular materials from storage or transportation units. The use of economical subterranean conveyor systems to reclaim stockpiled material was described in the literature.[28]

[26] Geller, L. B. Research in Improved Methods of Rock Breakage. Trans. Inst. Min. and Met. (London), v. 76, sec. A, No. 728, July 1967, pp. A105–A124.

[27] Howard, T. E. Rapid Excavation. Sci. American, v. 217, No. 5, November 1967, pp. 74–85.

[28] Matthews, C. W. Economical reclaiming--try subterranean conveyors. Rock Products, v. 70, No. 2, February 1967, pp. 98, 101, 102, 104–106.

Table 2.—Stone sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	1966 Quantity	1966 Value	1967 Quantity	1967 Value
Alabama	[1] 20,744	[1] $36,839	18,371	$33,346
Alaska	W	W	W	W
Arizona	2,271	4,091	1,910	3,491
Arkansas	19,109	24,588	17,454	23,236
California	43,051	61,336	37,186	55,263
Colorado	7,031	11,331	2,992	5,485
Connecticut	5,618	10,482	5,097	10,141
Delaware	210	525	210	525
Florida	35,023	38,167	[1] 33,971	[1] 38,723
Georgia	24,690	48,193	23,418	49,953
Hawaii	5,079	9,482	4,100	7,207
Idaho	2,694	5,415	1,986	4,833
Illinois	46,157	60,961	48,458	66,757
Indiana	24,323	42,474	26,977	46,725
Iowa	27,729	40,081	26,133	37,912
Kansas	14,027	18,789	13,551	17,806
Kentucky	22,667	31,179	24,812	35,481
Louisiana	[1] 8,091	[1] 11,253	7,599	11,174
Maine	1,092	3,622	1,159	2,999
Maryland	13,868	27,229	14,479	28,581
Massachusetts	6,424	17,624	6,203	17,724
Michigan	37,864	40,380	36,432	39,910
Minnesota	4,901	11,688	4,160	11,442
Mississippi	[1] 1,532	[1] 1,641	1,879	2,055
Missouri	35,240	53,393	36,585	53,953
Montana	4,150	5,212	4,782	6,037
Nebraska	5,055	7,916	4,846	7,483
Nevada	2,002	2,519	1,375	2,145
New Hampshire	206	2,091	473	2,887
New Jersey	12,453	28,056	12,611	28,253
New Mexico	2,652	4,056	1,391	2,403
New York	34,130	54,543	33,389	56,615
North Carolina	[1] 22,377	[1] 36,136	24,507	41,488
North Dakota	170	305	596	1,092
Ohio	45,002	72,900	45,458	72,534
Oklahoma	15,334	17,393	16,355	18,932
Oregon	33,288	48,335	13,201	20,256
Pennsylvania	59,088	99,233	60,155	103,157
Rhode Island	535	1,734	481	1,618
South Carolina	8,129	12,510	8,310	[1] 12,366
South Dakota	2,186	7,995	1,866	9,694
Tennessee	[1] 31,260	[1] 41,432	[1] 31,463	[1] 41,958
Texas	43,578	56,659	49,424	61,577
Utah	2,246	4,269	1,831	4,108
Vermont	2,650	19,926	2,761	20,520
Virginia	34,151	55,550	31,324	52,470
Washington	13,250	20,273	14,454	19,099
West Virginia	[1] 9,738	[1] 16,354	[1] 9,445	[1] 16,447
Wisconsin	16,150	23,735	17,122	24,863
Wyoming	1,393	2,560	1,246	2,375
Undistributed	2,766	8,260	1,602	5,144
Total [2]	813,374	1,260,715	785,592	1,240,244
American Samoa	12	12	28	50
Guam	900	1,396	511	820
Panama Canal Zone	114	267	100	245
Puerto Rico	5,732	10,541	7,269	12,795
Virgin Islands	88	303	183	851
Wake Island	11	66	31	150

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

[1] To avoid disclosing individual company confidential data, certain State totals are incomplete, the portion not included being combined with "Undistributed." The class of stone omitted from such State totals is noted in the State tables in the Summary chapter of this volume.

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

Table 3.—Stone sold or used by producers in the United States, by kinds

(Thousand short tons and thousand dollars)

Year	Granite		Basalt and related rocks (traprock)		Marble		Limestone and dolomite		Shell	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1963	48,793	$103,633	72,958	$111,538	1,902	$34,567	489,243	$680,060	19,019	$29,420
1964	56,331	114,465	66,090	108,929	2,093	36,693	511,026	713,675	19,493	30,157
1965	60,028	121,147	75,529	121,278	2,172	38,662	554,936	765,927	21,560	34,314
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
	Calcareous marl		Sandstone		Slate		Other stone [1]		Total [2]	
1963	1,164	989	28,978	58,015	902	11,365	25,407	38,521	688,366	1,068,108
1964	1,043	899	28,169	62,087	1,303	13,695	40,035	53,964	725,583	1,134,564
1965	1,291	1,125	29,097	61,710	1,263	13,697	34,366	45,971	780,242	1,203,831
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

[1] Includes mica schist, conglomerate, argillite, various light-colored volcanic rocks, serpentine not used as marble, soapstone sold as dimension stone, etc.
[2] Data may not add to total shown due to independent rounding.

Table 4.—Dimension stone sold or used by producers in the United States, by uses

Use	1966			1967		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	185	--------	$2,071	235	--------	$5,325
Architectural	287	3,854	6,137	273	3,640	6,257
Dressed:						
Sawed	455	5,963	17,335	270	3,530	15,952
Cut [1]	209	2,632	24,410	244	3,141	25,966
Rubble	528	--------	1,879	338	--------	1,583
Roofing (slate)	23	--------	2,243	21	--------	2,202
Millstock (slate)	26	--------	3,675	24	--------	3,801
Monumental (rough and dressed) [2]	252	3,102	22,096	238	2,920	23,416
Paving blocks	5	--------	158	6	--------	173
Curbing	156	1,901	4,689	167	2,037	4,956
Flagging [3]	201	1,042	5,121	130	--------	3,532
Miscellaneous uses (slate)	------	--------	--------	64	--------	2,309
Total [4]	2,327	--------	89,814	2,011	--------	95,472

[1] Includes a small quantity of stone for precision surface plates and monumental work.
[2] Includes stone for precision surface plates.
[3] Includes a small quantity of slate for miscellaneous uses in 1966.
[4] Data may not add to totals shown due to independent rounding.

Table 5.—Granite (dimension stone) sold or used by producers in the United States, by uses

Use	1966			1967		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	55	--------	$640	75	--------	$687
Architectural	22	257	1,054	39	462	1,594
Dressed:						
Construction	12	150	872	45	552	6,334
Architectural	60	726	7,884	21	252	5,581
Rubble	84	--------	387	59	--------	287
Monumental: [1]						
Rough	191	2,370	10,005	165	2,036	9,271
Dressed	43	520	8,256	55	661	10,144
Paving blocks	5	--------	158	6	--------	173
Curbing and flagging	154	1,870	4,591	166	2,023	4,929
Total [2]	626	--------	33,847	630	--------	39,000

[1] Includes stone for precision plates.
[2] Data may not add to totals shown due to independent rounding.

Table 6.—Granite (dimension stone) sold or used by producers in the United States in 1967, by State

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
California	7	9,838	$1,113,415	Oklahoma	9	12,016	$949,421
Colorado	4	1,160	41,840	South Carolina	3	14,700	W
Georgia	29	151,812	4,153,520	South Dakota	6	26,349	6,117,018
Maine	6	6,668	733,475	Texas	3	53,134	2,618,044
Minnesota	16	22,462	3,794,694	Wisconsin	11	9,504	2,198,558
Missouri	1	2,047	245,556	Other States [1]	30	259,795	13,643,498
New Mexico	1	40	15,000				
New York	4	22,127	488,837	Total	138	629,817	38,999,583
North Carolina	8	38,165	2,886,707	Puerto Rico	3	16,300	49,600

W Withheld to avoid disclosing company confidential data; included with "Other States."
[1] Includes plants in Connecticut (3); Massachusetts (9); New Hampshire (2); Pennsylvania (3); Rhode Island (2); Vermont (9); Washington (2).

Table 7.—Marble (dimension stone) sold or used by producers in the United States,[1] by uses

Use	1966			1967		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough: Architectural	17	203	$744	15	175	$568
Dressed:						
Sawed	20	228	1,935	11	126	1,507
Cut	28	328	7,905	30	353	10,011
Monumental (rough and finished)	18	212	3,835	19	221	4,000
Total [2]	83	-------	14,419	74	-------	16,086

[1] Produced by the following States in 1967 in order of value of output and with number of plants: Georgia (1); Vermont (8); Missouri (4); Tennessee (9); Alabama (1); North Carolina (1); Montana (3); Arkansas (2); New Mexico (2); Washington (4); Arizona (2); Colorado (1); California (2); Texas (1).
[2] Data may not add to totals shown due to independent rounding.

Table 8.—Limestone (dimension stone) sold or used by producers in the United States, by uses

Use	1966 Thousand short tons	1966 Thousand cubic feet	1966 Value (thousands)	1967 Thousand short tons	1967 Thousand cubic feet	1967 Value (thousands)
Building:						
Rough:						
Construction	57	--------	$364	38	5	$396
Architectural	206	2,838	3,510	190	2,602	3,688
Dressed:						
Sawed [1]	243	3,235	7,130	187	2,508	5,909
Cut	72	952	6,464	69	904	6,006
Rubble	129	--------	654	52	26	405
Curbing and flagging	21	272	148	26	335	147
Total [2]	728	--------	18,270	561	6,380	16,552

[1] Includes house stone veneer.
[2] Data may not add to totals shown due to independent rounding.

Table 9.—Limestone (dimension stone) sold or used by producers in the United States in 1967, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
Illinois	3	5,338	$109,970	Nebraska	3	10,989	$59,988
Indiana	22	349,099	10,772,336	Ohio	3	6,132	51,276
Iowa	3	12,420	248,529	Oklahoma	5	2,646	35,248
Kansas	8	6,906	507,610	Utah	1	500	15,000
Michigan	3	3,241	61,150	Wisconsin	27	82,716	1,455,945
Minnesota	7	24,634	1,987,151	Other States [1]	15	56,231	1,198,240
Missouri	4	W	49,100				
Montana	1	68	600	Total	105	560,920	16,552,143
				Puerto Rico	3	101,450	292,750

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes plants in Alabama (1); California (2); Colorado (2); Florida (1); Idaho (1); New York (2); Rhode Island (1); South Dakota (1); Texas (3); and Wyoming (1).

Table 10.—Limestone sold by producers in the Indiana oolitic limestone district, by classes

Year	Construction: Rough blocks Thousand cubic feet	Rough blocks Value (thousands)	Sawed and semifinished [1] Thousand cubic feet	Sawed and semifinished [1] Value (thousands)	Cut Thousand cubic feet	Cut Value (thousands)
1963	2,183	$2,533	2,518	$5,217	530	$2,258
1964	3,035	3,535	[2] 2,752	[2] 5,770	400	2,624
1965	2,651	3,095	[2] 2,052	[2] 4,503	481	3,091
1966	2,648	3,266	[2] 2,078	[2] 4,721	523	3,547
1967	2,424	3,202	[2] 1,755	[2] 4,283	464	3,254

Year	Construction—Continued: Total [3] Thousand cubic feet	Total [3] Thousand short tons	Total [3] Value (thousands)	Other uses Thousand short tons	Other uses Value (thousands)	Total [3] Thousand short tons	Total [3] Value (thousands)
1963	5,231	379	$10,008	197	$640	576	$10,648
1964	6,187	449	11,929	71	225	520	12,154
1965	5,184	376	10,689	70	224	446	10,913
1966	5,249	380	11,534	[2] 60	[2] 203	440	11,737
1967	4,643	337	10,740	[2] 12	[2] 32	349	10,772

[1] Includes house stone veneer.
[2] Includes small quantity produced outside the district.
[3] Data may not add to totals shown due to independent rounding.

Table 11.—Sandstone (dimension stone) sold or used by producers in the United States, by uses

Use	1966 Thousand short tons	1966 Thousand cubic feet	1966 Value (thousands)	1967 Thousand short tons	1967 Thousand cubic feet	1967 Value (thousands)
Building:						
Rough:						
Construction	58	--------	$918	68	111	$1,139
Architectural [1]	42	556	829	37	493	716
Dressed:						
Sawed [1]	129	1,749	4,704	118	1,627	4,374
Cut	44	564	1,644	26	332	1,733
Rubble	72	--------	289	40	53	344
Curbing	2	31	98	1	15	41
Flagging	58	714	1,621	56	675	1,995
Total	405	--------	10,103	346	--------	10,342

[1] Includes stone for refractory use to avoid disclosing individual company confidential data.

Table 12.—Sandstone (dimension stone) sold or used by producers in the United States in 1967, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
Arizona	11	4,609	$93,253	New Mexico	6	849	$5,475
Arkansas	6	8,965	265,971	New York	12	40,825	1,641,528
California	7	6,283	W	Ohio	15	125,794	4,691,241
Colorado	26	13,783	213,572	Oregon	1	335	6,700
Connecticut	3	8,920	55,065	Pennsylvania	32	74,988	1,571,971
Indiana	6	10,898	288,335	Tennessee	7	13,337	402,186
Kansas	1	141	3,800	Utah	9	1,665	56,855
Massachusetts	2	1,393	141,488	Wisconsin	9	2,826	50,231
Michigan	2	2,770	16,690	Wyoming	3	982	18,610
Minnesota	1	46	6,000	Other States [1]	23	25,044	776,879
Missouri	1	1,500	36,000				
Montana	1	25	625	Total	184	345,978	10,342,475

W Withheld to avoid disclosing individual company confidential data; included wtih "Other States."
[1] Includes plants in Georgia (2); Maryland (3); Nevada (2); New Jersey (1); South Dakota (2); Texas (2); Virginia (3); Washington (6); and West Virginia (2).

Table 13.—Slate (dimension stone) sold or used by producers in the United States,[1] by uses

Use	1966 Quantity Thousand short tons	1966 Quantity Thousand sq. ft.	1966 Value (thousands)	1967 Quantity Thousand short tons	1967 Quantity Thousand sq. ft.	1967 Value (thousands)
Roofing slate	23	157	$2,243	21	56	$2,202
Millstock:						
Electrical, structural, and sanitary slate	22	2,581	2,736	21	2,318	2,866
Blackboards and bulletin boards [2]	2	736	658	2	659	638
Billiard tabletops	2	230	281	2	225	296
Total [3]	26	3,547	3,675	24	3,201	3,801
Flagstones [4]	63	10,907	1,494	44	7,679	1,293
Miscellaneous uses [5]	54	--------	1,761	64	--------	2,309
Grand total [3]	166	--------	9,173	154	--------	9,605

[1] Produced by the following States in 1967 in order of value of output and with number of plants: Virginia (2); Pennsylvania (10); Vermont (21); New York (11); North Carolina (2); Utah (1); and Maine (1).
[2] Includes a small quantity of school slates.
[3] Data may not add to totals shown due to independent rounding.
[4] Includes slate used for walkways and stepping stones.
[5] Includes slate for aquarium bottoms, buildings, fireplaces, flooring, headstones, shims, and unspecified uses.

Table 14.—Miscellaneous varieties of dimension stone sold or used by producers in the United States,[1] by uses

Use	1966			1967		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Sawed [2]	51	601	$2,694	39	197	$2,708
Rubble	226	-------	516	150	1,684	484
Flagging	5	56	97	4	21	84
Total [3]	282	-------	3,307	194	1,903	3,275

[1] Produced by the following States in 1967 in order of value of output and with number of plants: California (15); Hawaii; Pennslyvania (3); Maryland (1); Wyoming; Oregon (1); New Mexico (5); Washington (3); Montana (1).

[2] Includes rough and cut stone and stone for refractory use to avoid disclosing individual company confidential data.

[3] Data may not add to totals shown due to independent rounding.

Table 15.—Crushed and broken stone sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1966		1967	
	Quantity	Value	Quantity	Value
Agriculture	30,326	$52,693	29,528	$52,027
Cement	102,702	109,997	98,263	106,416
Concrete and roadstone	514,324	705,617	521,364	720,320
Filtration	277	644	136	413
Flux	33,348	49,913	29,235	45,836
Glass	2,183	6,914	2,325	7,982
Lime and dead-burned dolomite	28,740	49,587	29,415	50,514
Mineral food	654	3,887	782	3,982
Poultry grit	686	4,913	412	3,753
Railroad ballast	14,061	17,045	13,486	16,277
Refractory	961	8,038	819	8,341
Riprap	36,739	48,030	30,637	45,840
Roofing, granules, aggregates, and chips	2,205	12,222	3,373	14,773
Stone sand	3,068	4,258	3,532	5,433
Terrazzo	333	4,738	304	4,482
Other uses [1] and unspecified	40,440	92,405	19,970	58,381
Total [2]	811,047	1,170,901	783,581	1,144,772

[1] Includes some uses listed separately in the Limestone and Sandstone sections.

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

Table 16.—Crushed stone sold or used by Government-and-Contractor producers in the United States, by uses [1]

(Thousand short tons and thousand dollars)

Use	1966		1967	
	Quantity	Value	Quantity	Value
Concrete and roadstone	43,462	$58,341	44,978	$53,818
Riprap	18,130	20,332	11,608	17,023
Agricultural (limestone)	168	327	166	317
Other uses	21,631	29,438	6,213	5,609
Total	83,391	108,438	62,965	76,767

[1] Figures represent tonnages reported by States, counties, municipalities, and other Government agencies, produced either by themselves or by contractors expressly for their consumption, often with publicly owned equipment; they do not include purchases from commercial producers.

Table 17.—Crushed stone for concrete and roadstone sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	1966 Quantity	1966 Value	1967 Quantity	1967 Value
Alabama	10,981	$13,048	[1] 8,787	[1] $10,887
Alaska	W	W	---------	---------
Arizona	[1] 210	[1] 471	[1] 210	[1] 524
Arkansas	11,718	14,109	10,236	12,906
California	13,856	[1] 18,662	[1] 13,055	[1] 16,614
Colorado	[1] 431	[1] 588	766	1,086
Connecticut	[1] 4,774	[1] 7,712	4,687	8,000
Delaware	W	W	W	W
Florida	[1] 29,515	[1] 30,713	[1] 28,885	[1] 30,737
Georgia	[1] 18,492	[1] 24,989	18,786	27,320
Hawaii	4,536	8,716	3,599	6,548
Idaho	[1] 2,109	[1] 3,004	811	1,330
Illidois	34,521	45,381	37,958	52,264
Indiana	17,784	23,055	20,597	27,266
Iowa	19,746	27,899	19,119	27,024
Kansas	[1] 9,136	[1] 12,238	8,889	11,860
Kentucky	17,965	24,425	19,690	28,050
Louisiana	[1] 6,237	[1] 8,600	[1] 5,671	[1] 8,039
Maine	340	882	430	978
Maryland	11,087	19,413	11,917	21,009
Massachusetts	5,149	8,855	4,905	8,960
Michigan	6,484	7,754	5,979	7,348
Minnesota	3,960	4,902	[1] 3,150	[1] 3,975
Mississippi	[1] 199	[1] 181	[1] 213	[1] 194
Missouri	[1] 18,711	[1] 25,524	[1] 20,246	[1] 26,065
Montana	[1] 2,371	[1] 2,519	2,541	2,206
Nebraska	1,886	3,145	1,621	2,677
Nevada	989	761	[1] 234	[1] 210
New Hampshire	W	W	W	W
New Jersey	10,389	21,649	[1] 10,784	[1] 22,496
New Mexico	1,884	2,785	850	1,589
New York	22,313	38,432	23,112	41,598
North Carolina	21,132	31,943	23,301	35,772
North Dakota	92	170	411	813
Ohio	24,577	32,744	26,321	35,136
Oklahoma	11,004	11,587	[1] 10,876	[1] 11,661
Oregon	[1] 14,275	[1] 20,879	10,992	16,115
Pennsylvania	[1] 34,120	[1] 49,003	[1] 36,673	[1] 52,220
Rhode Island	W	W	W	W
South Carolina	5,719	8,163	[1] 5,495	[1] 8,202
South Dakota	1,235	2,295	[1] 473	[1] 944
Tennessee	25,902	32,163	[1] 25,531	[1] 31,929
Texas	27,218	32,133	34,495	36,995
Utah	[1] 30	[1] 68	W	W
Vermont	2,176	3,504	2,205	3,843
Virginia	24,780	35,475	23,024	34,085
Washington	9,406	13,083	[1] 8,798	[1] 11,700
West Virginia	[1] 3,047	[1] 4,834	3,952	6,675
Wisconsin	[1] 13,288	[1] 13,935	14,352	14,991
Wyoming	269	421	147	157
Undistributed	8,281	12,805	6,037	7,773
Total [2]	514,324	705,617	520,810	718,769

W Withheld; included with "Undistributed."

[1] To avoid disclosing individual company confidential data, total is somewhat incomplete, the portion not included being combined as "Undistributed."

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

Table 18.—Number and production of commercial crushed-stone plants in the United States, by size of operation

Annual production (short tons)	1966 Number of plants	1966 Production: Thousand short tons	1966 Production: Percent of total	Cumulative total, thousand short tons	1967 Number of plants	1967 Production: Thousand short tons	1967 Production: Percent of total	Cumulative total, thousand short tons
Less than 25,000	996	8,812	1.2	8,812	1,013	8,352	1.2	8,352
25,000 to 50,000	324	11,823	1.6	20,635	363	13,099	1.8	21,452
50,000 to 75,000	231	14,192	2.0	34,827	226	14,058	1.9	35,509
75,000 to 100,000	203	17,507	2.4	52,334	213	18,773	2.6	54,282
100,000 to 200,000	522	75,009	10.3	127,343	508	71,471	9.9	125,753
200,000 to 300,000	265	64,553	8.9	191,896	266	65,178	9.1	190,931
300,000 to 400,000	183	63,028	8.7	254,924	216	75,117	10.4	266,043
400,000 to 500,000	138	62,206	8.5	317,130	131	58,021	8.1	324,068
500,000 to 600,000	114	62,099	8.5	379,229	98	53,891	7.4	377,960
600,000 to 700,000	75	48,064	6.6	427,293	69	44,673	6.2	422,632
700,000 to 800,000	54	39,890	5.5	467,183	60	44,589	6.2	467,221
800,000 to 900,000	34	28,301	3.9	495,484	41	34,543	4.8	501,764
900,000 tons and over	141	232,172	31.9	727,656	134	218,852	30.4	720,616
Total [1]	3,280	727,656	100.0	727,656	3,338	720,616	100.0	720,616

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

Table 19.—Crushed stone sold or used in the United States, by methods of transportation

Method of transportation	1966 Thousand short tons	1966 Percent of total	1967 Thousand short tons	1967 Percent of total
Commercial:				
Truck	517,030	64	515,328	66
Rail	93,299	11	89,124	11
Waterway	64,188	8	68,029	9
Unspecified	53,139	7	48,135	6
Total commercial	727,656	90	720,616	92
Government-and-contractor:				
Truck [1]	83,391	10	62,965	8
Grand total	811,047	100	783,581	100

[1] Entire output of Government-and-contractor operations assumed to be moved by truck.

Table 20.—Granite (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1966 Quantity	1966 Value	1967 Quantity	1967 Value
Concrete and roadstone	54,894	$78,088	54,018	$80,590
Railroad ballast	2,897	3,811	2,612	3,438
Riprap	2,957	5,121	2,816	6,075
Stone sand	938	989	1,311	1,604
Poultry grit	88	829	28	288
Other uses [1]	3,488	5,873	1,658	2,669
Total [2]	65,262	94,711	62,443	94,664

[1] Includes stone used for agriculture, fill, roofing granules, and unspecified uses.
[2] Data may not add to totals shown due to independent rounding.

Table 21.—Granite (crushed and broken stone) sold or used by producers in the United States in 1967, by States

State	Short tons	Value	State	Short tons	Value
Arizona	34,877	$117,313	New Mexico	160	$800
California	4,745,317	6,160,583	North Carolina	16,937,519	25,935,538
Colorado	282,548	376,519	South Carolina	6,351,454	9,026,187
Georgia	17,333,043	24,880,739	South Dakota	21,675	43,350
Idaho	526,288	711,200	Virginia	8,946,017	14,317,993
Michigan	2,800	61,600	Washington	242,937	550,866
Minnesota	340,368	677,553	Wisconsin	849,834	278,818
Montana	5,323	8,777	Other States [1]	4,234,080	8,891,253
Nevada	162,112	122,753			
New Hampshire	134,570	W	Total	62,442,893	94,664,414
New Jersey	1,291,971	2,502,572	Puerto Rico	246,500	515,800

W Withheld to avoid disclosing company confidential data; included with "Other States."
[1] Includes Alaska, Connecticut, Delaware, Maine, Maryland, Massachusetts, Missouri, New York, Pennsylvania, Texas, Vermont and Wyoming.

Table 22.—Basalt and related rocks (traprock) (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1966 Quantity	1966 Value	1967 Quantity	1967 Value
Concrete and roadstone	63,465	$104,890	57,977	$97,202
Railroad ballast	1,563	2,380	1,500	2,293
Riprap	4,538	9,389	3,695	7,639
Other uses [1]	19,020	30,240	5,257	9,167
Total [2]	88,586	146,899	68,430	116,301

[1] Includes stone used for concrete products, dam construction, fill, filler, filtration, poultry grit, road base (including stabilized), rock wool, roofing granules, and unspecified uses.
[2] Data may not add to totals shown due to independent rounding.

Table 23.—Basalt and related rocks (traprock) (crushed and broken stone) sold or used by producers in the United States in 1967, by States

States	Short tons	Value	States	Short tons	Value
Arizona	145,975	$364,937	New Mexico	69,134	$110,039
California	2,130,163	2,541,030	North Carolina	3,472,274	5,247,463
Colorado	100	100	Oregon	12,425,652	18,886,429
Connecticut	4,284,350	7,278,828	Utah	36	90
Hawaii	2,623,521	5,052,440	Virginia	3,533,863	5,816,761
Idaho	1,075,661	2,011,463	Washington	12,965,106	15,615,931
Maryland	3,835,588	7,261,406	Wyoming	1,000	2,250
Massachusetts	3,963,216	7,204,776	Other States [1]	7,166,203	16,158,498
Michigan	27,066	34,956			
Minnesota	65,000	95,000	Total	68,429,537	116,301,341
Nevada	169	189			
New Jersey	10,645,460	22,618,755			

[1] Includes Montana, New York, Pennsylvania, Texas, Wisconsin.

Table 24.—Marble (crushed and broken stone) sold or used by producers in the United States,[1] by uses

(Thousand short tons and thousand dollars)

Use	1966 Quantity	1966 Value	1967 Quantity	1967 Value
Terrazzo	317	$4,448	303	$4,452
Concrete and roadstone	W	W	W	W
Other uses [2]	1,844	17,336	1,855	14,707
Total	2,161	21,784	2,158	19,159

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1] Produced by the following States in 1967, in order of tonnage: Alabama, Georgia, Oklahoma, New York Missouri, Vermont, California, Arizona, Tennessee, Washington, North Carolina, Virginia, New Jersey Maryland, Montana, Texas, Nevada, Colorado, Wyoming, Arkansas.
[2] Includes stone used for acid neutralization, agriculture, asphalt filller, cast stone, poultry grit, roofing chips, stucco, whiting (excluding marble whiting made by companies that purchase marble), and unspecified uses.

Table 25.—Limestone and dolomite (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1966 Quantity	1966 Value	1967 Quantity	1967 Value
Concrete and roadstone	343,864	$449,807	356,534	$468,351
Flux	32,788	47,751	28,778	43,853
Agriculture	30,080	52,378	29,245	51,463
Railroad ballast	6,000	7,355	5,634	6,729
Riprap	14,592	16,083	13,570	16,464
Alkali manufacture	2,822	3,131	2,026	2,150
Cement-portland and natural	96,231	101,266	91,456	96,878
Coal-mine dusting	596	2,471	536	2,245
Filler (not whiting substitute):				
Asphalt	1,523	4,364	1,640	4,831
Fertilizer	485	1,251	371	898
Other	407	1,533	335	1,634
Filtration	236	469	84	194
Glass manufacture	1,836	5,786	1,840	5,983
Lime and dead-burned dolomite	28,401	49,178	28,325	49,039
Limestone sand	1,743	2,768	1,795	3,198
Limestone whiting [1]	802	9,861	821	9,657
Mineral food	654	3,887	776	3,930
Paper manufacture	295	816	356	1,018
Poultry grit	138	1,136	132	1,075
Refractory (dolomite)	592	4,383	463	3,415
Sugar refining	571	1,331	653	1,536
Other uses [2]	2,043	6,422	3,152	7,961
Use unspecified	2,150	2,582	380	634
Total [3]	568,849	776,009	568,902	783,135

[1] Includes stone for filler for abrasives, calcimine, calking compounds, ceramics, chewing gum, fabrics, floor coverings, insecticides, leather goods, paint, paper, phonograph records, plastics, pottery, putty, roofing, rubber, wire coating, and unspecified uses. Excludes limestone whiting made by companies from purchased stone.
[2] Includes stone for acid neutralization, calcium carbide, cast stone, chemicals (unspecified), concrete products, disinfectant, fill and animal sanitation, electrical products, magnesia, magnesium, mineral wool, oil-well drilling, patching plaster, roofing granules, stucco, terrazzo, and water treatment.
[3] Data may not add to totals shown due to independent rounding.

Table 26.—Limestone and dolomite (crushed and broken stone) sold or used by producers in the United States in 1967, by States and uses

State	Riprap		Fluxing stone		Concrete and roadstone		Railroad ballast		Agriculture		Miscellaneous		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	W	W	1,143,877	$1,925,125	8,786,749	$10,886,970	W	W	839,869	$1,381,908	5,391,779	$5,860,555	16,511,315	$20,566,939
Arizona	-----	-----	127,897	209,755	W	W	-----	-----	-----	-----	W	W	1,449,230	1,934,303
Arkansas	426	$426	W	W	1,763,023	1,913,128	-----	-----	W	W	2,061,938	2,543,964	5,236,403	6,229,020
California	W	W	W	W	W	W	-----	-----	W	W	12,029,700	18,591,794	13,852,521	20,491,502
Colorado	W	W	W	W	408,791	578,922	-----	-----	-----	-----	W	W	2,214,396	3,822,707
Connecticut	-----	-----	W	W	-----	-----	-----	-----	W	W	W	W	198,629	956,686
Florida	W	W	-----	-----	28,884,733	30,737,421	W	W	776,967	2,412,194	2,892,981	3,437,082	32,617,760	36 669,597
Georgia	W	W	W	W	2,331,909	3,517,518	-----	-----	200,826	385,441	W	W	3,499,997	5,353,661
Hawaii	76	267	-----	-----	513,618	930,606	-----	-----	20,805	64,192	386,705	365,027	921,204	1,360,092
Idaho	W	W	-----	-----	-----	-----	-----	-----	-----	-----	W	W	161,718	244,841
Illinois	636,357	1,202,951	373,291	497,843	37,957,962	52,263,691	560,956	$630,281	3,879,073	5,982,505	5,044,289	6,066,627	48,451,928	66,643,898
Indiana	592,156	1,809,616	32,187	46,847	20,596,598	27,266,491	425,091	550,773	1,887,917	2,781,286	3,024,450	3,168,352	26,558,399	35,623,365
Iowa	386,628	449,772	W	W	19,118,967	27,024,107	168,879	173,414	2,487,558	4,421,356	W	W	26,120,408	37,663,388
Kansas	W	W	500	1,000	8,434,686	11,208,321	W	W	546,384	885,078	2,845,251	3,250,931	12,768,628	16,086,029
Kentucky	W	W	W	W	19,689,862	28,050,527	W	W	2,109,868	3,364,858	W	W	24,811,776	35,481,288
Maine	W	W	-----	-----	W	W		W	W	W	W	W	880,084	1,443,346
Maryland	W	W	W	W	7,506,691	12,852,561	W	W	W	W	2,269,812	5,061,971	9,862,677	18,108,214
Massachusetts	-----	-----	W	W	W	W	-----	-----	146,925	541,756	W	W	715,964	3,467,240
Michigan	W	W	11,270,204	13,637,604	5,952,331	7,312,601	308,427	379,832	756,761	1,092,679	W	W	36,264,581	39,632,606
Minnesota	103,624	136,290	W	W	2,968,379	3,646,633	13,799	18,819	460,839	772,391	W	W	3,621,879	4,687,693
Mississippi	798,087	798,087	-----	-----	212,873	193,673	-----	-----	W	W	W	W	1,166,816	1,157,616
Missouri	2,455,989	1,825,351	W	W	20,245,916	26,064,634	W	W	3,827,108	6,430,075	8,830,448	14,502,527	35,491,761	49,084,392
Montana	W	W	W	W	6,707	8,579	-----	-----	-----	-----	971,419	1,222,631	1,028,550	1,323,752
Nebraska	2,004,121	2,170,826	-----	-----	1,620,819	2,676,740	W	W	228,157	390,949	W	W	4,835,035	7,422,956
Nevada	275	275	W	W	95,625	67,500	-----	-----	W	W	W	W	W	W
New Jersey	-----	-----	W	W	99,741	216 048	-----	-----	W	W	W	W	W	W
New Mexico	W	W	10,580	16,850	171,990	192,829	-----	-----	-----	-----	W	W	649,191	919,066
New York	264,486	524,757	W	W	19,895,042	35,803,603	243,869	383,325	371,168	1,376,093	W	W	29,614,961	46,826,345
North Carolina	-----	-----	-----	-----	W	W	W	W	8,169	20,014	W	W	3,935,915	6,136,940
Ohio	455,253	545,488	4,416,337	6,352,311	26,210,640	35,014,152	944,566	1,176,435	2,169,923	3,764,703	W	W	44,584,338	65,602,195
Oklahoma	W	W	-----	-----	10,632,975	11,355,842	W	W	409,268	603,210	2,145,034	3,239,970	13,540,196	15.558150
Oregon	-----	-----	W	W	89,256	53,669	-----	-----	W	W	W	W	587,744	814,775
Pennsylvania	W	W	5,789,922	11,392,163	28,785,442	40,119,878	W	W	1,109,837	3,414,179	14,618,148	20,496,468	50,711,972	76,043,390
Rhode Island	-----	-----	W	W	-----	-----	-----	-----	W	W	W	W	W	W
South Carolina	-----	-----	W	W	W	W	-----	-----	W	W	W	W	1,944,213	3,339,754
South Dakota	W	W	-----	-----	W	W	106,206	123,096	-----	-----	W	W	882,273	1.398,984
Tennessee	W	W	W	W	25,530,828	31,929,229	W	W	2,467,255	2,998,425	3,199,829	4,704,600	31,429,126	39,956,613
Texas	794,224	912,634	466,720	594,003	25,274,068	24,422,273	615,536	556,074	660,020	672,490	8,343,595	13,214,563	36,153,163	40,372,037
Utah	46,614	121,741	W	W	W	W	W	W	-----	-----	926,322	1,960,075	1,766,852	3,848,469
Vermont	W	W	-----	-----	W	W	-----	-----	W	W	W	W	1,162,189	4,013,896
Virginia	10,832	11,725	805,351	1,320,384	10,093,556	13,446,538	267,576	308,536	1,131,735	2,045,044	4,586,384	7,660,494	16,895,434	24,792,721
Washington	1,281	5,124	W	W	W	W	-----	-----	7,025	35,650	876,830	1,378,931	913,857	1,470,792
West Virginia	W	W	W	W	2,818,757	4,387,812	563,012	594,345	130,862	326,678	2,575,255	4,591,746	7,855,706	13,536,710

See footnotes at end of table.

Table 26.—Limestone and dolomite (crushed and broken stone) sold or used by producers in the United States in 1967, by States and uses —Continued

State	Riprap		Fluxing stone		Concrete and roadstone		Railroad ballast		Agriculture		Miscellaneous		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Wisconsin	49,518	63,392	W	W	13,374,030	14,424,106	W	W	927,217	1,354,564	275,808	845,831	14,686,293	16,716,194
Wyoming	17,452	26,921	----------	----------	W	W	W	W	----------	----------	391,951	1,103,853	706,954	1,532,678
Undistributed	4,952,667	5,858,200	4,341,631	7,858,853	6,461,996	9,685,069	1,416,319	1,834,076	1,683,216	3,945,084	51,452,616	73,008,201	1,639,619	4,805,413
Total	13,570,066	16,463,843	28,778,497	43,852,738	356,533,560	468,350,671	5,634,236	6,729,006	29,244,752	51,462,802	135,140,544	196,276,193	568,901,655	783,135,253
Guam	----------	----------	----------	----------	241,033	421,860	----------	----------	----------	----------	W	W	374,550	684,240
Puerto Rico	16,500	14,800	----------	----------	2,391,450	6,562,700	----------	----------	65,300	220,400	3,104,978	1,969,535	5,578,228	8,767,435

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

Table 27.—Sales of fluxing limestone, by uses

(Thousand short tons and thousand dollars)

Year	Blast furnace		Open-hearth plants		Other smelters [1]		Other metallurgical [2]		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1963	18,514	$26,456	5,772	$8,511	741	$1,162	2,158	$3,193	27,185	$39,322
1964	22,364	31,437	5,625	8,082	1,075	1,278	2,390	3,714	31,454	44,511
1965	23,168	32,980	5,594	8,189	1,167	1,487	2,601	4,195	32,530	46,851
1966	22,835	32,907	5,590	8,132	1,226	1,962	3,137	4,750	32,788	47,751
1967	21,061	32,146	3,798	5,721	1,038	1,246	2,881	4,740	28,778	43,853

[1] Includes flux for copper, gold, lead, zinc, and unspecified smelters.
[2] Includes flux for foundries and for cupola and electric furnaces.

Table 28.—Shell sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1966		1967	
	Quantity	Value	Quantity	Value
Concrete and road material	14,385	$19,139	15,143	$20,832
Cement	4,959	7,094	5,310	7,909
Lime	339	409	1,090	1,475
Poultry grit	460	2,948	252	2,388
Other uses [1]	1,519	3,193	230	729
Total [2]	21,662	32,783	22,026	33,334

[1] Includes alkali, whiting, asphalt filler, other filler, mineral food, and unspecified uses.
[2] Data may not add to totals shown due to independent rounding.

Table 29.—Shell sold or used by producers in the United States in 1967, by States

State	Short tons	Value	State	Short tons	Value
Alabama	1,265,463	$2,419,298	Louisiana	7,599,395	$11,174,114
Arkansas	94	10,102	Texas	10,776,368	15,417,035
Florida	1,352,878	2,053,521	Other States [1]	1,032,235	2,259,641
			Total	22,026,433	33,333,711

[1] Includes California, Maryland, Mississippi, New Jersey, Pennsylvania, and Virginia.

Table 30.—Calcareous marl sold or used by producers in the United States,[1] by uses

(Thousand short tons and thousand dollars)

Use	1966		1967	
	Quantity	Value	Quantity	Value
Agriculture [2]	224	$154	191	$143
Cement	1,134	1,041	1,036	940
Total [3]	1,358	1,195	1,227	1,084

[1] Produced by the following States in 1967, in order of tonnage: Va., Miss., Tex., Mich., Ind., Minn., Wisc. and Nev.
[2] Includes marl used in mineral food, other uses, and other uses not listed.
[3] Data may not add to totals shown due to independent rounding.

Table 31.—Sandstone, quartz, and quartzite (crushed and broken stone)[1] sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1966		1967	
	Quantity	Value	Quantity	Value
Concrete and roadstone	17,845	$26,225	17,788	$25,905
Railroad ballast	1,160	1,345	1,410	1,820
Riprap	3,189	4,381	3,661	5,701
Refractory stone (ganister)	369	3,655	354	4,924
Abrasives	74	356	50	340
Ferrosilicon	80	500	236	905
Filtration	4	17	33	86
Flux	560	2,162	453	1,981
Foundry	24	104	182	670
Glass	347	1,128	484	1,999
Other uses [2]	3,436	7,061	2,251	5,822
Total [3]	27,088	46,934	26,903	50,152

[1] Includes ground sandstone, quartz, and quartzite. Friable sandstone is reported in the chapter on sand and gravel.
[2] Includes cement, fill, filler, porcelain, pottery, roofing granules, stone sand, terrazzo, tile, and unspecified uses, roofing chips and aggregates, other uses not listed.
[3] Data may not add to totals shown due to independent rounding.

Table 32.—Sandstone, quartz, and quartzite (crushed and broken stone) sold or used by producers in the United States in 1967, by States

State	Short tons	Value	State	Short tons	Value
Arizona	206,644	$611,270	Oklahoma	1,248,159	$1,469,265
Arkansas	7,078,800	8,411,771	Pennsylvania	3,258,686	8,124,335
California	3,656,894	6,384,066	South Dakota	780,710	1,622,592
Colorado	266,815	633,894	Utah	52,297	105,380
Illinois	600	3,150	Vermont	18,625	31,923
Indiana	7,065	7,065	Virginia	673,140	1,080,377
Minnesota	80,318	190,399	Washington	193,944	818,316
Missouri	31,138	31,138	West Virginia	1,590,257	2,909,873
Montana	428,753	846,486	Wyoming	11,998	21,895
New York	534,636	969,195	Other States [1]	5,951,897	12,868,504
North Carolina	89,351	821,376			
Ohio	741,878	2,189,330	Total	26,902,605	50,151,600

[1] Includes Alabama, Connecticut, Georgia, Idaho, Kansas, Maryland, Nevada, New Hampshire, New Mexico, Oregon, Tennessee, Texas, Wisconsin.

Table 33.—Miscellaneous stone (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1966		1967	
	Quantity	Value	Quantity	Value
Concrete and roadstone	19,871	$27,468	19,224	$25,684
Railroad ballast	2,441	2,154	2,330	1,997
Riprap	11,463	13,056	6,895	9,961
Other uses [1]	1,116	3,401	1,938	4,291
Total [2]	34,891	46,079	30,387	41,933

[1] Includes stone used for agriculture, fill, filtration, flux, roofing granules, stone sand, terrazzo, and unspecified uses.
[2] Data may not add to totals shown due to independent rounding.

Table 34.—Miscellaneous varieties of stone (crushed and broken stone) sold or used by producers in the United States in 1967, by States

State	Short tons	Value	State	Short tons	Value
Arizona	45,631	$77,161	Pennsylvania	1,763,000	$2,302,850
Arkansas	5,017,211	7,264,496	South Dakota	150,587	498,574
California	12,152,898	16,690,840	Utah	7,910	17,093
Colorado	210,484	366,456	Vermont	1,200,154	2,097,499
Hawaii	542,055	701,243	Wyoming	56,846	101,998
Massachusetts	566,253	1,074,054	Other States [1]	2,666,207	4,535,653
Missouri	513,477	538,781			
Montana	3,256,116	3,524,038	Total	30,387,098	41,932,949
Nevada	77,738	125,680	Panama Canal Zone	58,546	114,680
North Dakota	596,202	1,091,500	Puerto Rico	1,223,300	2,848,800
Oklahoma	1,552,473	920,323			
Oregon	11,856	4,710			

[1] Includes, Alaska, Kansas, Louisiana, Maine, Maryland, New Hampshire, New Jersey, New Mexico, New York, Rhode Island, Texas, Virginia and Washington.

Table 35.—U.S. exports of stone

Year	Building and monumental stone				Crushed, ground, or broken				Other manufactures of stone (value thousands)
	Dolomite		Other		Limestone		Other		
	Short tons (thousands)	Value (thousands)	Cubic feet (thousands)	Value (thousands)	Short tons (thousands)	Value (thousands)	Short tons (thousands)	Value (thousands)	
1965	253	$2,032	264	$1,259	1,165	$2,905	73	$1,955	$1,480
1966	101	1,692	NA	1,104	1,207	3,500	276	3,406	1,432
1967	113	1,756	NA	958	1,159	3,496	306	3,743	1,203

NA Not available.

Table 36.—U.S. exports of slate, by uses [1]

(Value)

Use	1963	1964	1965	1966	1967
Roofing	W	W	W	W	W
Structural and flagging	$20,081	$17,263	$19,711	12,343	9,597
Other uses [2]	56,228	43,312	56,297	51,298	27,102
Total	76,309	60,575	76,008	63,641	36,699

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1] Figures collected by the Bureau of Mines from shippers of products named.
[2] Includes electrical slate, school slate, blackboards, billiard tabletops, millstock (unspecified), and sculpings.

Table 37.—U.S. imports for consumption of stone and whiting, by classes

Class	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)
Granite:				
Monumental, paving, and building stone:				
Rough ---- cubic feet	150,647	$818	169,193	$1,001
Dressed, manufactured ---- do	134,409	1,156	173,064	1,662
Not manufactured and not suitable for monumental, paving, or building stone ---- short tons	457	11	269	11
Other, n.s.p.f	---------	73	---------	71
Total	---------	2,058	---------	2,745
Marble, breccia, and onyx:				
In block, rough or squared ---- cubic feet	49,043	370	53,668	360
Sawed or dressed over 2 inches thick ---- do	5,349	32	5,164	38
Slabs and paving tiles ---- superficial feet	8,402,099	6,541	6,025,706	5,139
All other manufactures	---------	4,062	---------	3,776
Total	---------	11,005	---------	9,313
Travertine stone:				
Rough, unmanufactured ---- cubic feet	58,600	163	45,463	138
Dressed, suitable for monumental, paving, and building stone ---- short tons	31,575	1,338	34,537	1,035
Other, n.s.p.f	---------	112	---------	77
Total	---------	1,613	---------	1,250
Limestone:				
Monumental, paving, and building stone:				
Rough ---- cubic feet	800	(1)	1,378	3
Dressed, manufactured ---- short tons	3,190	69	4,502	72
Crude, not suitable for monumental, paving, or building stone ---- short tons	251,955	351	41,600	121
Other, n.s.p.f	---------	53	---------	49
Total	---------	473	---------	245
Slate:				
Roofing ---- square feet	5,166	1	---------	------
Other, n.s.p.f	---------	1,478	---------	2,333
Total	---------	1,479	---------	2,333
Quartzite ---- short tons	151,869	588	4,213	260
Stone and articles of stone, n.s.p.f.:				
Statuary and sculptures	---------	363	---------	266
Stone, unmanufactured ---- short tons	3,760	75	7,561	107
Building stone, rough ---- cubic feet	6,384	11	5,517	9
Building stone, dressed ---- short tons	40	3	1,232	41
Other	---------	28	---------	157
Total	---------	480	---------	580
Stone, chips, spalls, crushed or ground:				
Marble, breccia, and onyx chips ---- short tons	10,611	117	8,129	127
Limestone, chips and spalls, crushed or ground ---- do	929,817	1,263	1,196,166	1,529
Stone chips and spalls, and stone crushed or ground, n.s.p.f. short tons	1,408,153	1,318	1,070,730	1,079
Slate chips and spalls, and slate crushed and ground ---- do	15	1	---------	------
Total	2,348,596	2,699	2,275,025	2,735
Whiting:				
Whiting, dry, ground, or bolted ---- short tons	10,408	179	11,558	206
Chalk whiting, precipitated ---- do	2,225	165	2,113	156
Chalk, whiting, putty ---- do	(1)	(1)	(1)	(1)
Total	12,633	344	13,671	362
Grand total	---------	20,739	---------	19,823

[1] Less than ½ unit.

Sulfur and Pyrites

By Richard W. Lewis [1]

Increased domestic production of Frasch and recovered elemental sulfur amounted to only 40,000 long tons, which made an insignificant contribution toward alleviating the supply shortage. In effect, the increased demand more than offset the small increase in output and again producers' stocks were drawn down. Fertilizers used about half of the sulfur consumed in the United States; a use that is expected to continue to increase.

It appeared that most of the producing Frasch mines in the past 2 years were operating at nearly peak production. Recently reopened domes at Sulphur, La., and in Fort Bend County, Tex., which began producing late in 1966, contributed a relatively small quantity to the supply.

Louisiana again was the leading producing State with 4.1 million long tons of elemental sulfur comprising both Frasch and recovered; Texas was second with 3.6-million tons output.

Table 1.—Salient sulfur statistics

(Long tons, sulfur content)

	1963	1964	1965	1966	1967
United States:					
Production (native)	4,881,927	5,228,365	r 6,116,406	r 7,001,503	7,014,448
All forms	6,643,802	r 7,093,171	r 8,212,363	r 9,155,415	9,136,111
Exports, sulfur	1,612,637	1,928,092	r 2,635,000	2,373,000	2,193,000
Imports, pyrites and sulfur	1,444,000	1,582,211	1,646,000	1,674,000	1,639,000
Stocks Dec. 31: Producer, Frasch and recovered sulfur	4,682,496	4,226,524	3,425,161	2,704,349	1,953,877
Consumption, apparent, all forms [1]	6,607,000	r 7,260,154	r 7,997,295	r 9,160,193	9,316,070
World: Production:					
Sulfur, elemental	12,699,000	13,937,000	15,308,000	16,465,000	17,247,000
Pyrites	8,900,000	9,200,000	9,560,000	9,511,000	e 9,764,000

r Revised. e Estimate.
[1] Measured by quantity sold, plus import, minus exports.

DOMESTIC PRODUCTION

Native Sulfur.—There were 13 Frasch process mines in operation throughout 1967: Four mines of Freeport Sulphur Co. at Grande Ecaille, Garden Island Bay, and Lake Pelto, all in Louisiana, and Grand Isle, 7 miles off the Louisiana coast in the Gulf of Mexico; five mines of Texas Gulf Sulphur Co. at Newgulf, Fannett, Moss Bluff, Spindletop, and Gulf, Texas; one mine of Duval Corp. at Orchard Dome, Texas; one mine at Long Point Dome in Texas owned by Jefferson Lake Sulphur Co.; and two mines that were reopened late in 1966, one by Phelan Sulphur Co. at Nash Dome Louisiana, and the other, the Sulphur mine in Louisiana, by Union Texas Petroleum Co.

Freeport Sulphur Co. increased its production in 1966 by approximately 500,000 tons to a record annual output of over 4 million tons.[2] The firm maintained its high production rate and in 1967 produced about the same quantity. Freeport's new Caminada mine, under development in 50

[1] Commodity specialist, Division of Mineral Studies.
[2] Freeport Sulphur Co. 54th Annual Report 1966, p. 3.

feet of water about 6 miles off the Louisiana shore and 6 miles southwest of the Grand Isle mine in the Gulf of Mexico, was nearly completed by yearend. Production was to begin in late February 1968, but the output was not expected to be as great as that from the Grand Isle mine due to the nature of the sulfur-bearing formation.[3]

[3] Freeport Sulphur Co., 55th Annual Report 1967, pp. 5–6.

Table 2.—Production of sulfur and sulfur-containing raw materials by producers in the United States

(Long tons)

	1964		1965	
	Gross weight	Sulfur content	Gross weight	Sulfur content
Native sulfur or sulfur ore:				
Frasch-process mines	5,228,207	5,228,207	6,116,273	6,116,273
Other mines	794	158	2,592	133
Total	---------	5,228,365	---------	6,116,406
Recovered elemental sulfur	1,024,649	1,021,358	1,219,312	1,215,168
Pyrites	847,493	353,831	874,957	353,645
Byproduct sulfuric acid (basis 100 percent) produced at Cu, Zn, and Pb plants	1,119,976	r 366,143	r 1,188,314	r 388,484
Other byproduct sulfur compounds [1]	143,689	123,474	162,668	138,660
Total	---------	r 7,093,171	---------	r 8,212,363
	1966		**1967**	
	Gross weight	Sulfur content	Gross weight	Sulfur Content
Native sulfur or sulfur ore:				
Frasch-process mines	7,001,360	7,001,360	7,014,164	7,014,164
Other mines	557	143	568	284
Total	---------	7,001,503	---------	7,014,448
Recovered elemental sulfur	r 1,243,960	r 1,240,386	1,270,289	1,267,955
Pyrites	872,414	r 355,592	860,909	355,033
Byproduct sulfuric acid (basis 100 percent) produced at Cu, Zn, and Pb plants	r 1,297,184	r 424,075	1,114,881	364,477
Other byproduct sulfur compounds [1]	161,962	133,859	157,262	134,198
Total	---------	r 9,155,415	---------	9,136,111

r Revised.
[1] Hydrogen sulfide and liquid sulfur dioxide. Does not include acid sludge converted to H_2SO_4.

Table 3.—Sulfur produced and shipped from Frasch mines in the United States

Year	Produced (long tons)			Shipped	
	Texas	Louisiana	Total	Long tons	Approximate value (thousands)
1963	2,412,653	2,468,859	4,881,512	4,995,023	$99,014
1964	2,488,975	2,739,232	5,228,207	6,035,670	120,777
1965	2,534,045	3,582,228	6,116,273	7,250,907	164,654
1966	2,916,479	4,084,881	7,001,360	7,720,927	201,292
1967	2,955,629	4,058,535	7,014,164	7,681,605	251,670

Table 4.—Sulfur ore (10 to 70 percent S) produced and shipped in the United States [1]

Year	Produced (long tons)	Shipped: Long tons	Shipped: Value (thousands)
1963	1,371	1,371	$15
1964	794	794	8
1965	2,592	2,852	11
1966	557	557	5
1967	568	568	3

[1] California, Nevada, and Utah.

Sulfur production by Texas Gulf Sulphur Co. (TGS) in 1967 amounted to more than 3 million long tons, but the increase was only 0.2 percent over that of 1966. TGS expected to have its new Frasch mine at Bullycamp, 40 miles southwest of New Orleans, La., in operation by mid-1968. Because the marshy and canal-riddled location of the Bullycamp mine, it was necessary to design off-shore style facilities. All materials required for its construction were delivered in barges. When the plant is completed, drilling, water heating, and sulfur collection will be carried out on barge-mounted facilities. An annual production rate of more than 300,000 long tons was expected from Bullycamp when it is fully operational.[4]

According to their annual report,[5] Duval Corp. produced 107,415 long tons of sulfur from its Orchard Dome property and the pilot operation at its Fort Stockton property in Pecos County, Tex. The results obtained from the Fort Stockton operation proved the feasibility of producing sulfur at the property by the Frasch process. The company developed a process for utilizing the brackish water, common to the area, as feed for the mine water heating system. Commercial scale development of the property began in June and was scheduled for completion by mid-1968. The designed capacity of the plant was reportedly 1,000 tons per day.

Jefferson Lake Sulphur Co., a subsidiary of Occidental Petroleum Corp., completed construction of its new $5 million Frasch plant at Lake Hermitage Dome in Plaquemines Parish, La., about 30 miles south of New Orleans. The water heating plant reportedly was operating at close to its designed capacity of 3 million gallons of hot water per day.[6] Earlier reports indicated that the Lake Hermitage Dome would produce 200,000 tons per year.[7] The land was acquired by Jefferson Lake Sulphur Co. from Humble Oil & Refining Co. and Gulf Oil Corp. Royalties would be 19 percent on the first 800,000 tons and 26 percent on all other production. The facilities were to be mounted on floating equipment and the liquid sulfur was to be transported by barge to market.

The Chacahoula dome in La Fourche Parish, La., was reopened in August by John W. Mecom. The mine had been operated by Freeport Sulphur Co. from February 1955 to September 1962 when it was closed because it was no longer economical to operate due to low sulfur prices. It was estimated that the lease still contains about 4.25 million tons of recoverable sulfur.[8]

There was a rush for sulfur lands in western Texas in 1966. Lack of interpretation of mining laws had hampered the acquisition of State sulfur land until a ruling by the State Supreme Court declaring the mining law of 1919 valid. Under that law, lands could be rented at $0.50 per acre annually and patented at a cost of $7.50 per acre after 5 years of development. The ruling did not affect oil and gas leasing on the same lands that are offered by the State at competitive lease sales. Duval Corp., Humble Oil & Refining Co., Piper Petroleum, Sinclair Oil & Gas Co., and Texas American Oil Corp. were reported to have filed on most of the sulfur land in Pecos County. Atlantic Richfield Co. and Phillips Petroleum Corp. were reported to be active in Culbertson County.[9] Exploration continued throughout 1967, but no new mines were developed.

Hooker Chemical Corp. began production of sulfur at Bryan Mound, Tex., for use in its evaluation plant. If the plant tests indicate favorable economics, the firm expected to proceed to commercial scale Frasch operation. The Bryan Mound dome is located near Freeport, Tex., on the

[4] Texas Gulf Sulphur Co. 1967 Annual Report, pp. 17–18.
[5] Duval Corp. Annual Report for 1967, pp. 4–5.
[6] Occidental Petroleum Corp. 1967 Annual Report, p. 30.
[7] Wall Street Journal. v. 168, No. 70, Oct. 10, 1966, p. 25.
[8] Wall Street Journal. v. 170, No. 35, Aug. 21, 1967, p. 15.
[9] Oil and Gas Journal. Texas Sulfur Rush On Again. v. 64, No. 43, Oct. 24, 1966, p. 69.

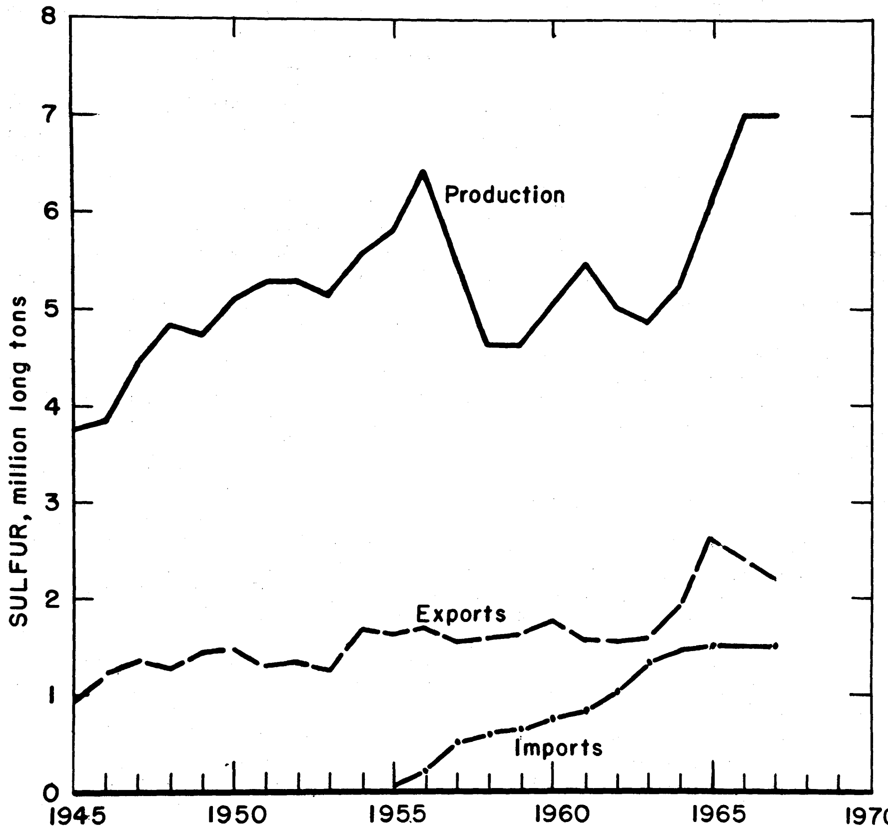

Figure 1.—Domestic native production, imports, and exports of native sulfur.

Brazos River adjacent to the Gulf of Mexico.[10]

Texas American Oil Corp. formed a subsidiary, Texas American Sulphur Co., to manage and operate its sulfur properties.

A joint venture was being considered by Great American Industries near Sulphur, Nev., which would produce 360,000 long tons of sulfur per year. The sulfur ore deposits were reportedly within 10 feet of the surface and suitable for strip mining. The sulfur would be upgraded from 20 percent to 70 percent by flotation. The exact amount of reserves was not yet determined, because only about 10 percent of the total 3,500 acres had been prospected. About 15 chemical companies were said to be negotiating with Great American Industries for an operating partnership in the venture.[11]

The SS Marine Floridian, Texas Gulf Sulphur Co.'s new seagoing tanker and sister ship of the SS Marine Texan, completed its maiden voyage on June 30. The new sulfur tanker will operate regularly between Beaumont, Tex., and Tampa, Fla., with occasional calls to East Coast ports. The ship has a capacity of 24,000 long tons of liquid sulfur and a cruising speed of 14 knots.

Close to $40 million was spent during the last 2 years of off-shore and outer continental shelf leases in the Gulf of Mexico in an effort to locate new domes with commercial quantities of sulfur. Several oil

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[10] Oil, Paint and Drug Reporter. Sulfur Output Started at Hooker's Test Facility. v. 191, No. 26, June 26, 1967, p. 3.

[11] Engineering and Mining Journal. Chemical Firms Eager to Join in Sulphur Mining Venture. v. 168, No. 4, April 1967, p. 126.

companies, Freeport Sulphur Co., and Texas Gulf Sulphur Co., were active in the search. An undisclosed amount of money, in the millions, went into the exploration drilling. No commercial quantities of sulfur were discovered, and by yearend 1967 hopes of locating any new Frasch process sulfur domes in the area were diminishing.

Recovered Sulfur.—Production of recovered sulfur from sour natural and refinery gases was 1,270,289 long tons. Texas and California again were the leading producing States. Texas production amounted to 675,000 tons which was 53 percent of the total recovered elemental sulfur. California's production totaled 138,000 tons.

Sulfur recovery plants brought on-stream in 1967 were as follows:[12]

Company	*Plant location*	*Daily capacity (tons sulfur)*
From natural gas:		
Amarillo Oil Co	Odessa, Tex	10
Marathon Oil Co	Iraan, Tex	65
National Sulphur Co	Marshall County, Okla	8
Northwestern Refining Co	St. Paul, Minn	33
Phillips Petroleum Co	Sweeney, Tex	25
Texas Gulf Sulphur Co	Dumas, Tex	10
Union Oil Co	San Juan County, Utah	10
From oil refinery gas:		
Atlantic Richfield Co	Long Beach, Calif	65
Humble Oil & Refining Co	Baton Rouge, La	10
Marathon Oil Co	Lakewood, N.Mex	23
Mobil Oil Corp	Torrance, Calif	85
Powerine Corp	Santa Fe, Calif	20
Signal Oil and Gas Co	Houston, Tex	10

Texas Gulf Sulphur Co. closed its sulfur recovery plant at Worland, Wyo., after 18 years of operation. Since 1949 when the plant went on stream, it has recovered 1,013,490 long tons of sulfur from sour natural gas. The closure was necessitated by the depletion of the sour gas reserve. Originally the plant had been the largest of its kind in the world.[13]

Elcor Chemical Corp. announced on August 24, that its wholly owned subsidiary, National Sulphur Co., planned to produce elemental sulfur from gypsum. Pilot-plant studies convinced company officials that the process would be competitive with conventional sulfur production methods. A commercial plant capable of producing 350,000 tons of sulfur per year was to be built at the firm's large gypsum deposit in Culbertson County, Tex. Completion date for the project was scheduled for late 1968. No details of the process were revealed, but it is assumed to be a departure from other processes, since Elcor Chemical Corp. was reportedly seeking to patent it.

[12] Sulphur (London). Major World Brimstone Producers in 1967. No. 75, March/April 1968, p. 17.
[13] Skilling's Mining Review. Texas Gulf Closes Worland Plant. v. 56, No. 38, Sept. 23, 1967, p. 18.

Table 5.—Recovered sulfur produced and shipped in the United States
(Long tons)

Year	Production		Shipments		
	Gross weight	Sulfur content	Gross weight	Sulfur content	Value (thousands)
1963	949,567	946,753	932,147	929,369	$19,401
1964	1,024,649	1,021,358	993,643	990,437	21,088
1965	1,219,312	1,215,168	1,172,840	1,168,831	24,574
1966 r	1,243,960	1,240,386	1,264,512	1,260,854	30,166
1967	1,270,289	1,267,955	1,286,408	1,283,995	40,984

r Revised.

Table 6.—Production and shipments of pyrites (ores and concentrates) in the United States

(Long tons)

Year	Production			Shipments		
	Gross weight	Sulfur content	Value (thousands)	Gross weight	Sulfur content	Value (thousands)
1963	824,800	343,566	$5,698	72,618	33,449	$303
1964	847,493	353,831	5,471	49,829	23,832	239
1965	874,957	353,645	5,333	57,184	27,278	272
1966	872,414	355,592	5,088	52,481	25,122	205
1967	860,909	355,033	7,943	48,010	23,553	184

Pyrites.—Production of pyrite concentrate with an average grade of 41-percent sulfur increased. Tennessee, the leading producing State, accounted for about 85 percent of the total domestic output. Other producing States in decreasing order of tonnage were Pennsylvania, Colorado, Arizona, Utah, and South Carolina.

Byproduct Sulfur Compounds.—Sulfur dioxide was recovered at one lead smelter in California and one copper smelter in Tennessee. Hydrogen sulfide was recovered at eight refineries in California, Louisiana, New Jersey, and Pennsylvania. Sulfuric acid was recovered at one lead smelter in California; four copper smelters in Arizona, Tennessee, and Washington; and 11 zinc smelters in Idaho, Illinois, Indiana, Kansas, Montana, Ohio, Oklahoma, and Pennsylvania.

A new 500-ton-per-day sulfuric acid plant was put on stream at Garfield, Utah, by Kennecott Copper Corp. The plant will recover the equivalent of about 160 tons per day of sulfur from smelter gases containing an average of 4 percent of sulfur dioxide.

Table 7.—Byproduct sulfuric acid [1] (basis, 100 percent) produced at copper, zinc, and lead plants in the United States

(Short tons)

Plants	1963	1964	1965	1966	1967
Copper [2]	358,503	330,273	369,321	469,728	348,497
Zinc	861,763	924,100	961,591	983,118	900,170
Total	1,220,266	1,254,373	1,330,912	1,452,846	1,248,667

[1] Includes acid from foreign materials.
[2] Includes acid produced at a lead smelter.

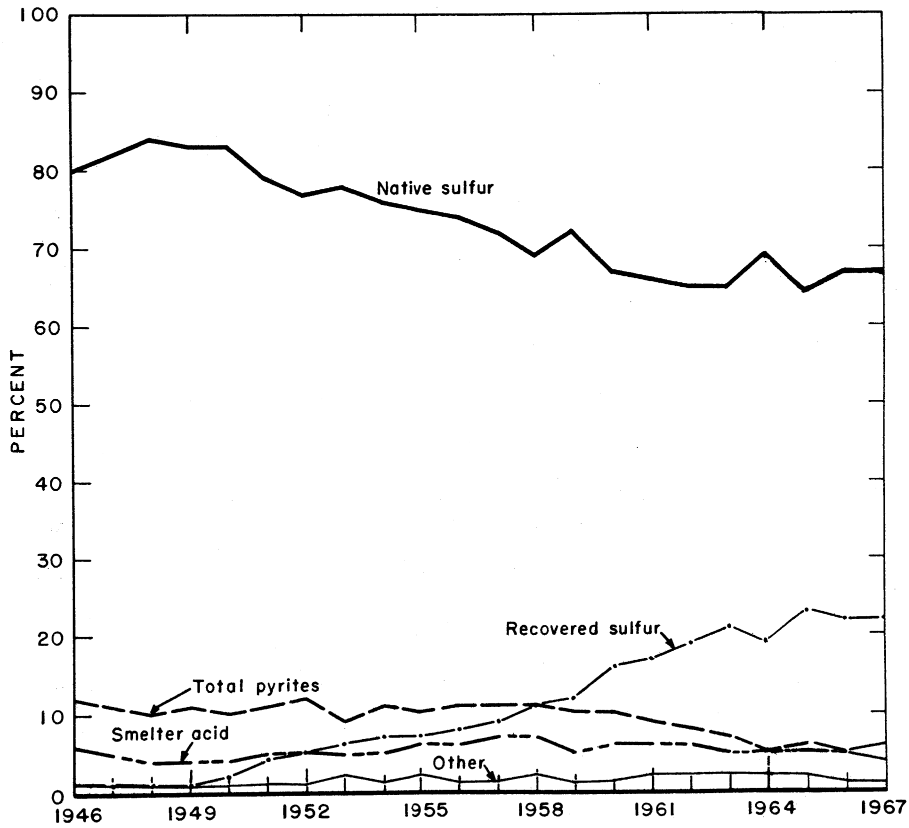

Figure 2.—Sulfur supply sources as a percent of total apparent consumption based on sulfur content.

CONSUMPTION

The apparent consumption of sulfur in all forms in the United States again set a new record of 9.3 million tons, 2 percent greater than that in 1966. Consumption of sulfur in the manufacture of phosphatic fertilizers was responsible for the increase and had not both the spring and fall fertilizer seasons been hampered by adverse weather conditions which reduced the demand for fertilizer, the sulfur consumption probably would have been much greater.

The consumption of sulfur for industrial acid decreased chiefly due to a decline in the use of sulfur by the nonferrous metals industry because of the extended copper strike, a decline in demand for use in the rayon industry because of a rubber industry strike resulting in reduced production of tires using rayon cord, and less demand by the steel industry because of the increasing use of hydrochloric acid, instead of sulfuric acid, in steel pickling.

Consumption of sulfur throughout the rest of the free world was estimated to have been 1 million long tons more than in 1966. The fertilizer industry accounted for about 60 percent of the increase.

Table 8.—Apparent consumption of native sulfur in the United States

(Long tons)

	1963	1964	1965	1966	1967
Apparent sales to consumers [1]	5,050,923	5,775,399	6,938,147	7,687,389	7,729,297
Imports	863,385	890,604	831,000	799,000	724,000
Total	5,914,308	6,666,003	7,769,147	8,486,389	8,453,297
Exports:					
Crude	1,603,438	1,920,392	2,624,052	2,326,000	2,043,000
Refined	9,199	7,700	r 10,861	47,000	150,000
Total	1,612,637	1,928,092	r 2,634,913	2,373,000	2,193,000
Apparent consumption	4,301,671	4,737,911	r 5,134,234	6,113,389	6,260,297

r Revised.
[1] Production adjusted for net change in stocks during year.

Table 9.—Apparent consumption of sulfur in all forms in the United States [1]

(Long tons)

	1963	1964	1965	1966	1967
Native sulfur	4,301,700	4,737,911	r 5,134,234	6,113,389	6,260,297
Recovered sulfur:					
Sales	929,400	987,600	1,166,716	r 1,258,201	1,286,871
Imports	487,800	571,200	655,556	715,077	750,194
Pyrites:					
Domestic production	343,600	353,800	353,645	355,592	355,033
Imports e	93,000	120,000	160,000	160,000	165,000
Total pyrites	436,600	473,800	513,645	515,592	520,033
Smelter-acid production	335,700	r 366,143	r 388,484	r 424,075	364,477
Other production [2]	115,800	123,500	138,660	133,859	134,198
Grand total	6,607,000	r 7,260,154	r 7,997,295	r 9,160,193	9,316,070

e Estimated. r Revised.
[1] Crude sulfur or sulfur content.
[2] Hydrogen sulfide and liquid sulfur dioxide. Does not include acid sludge converted to H_2SO_4.

STOCKS

Withdrawals from producers' stocks have been necessary since demand first exceeded production in mid-1963. At the start of 1967, only 2,616,310 long tons of Frasch and 88,039 tons of recovered sulfur remained in stocks. Further withdrawals were necessary during 1967, and by yearend the total Frasch and recovered sulfur in stock dropped to 1,953,877 tons, less than a 3-month supply for domestic requirements. Data on liquid sulfur storage capacity are not available.

PRICES

Sales incentives, such as absorption of some freight or terminal charges dating back to 1959, were all eliminated by the end of 1966. Jefferson Lake Sulphur Co. established a price of $27.50 per long ton for bright sulfur in September 1965 which remained firm through 1966. Effective July 1, 1966, Duval Corp. set the price for dark sulfur at $27.50 and for bright sulfur $1 higher. Freeport Sulphur Co. increased prices $2.50 per ton to $28.50 for dark and $29.50 for bright, f.o.b. Port Sulphur, La., effective December 1, 1966. Texas Gulf Sulphur Co. also increased its prices $2.50 per ton to $29.50 f.o.b. Beaumont, Texas for bright sulfur. Most Frasch sulfur at yearend 1966 was selling at $28.50 for dark and $1 more for bright, f.o.b. Gulf Ports.

The continued heavy demand in 1967 prompted further price increases. Domestic prices were increased $4 per ton about the end of March 1967 and $5.50 per ton effective October 1, 1967. At yearend the domestic price for dark sulfur was $38 per long ton and $1 to $2 higher for bright f.o.b. Gulf Ports. Export prices at yearend ranged from $40 to $50 depending upon the quality, market, and seller. The outlook for 1968 was a continuing tight domestic supply with further price advances on domestic sales. Little if any change was expected in export prices.

FOREIGN TRADE

The quantity of sulfur exported was reduced by about 300,000 tons in order to make more available for domestic use. Export sales reached a record high of 2.6 million tons in 1965. Continued strong worldwide demand coupled with a short supply made it necessary for U.S. producers to limit their export sales.

Imports showed a steady growth reaching a record high in 1966 but declined somewhat in 1967. Complete data on imports of pyrites are not available, but it is estimated that about 350,000 tons containing 165,000 tons of sulfur was imported in 1967, slightly more than the previous year.

Table 10.—U.S. exports and imports for consumption of sulfur

(Thousand long tons and thousand dollars)

Year	Exports				Imports	
	Crude		Crushed, ground, refined, sublimed, and flowers		Quantity	Value
	Quantity	Value	Quantity	Value		
1965	2,624	$64,278	11	$1,271	1,486	$27,298
1966	2,326	78,759	47	3,404	1,514	33,525
1967	2,043	81,492	150	9,522	1,474	47,612

Table 11.—U.S. exports of sulfur, by countries

Destination	Crude				Crushed, ground, refined, sublimed and flowers			
	1966		1967		1966		1967	
	Long tons (thousands)	Value (thousands)	Long tons (thousands)	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
Argentina	34	$1,151	25	$1,056	272	$37	56	$25
Australia	164	5,609	223	8,464	6,448	353	297	92
Austria	42	1,492	31	1,254	------	-----	-------	-----
Belgium-Luxembourg	8	270	30	1,191	17	7	14	5
Brazil	172	6,040	192	7,652	1,083	161	411	106
Canada	136	3,900	123	4,554	r 3,366	337	813	236
Chile	8	283	4	185	984	57	2	1
Colombia	-----	------	1	55	423	33	119	29
Costa Rica	-----	------	(1)	1	9	1	17	5
Czechoslovakia	17	539	5	202	------	-----	-------	-----
El Salvador	4	147	8	368	14	2	63	11
France	49	1,671	5	195	291	26	63	28
Germany, West	153	5,564	66	2,647	221	76	17	3
Guatemala	(1)	2	-----	------	227	26	49	9
India	180	6,178	131	6,195	25,503	1,568	90,252	5,695
Indonesia	4	158	-----	------	500	18	-------	-----
Iraq	-----	------	(1)	12	300	16	-------	-----
Ireland	46	1,615	77	3,031	------	-----	-------	-----
Israel	48	1,669	34	1,444	97	11	1	(1)
Italy	21	857	5	238	1,075	61	5,883	261
Jamaica	1	35	2	96	26	3	1,134	64
Korea, South	1	78	3	213	69	6	1,070	76
Mexico	(1)	(1)	-----	------	793	86	233	82
Netherlands	641	22,053	564	21,978	3	1	-------	-----
New Zealand	129	4,322	64	2,452	323	37	86	18
Nicaragua	-----	------	(1)	1	79	6	-------	-----
Norway	1	33	6	224	54	4	36	3
Peru	13	417	17	665	380	49	102	31
Philippines	(1)	8	(1)	7	308	32	3,567	236
Saudi Arabia	2	97	1	66	309	17	318	24
South Africa, Republic of	68	1,976	67	2,123	652	82	15,521	743
Spain	10	326	8	307	30	14	25	10
Sweden	1	49	9	343	17	1	-------	-----
Switzerland	31	1,131	3	106	------	-----	30	4
Taiwan	22	779	73	3,675	2,004	121	11,752	743
Tunisia	46	1,630	51	1,974	------	-----	-------	-----
United Kingdom	211	6,445	150	5,745	185	17	85	17
Uruguay	11	370	10	432	45	12	-------	-----
Venezuela	2	60	2	108	455	52	17,139	841
Other	50	1,805	53	2,233	777	74	670	124
Total	2,326	78,759	2,043	81,492	47,339	3,404	149,825	9,522

r Revised.
1 Less than ½ unit.

Table 12.—U.S. imports for consumption of sulfur, by countries

(Thousand long tons and thousand dollars)

Country	1966		1967	
	Quantity	Value	Quantity	Value
Bahamas	11	$293	-----	------
Canada	703	12,084	750	$18,371
Canal Zone	1	10	-----	------
Germany, West	(1)	20	(1)	12
Japan	-----	------	(1)	8
Mexico	799	21,117	724	29,221
United Kingdom	(1)	1	(1)	(1)
Total	1,514	33,525	1,474	47,612

1 Less than ½ unit.

WORLD REVIEW

Australia.—The world shortage of brimstone caused fertilizer companies to increase their consumption of pyrites. In February, Australian Fertilizers Ltd., and A.C.F. and Shirleys Fertilizers Ltd. formed Central Queensland Acid Pty. to construct a $10 million plant at Gladstone, Queensland, to produce sulfuric acid from pyrites mined at Mount Morgan. The plant reportedly will produce 1,000 tons of acid per day processing about 250,000 tons of pyrites annually. Pyrites have been produced by Mount Morgan Ltd. as a low cost byproduct for many years, but very little was ever used to produce acid. The cost of freight from mine to Australia's acid plants was relatively high, $14.08 per ton sulfur content to Brisbane, Queensland, and $23.10 per ton to Newcastle, New South Wales. The Government has been paying a bounty to both producers of pyrite and producers of acid from pyrite, but the incentive was not enough.[14] Australia has no native sulfur deposits and has been obliged to import all of its elemental sulfur requirements. In view of this situation, the Government was considering an intensive search for sulfur and possibly calling in an internationally recognized expert to advise on the most likely areas to prospect.[15]

Canada.—Shell Canada Ltd. announced plans for erecting a sulfur recovery plant at its Shellburn refinery, Burnaby, British Columbia. The plant costing in excess of $600,000 would have a designed capacity of 15 tons per day of liquid sulfur. Shell expanded the production capabilities of its Waterton, Alberta, plant from 1,200 to 1,650 tons per day and expected to increase the output capacity of its Jumping Pound, Alberta, plant from 100 to 240 tons per day by January 1968.

Pan American Petroleum Corp., a subsidiary of Standard Oil Co. (Indiana), was building a new gas processing and sulfur recovery facility at Bigstone Field, Alberta. The daily output from this facility was expected to be 320 tons when production begins in February 1968. Pan American Petroleum Corp. will operate another facility under construction at East Crossfield, Alberta. The plant was scheduled to be on stream early in 1968. Canadian Superior Oil Ltd. and Pan American Petroleum Corp., each hold a 40 percent interest while the remaining 20 percent is divided among 18 other owners. The estimated daily output of this plant was 1,400 tons.

Petrogas Processing Ltd., owned by Jefferson Lake Petrochemicals of Canada Ltd., Mobil Oil Co., and 26 other companies but operated by Jefferson Lake, doubled the output of sulfur at its plant at East Calgary, Alberta. The company estimated its production increased from 229,000 tons in 1966 to 500,000 tons in 1967. A further increase to 600,000 tons was planned for 1968.[16]

In October, Great Canadian Oil Sands Ltd. (GCOS) (82 percent owned by Sun Oil Co.) began commercial-scale sulfur recovery from the fabulous Athabasca tar sands. These huge tar sand deposits, which cover some 30,000 square miles of Northern Alberta, reportedly contain the world's largest known oil reserves and vast tonnages of sulfur. The GCOS leases cover only 4,000 acres or about 1/20 of 1 percent of the total. The Alberta Government maintains control of production from the area. The sulfur recovery plant is part of a $235 million complex which will produce 45,000 barrels of oil, 300 tons of sulfur, and 2,800 tons of coke daily. There were three more tar sand projects, all larger than the GCOS venture, awaiting government approval to proceed.[17]

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[14] U.S. Embassy, Cranberra, Australia. State Department Airgram A-416, Mar. 18, 1967, p. 1, Enc. 1.

[15] European Chemical News. Australia Considers Search For Sulfur. v. 11, No. 281, June 16, 1967, p. 26.

[16] Chemical Week. Sulfur From Canada: Twice As Much By '70. v. 100, No. 24, June 17, 1967, pp. 104–106.

[17] Northern Miner (Toronto). Mining Project Taps New Northern Resource With Production From Athabasca Tar Sands. No. 28, Oct. 5, 1967, pp. 1, 5.

Table 13.—World production of elemental sulfur, by countries [1]

(Long tons)

Country	1963	1964	1965	1966	1967 p
Native sulfur:					
Frasch:					
Mexico	1,456,656	1,635,773	1,481,241	1,611,446	1,793,085
United States	4,881,927	5,228,365	r 6,116,406	r 7,001,503	7,014,448
Total	6,338,583	6,864,138	r 7,597,647	r 8,612,949	8,807,533
From sulfur ores:					
Argentina	22,338	21,955	23,391	r 29,942	NA
Bolivia (exports)	9,793	10,635	9,306	56,554	49,513
Canary Islands	6,889	r 9,842	e 7,000	e 7,000	e 7,000
Chile	r 42,751	r 43,185	r 34,413	r 39,671	NA
China, mainland e	120,000	120,000	120,000	120,000	120,000
Colombia	12,795	11,942	18,114	20,649	NA
Ecuador	163	232	150	123	NA
Indonesia	1,033	1,668	r 1,268	e r 1,200	e 1,800
Italy	r 134,640	r 94,484	r 93,992	r 92,122	e 85,000
Japan [2]	219,095	237,413	209,881	226,087	250,375
Mexico	28,968	25,989	33,800	29,322	23,542
Philippines	47	68	47	14	NA
Poland	231,486	289,948	424,195	468,976	NA
Taiwan	7,144	6,389	4,424	4,522	NA
Turkey	19,123	21,849	21,947	22,292	24,983
U.S.S.R. e	950,000	950,000	1,000,000	1,000,000	1,050,000
United Arab Republic (Egypt)	e 490	----------	----------	----------	NA
United States	415	158	133	143	284
Total [3]	r 1,807,170	r 1,845,757	r 2,002,061	r 2,118,617	e 2,203,137
Total native sulfur	r 8,145,753	r 8,709,895	r 9,599,708	r 10,731,566	e 11,010,670
Other elemental:					
Recovered:					
Belgium	4,921	4,921	3,445	4,921	NA
Brazil [4]	5,659	NA	4,943	5,825	6,112
Bulgaria [5]	6,291	6,720	6,720	e 11,000	NA
Canada (sales) [6]	1,115,968	1,596,574	1,846,778	r 1,822,800	2,073,413
China, mainland e [4] [5]	130,000	130,000	130,000	130,000	130,000
Finland	37,611	67,063	72,606	72,478	e 75,000
France [7]	1,386,285	1,486,846	1,497,180	r 1,515,683	1,719,019
Germany:					
East	117,981	123,081	122,836	r 125,682	e 130,000
West	84,949	76,602	75,412	r 78,540	e 100,000
Hungary	2,938	3,050	3,396	e 3,500	NA
Iran e [4]	20,000	r 20,000	r 20,000	r 20,000	NA
Italy	1,279	787	2,461	e 2,500	NA
Japan [4]	11,429	18,499	35,988	52,187	61,201
Mexico [7]	43,308	36,284	45,984	38,111	47,577
Netherlands [5]	34,447	28,444	26,475	r 38,876	NA
Netherlands Antilles: Aruba and Curacao e	34,400	28,500	30,000	30,000	NA
Portugal	r 15,358	r 6,033	r 9,583	r 6,228	NA
South Africa, Republic of [4]	1,981	5,701	7,102	r 8,904	e 9,000
Spain	68,036	75,452	r 43,253	r 27,819	42,120
Sweden [8]	25,885	27,009	r 21,082	r 9,842	----------
Taiwan [4]	2,310	2,780	2,348	2,337	NA
Trinidad [4]	6,629	5,322	3,723	r 4,010	NA
U.S.S.R. e	400,000	400,000	r 430,000	r 430,000	450,000
United Arab Republic (Egypt)	2,355	2,427	3,648	11,490	NA
United Kingdom [9]	46,529	53,701	47,992	r 39,898	NA
United States	946,753	1,021,358	1,215,168	r 1,240,386	1,267,955
Uruguay [4]	----------	----------	----------	49	NA
Total other elemental	r 4,553,302	r 5,227,154	r 5,708,123	r 5,733,066	e 6,236,497
World total	r 12,699,055	r 13,937,049	r 15,307,831	r 16,464,632	e 17,247,167

e Estimate. p Preliminary. r Revised. NA Not available, estimates are included in totals.
[1] Compiled mostly from data available May 1968.
[2] Includes sulfur from mined sulfur-sulfide ore.
[3] In some years Iran produces mine sulfur equivalent to 250–1,500 tons of sulfur. No estimates in total.
[4] From refinery gases.
[5] From sulfide ore.
[6] Produced from natural gas, includes a small quantity derived from treatment of nickel-sulfide matte at Fort Colborne, Ontario.
[7] From natural gas.
[8] From shale oil.
[9] Including sulfur recovered from petroleum refineries.

Table 14.—World production of pyrites (including cupreous pyrites)[1]
(Thousand long tons)

Country	1965		1966		1967 [p]	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
North America:						
Canada (shipments)	315	[r] 167	[r] 324	[e] [r] 143	335	164
Cuba [e]	30	13	30	13	NA	NA
United States	875	354	[r] 872	[r] 356	861	355
Europe:						
Bulgaria	151	63	[e] 157	[e] 66	NA	NA
Czechoslovakia	[r] 369	[e] [r] 144	[r] 346	[e] [r] 135	NA	NA
Finland	573	278	508	[e] [r] 261	NA	NA
France	132	56	87	[r] 36	[e] 84	[e] 34
Germany, West	432	194	443	203	541	232
Greece	[r] 102	[e] [r] 46	133	[e] 60	NA	NA
Italy	1,379	[e] 607	1,284	578	[e] 1,407	[e] 633
Norway	698	[r] 312	[r] 667	[r] 297	[e] 632	[e] 281
Poland [e]	235	90	235	90	NA	NA
Portugal	604	279	549	253	[e] 512	[e] 235
Rumania [e]	405	160	[r] 354	[r] 138	354	138
Spain	[r] 2,386	[r] 1,131	[r] 2,380	[r] 1,115	2,255	1,069
Sweden	434	217	[r] 427	[r] 218	[e] 433	[e] 217
U.S.S.R. [e]	3,250	1,720	3,250	1,720	3,450	1,820
Yugoslavia	400	160	372	[r] 156	[e] 418	[e] 175
Africa:						
Algeria	56	26	[e] 50	[e] 25	NA	NA
Morocco	18	5	15	4	------	-----
Rhodesia, Southern	[e] 81	[e] 30	NA	NA	NA	NA
South Africa, Republic of	422	[e] 170	474	[e] 189	[e] 541	[e] 217
Asia:						
China (mainland) [e]	1,480	665	1,480	665	1,480	665
Cyprus	978	[e] 475	972	[r] 380	[e] 1,181	[e] 472
Japan [2]	4,255	1,808	[r] 4,659	[r] 1,958	[e] 4,480	[e] 1,900
Korea:						
North [e]	445	177	[r] 490	[r] 195	490	195
South	(3)	(3)	4	1	4	1
Philippines	104	48	113	51	144	67
Taiwan	39	16	41	17	38	15
Turkey	130	60	171	81	123	59
Oceania: Australia	204	89	[r] 246	[r] 107	NA	NA
Total	[r] 20,982	[r] 9,560	[r] 21,133	[r] 9,511	[e] 21,618	[e] 9,764

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available, estimates are included in total.
[1] Compiled mostly from data available May 1968.
[2] Pyrite data covering pyrites, cupreous pyrites, and pyrrhotite only are as follows: (in thousand long tons) 1965, 3,330 tons; 1966, 3,507 tons; and 1967, NA.
[3] Less than ½ unit.

Extensive exploration in Northern Alberta indicated the possibility of significant native sulfur deposits. Over 20 prospecting permits were issued covering 375,301 acres of which 276,480 acres were about 265 miles north-northwest of Edmonton bordering the southwest corner of Wood Buffalo National Park. Samples from this area reportedly indicated the presence of large native sulfur ore bodies with sulfur content up to 90 percent. The remaining acreages were located in the Hay River area about 25 miles northwest of the Rainbow Lake oil field, the Winifred Lake region about 185 miles northeast of Edmonton, and the Daysland area about 80 miles southeast of Edmonton.[18]

Chile.—The Government was making a concerted effort to increase domestic sulfur production. Prime responsibility for this effort was assigned to the Committee for Sulfur Production (Comité para la Producción del Azufre) within the Chilean Development Corporation (Corporación de Fomento de la Producción). According to a fact sheet on Chilean sulfur prepared by the Committee, known reserves in Chile amount to 50 million tons, are of volcanic origin, and the sulfur content varies from 40 to 75 percent. The most promising deposits are located in the northern most provinces, Tarapacá, Antofagasta, and Atacama.[19]

Costa Rica.—Consolidated Negus Mines Ltd. was engaged in exploration by drilling, trenching, and tunneling of its prop-

[18] U.S. Embassy, Calgary, Canada. State Department Airgram A-52, Nov. 28, 1967, p. 1.
[19] U.S. Embassy, Santiago, Chile. State Department Airgram A-257, Nov. 24, 1967, p. 1; Enc. 1.

erty in Guanacaste Province. Trench samples near the No. 1 drill hole showed up to 47 percent sulfur. Much more exploraion is required but plans were being formulated to mine the ore and truck it to port, 75 miles away.[20]

Pascar Oils Ltd. was drilling its optioned concessions in Guanacaste Province, 18 miles from the town of Liberia. Assays of a drill core taken from a 273-foot hole showed 47 feet of 25.2 percent sulfur from 33 to 80 feet deep. Some channel samples taken in another area averaged 34.2 percent sulfur. Additional exploration was underway.[21]

Ecuador.—Sulfur deposits amounting to about 30 million tons were reportedly discovered near Tufino in the Province of Carchú. Cia. Azufrera Ecuatoriana was planning to erect a $2.5 million refinery to produce 2,000 tons of sulfur per day.

Guatemala.—A consortium of American, Canadian, and Italian business interests was developing a volcanic sulfur deposit at Lake of Ixpaco. Reserves of 2.3 million tons were reportedly proved. The company, Azufres de Guatemala, expected to be producing 300 tons of sulfur daily by yearend. Several obstacles had to be overcome before large-scale operations could begin. Among these were the lack of electric power at the mine site and lack of transportation facilities from mine to the Pacific coast highway.[22]

India.—The Government-owned Pyrites & Chemical Development Corp. will build and operate India's first sulfuric acid plant at Sindri, Bihar. Construction was started in February and the plant was scheduled for a daily output of 400 tons of acid by June 1968. The plant will use pyrite ore from the Amjhore deposits near Sindri which contain an estimated 384 million tons of pyrite ore averaging 40 percent sulfur.[23]

Table 15.—Mexico: Exports of sulfur, by countries
(Long tons)

Destination	1966	1967
North America: United States	818,329	711,781
South America:		
Brazil	4,000	---------
Chile	10,169	---------
Europe:		
Belgium	4,400	---------
France	95,055	145,700
Netherlands	46,409	71,892
United Kingdom	238,143	297,805
Africa:		
South Africa, Republic of	10,002	20,161
Tunisia	51,891	41,448
United Arab Republic	14,994	---------
Asia:		
India	20,549	86,624
Israel	---------	5,998
Taiwan	9,842	45,228
Oceania:		
Australia	101,554	127,839
New Zealand	60,465	47,607
Total	1,485,802	1,602,083

Source: Compiled from U.S. Embassy, Mexico, D.F., Mexico, State Department Airgram A-1077 Apr. 27, 1967, p. 2; Airgram A-682, Jan. 31, 1968, Enc. 2. A-1121, June 19, 1968, Enc. 2.

Mexico.—Pan American Sulphur Co. stockholders approved the offer of the Mexican Government and private investors to purchase 66 percent of the common stock of its subsidiary, Azufrera Panamericana, S.A. de C. V., the largest Frasch sulfur producer in Mexico. Under the agreement royalities were reduced from 20 percent to 12 percent of value, and Pan American Sulphur Co. received 34 percent of the earnings after March 30.

[20] Northern Miner (Toronto). Consider Mining Sulphur Property of Cons. Negus, No. 26, Sept. 21, 1967, p. 16.

[21] Northern Miner (Toronto). More Sulphur Values In Pascar Drilling. No. 33, Nov. 9, 1967, p. 10.

[22] Bureau of Mines. Mineral Trade Notes. v. 64, No. 8, August 1967, pp. 10–11.
U.S. Embassy, Guatemala City, Guatemala. State Department Airgram A-110, Aug. 31, 1967, pp. 1–2.

[23] Bureau of Mines. Mineral Trade Notes. v. 64, No. 5, May 1967, p. 29.

An agreement between Texas Gulf Sulphur Co. (TGS) and the Mexican Government was reached which allowed Compañia Exploradora del Istmo, a TGS subsidiary, to resume operations as an affiliate. Under the terms of the agreement, the Mexican Government acquired a 33-percent interest in the subsidiary and a group of private Mexican investors, 33 percent, leaving 34 percent retained by TGS. On October 23, Exploradora del Istmo resumed sulfur production at Nopalapa. Operations had been suspended more than 5 years ago at the property on the Isthmus of Tehuantepec. A 1,000 ton-per-day melting facility was completed which will be used to liquify the 300,000 ton stockpile at Nopalapa belonging to TGS. Additional drilling by the affiliate at Texistepec increased the indicated sulfur reserves, and the construction of another Frasch mining facility there was being considered.

Several large U.S. phosphatic fertilizer producing firms concerned over the current sulfur shortage and the attendant price increases joined a rush for Mexican sulfur. As required by law, each formed a joint company with the Mexican Government and Nationals holding at least a 66-percent interest. The following new companies were actively seeking sulfur deposits to exploit:

Unión Minera del Sur S.A. (Cities Service Co., 34-percent interest), Azufrera Intercontinental S.A. de C.V. (International Minerals & Chemicals Corp., 34-percent interest), Minera de Sotavento S.A. de C.V. (Hooker Chemical Corp., 34-percent interest), Azufrera Industrial S.A. de C.V. (Continental Oil Co., 34-percent owner), and Azufrera Nacional S.A. de C.V. (24.5-percent owned by Sulphur Exploration Co. of Houston, Tex.).

In addition to the U.S. firms, two Canadian firms, one large French oil company, and several private investors reportedly had jointed the rush. International Helium Co. Ltd. (Toronto) took a 34-percent interest in a newly formed company, Azufres Nacionales Mexicános S.A. de C.V., to explore and mine sulfur domes in the Istmus of Tehuántepec. The Mexican Government and Mexican investors held 66 percent of the shares in this new venture.

New Zealand.—Large deposits of pyrites were reportedly found in the Waihi area. The Zeacon Mining Company Ltd. was further exploring the area to determine the feasibility of sulfur production.

Philippines.—The presence of 18.8 million tons of sulfur bearing material of volcanic origin assaying 28 percent sulfur was reported by Benguet Consolidated Inc. Additional drilling, testing, and feasibility studies were scheduled on the deposits which were in Negros Oriental Province about 400 miles south of Manila.[24]

Poland.—Current projects for increasing the output of native sulfur were expected to boost capacity to 1 million tons by 1970. Polish chemical executives qualified this by adding a provision that capacity would be increased if the world market is able to absorb the additional export tonnage of 500,000 tons.[25]

Saudi Arabia.—The first sulfur recovery plant in the middle East was being planned for Damman by Occidental Petroleum Corp. The initial annual capacity of the plant would be about 250,000 tons with production expected in 1968. The Kingdom of Saudi Arabia's General Petroleum and Mineral Organization reached an agreement early in the year with Occidental Petroleum Corp. and Allied Chemical Corp. for the development of the $19 million venture.[26]

Yugoslavia.—A new electrolytic zinc plant was established in Kosovska, Mitrovica, which will supply 85,000 tons of sulfuric acid annually as a byproduct.[27]

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[24] World Mining. Benguet Proves Large Sulphur Deposit on Negros Oriental. v. 3, No. 10, September 1967, p. 51.

[25] Oil, Paint and Drug Reporter. Sulfur's Production in Poland Is Seen Up to Million Tons in '70 If World's Demand Helps. v. 192, No. 19, Nov. 6, 1967, pp. 5, 48.

[26] Mines Magazine. Agreement Reached to Build Sulphur Recovery Plant in Kingdom of Saudi Arabia. v. 57, No. 1, January 1967, p. 32.

[27] Foreign Trade (Ottawa). v. 126, No. 2, Jan. 21, 1967, p. 35.

TECHNOLOGY

The petroleum industry has become an important source of sulfur and data on the sulfur content of most of the important oil fields of the free world were assembled and reported in a single source. The sulfur content of 1,060 United States crude oils and 201 foreign crude oils were given.[28]

Sulfur dioxide (SO_2) that could be converted to elemental sulfur or sulfuric acid was recovered from stack gases at Tampa Electric Co's., Gannon Plant. Flyash and sulfur trioxide (SO_3) were removed in a reactor, and SO_2 was removed by solutions in special receiving and treatment tanks. Part of the solution was returned to the reactor, and clean gas was discharged to the stack. The remainder of the solution was pumped to a cooler and stripping column from which SO_2 was sent to a compressor. The stripped solution was returned to the absorption cycle. The SO_2 produced was 99.9 percent pure. The calculated costs reported were such that an operation producing 81,000 tons of sulfur equivalent from the 1,300-Mw plant, using 2,730,000 tons of coal containing 3.5 percent sulfur, would break even if sulfur were $25 per ton at the power plant.[29]

A process was developed at the Bureau of Mines Salt Lake City, Utah, Metallurgical Research Center for recovering sulfur as a coproduct from brines containing sodium sulfate. Featured in the process was the use of a barium resin which could be regenerated and reused. In the processing, the sulfur contained in the brine as a sulfate was reduced to the sulfide and combined with hydrogen. Sulfur was then recovered from the hydrogen sulfide by one of the well known processes. Approximately 145 pounds of sodium carbonate and 45 pounds of sulfur could be recovered from 1,000 gallons of lake brine containing 16 grams of sulfate (SO_4) per liter.[30]

The use of alkalized alumina for removing sulfur dioxide from flue gases at 625° F was tested on a small pilot plant scale. The absorbent was regenerated with the reducing gases—reformed natural gas and hydrogen. Twenty cycles were completed without loss of activity.[31]

A method for recovering hydrogen sulfide from natural gas developed by Shell Canada may be available to other gas processors under license from the developer. Lower plant construction costs was the principal benefit of the process used at Waterton, Alberta, since 1962.[32]

An optimized sulfur production system at Lacq, France, promised increased recovery and cleaner tail gas from desulfurization units using the Claus process. Automatic equipment consists of a monitor for continuous measurement of sulfur losses, an automatic network for controlling input to catalytic converters, an anticipatory analog computer for correcting all measurable changes, and a minimum loss search system to correct for and keep nonmeasurable changes at a minimum.[33]

Liquid sulfur containing carbonaceous material was cleaned by heating to 600° to 825° F to vaporize the part of the sulfur containing the combustion products. The vaporized material was passed across a packing bed, countercurrent, to makeup liquid sulfur which cooled the sulfur vapor to liquid sulfur and permitted the combustion products to remain in a gaseous state.[34]

Steel producers claimed that hydrochloric acid (HCl) pickling produced a whiter, brighter sheet than sulfuric acid (H_2SO_4) pickling, and a prediction was made that half the pickling lines would use HCl by 1970. It was stated that better sheet with more consistent quality from one end of the coil to the other was possible, as well as an increase of 66.7 percent in line speed using HCl. Regeneration of HCl would decrease the problem of pollution of streams and rivers. Plant cost was lower with HCl, but acid costs were com-

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[28] McKinney, C. M., and Ella Mae Shelton. Sulfur Content of Crude Oils of the Free World, BuMines Rept. of Inv. 7059, 1967, 36 pp.

[29] Electrical World. Pilot Plant Absorbs Sulfur In Station Stack Gases. v. 168, No. 15, Oct. 9, 1967, pp. 29, 30.

[30] George, D'Arcy R., J. M. Riley, and Laird Crocker. Preliminary Process Development Studies for Desulfating Great Salt Lake Brines and Sea Water. BuMines Rept. of Inv. 6928, 1967. 34 pp.

[31] Bienstock, D., J. H. Field, and J. G. Myers. Process Development in Removing Sulfur Dioxide from Hot Flue Gases. BuMines Rept. of Inv. 7021, 1967, 52 pp.

[32] Engineering and Mining Journal. Shell May License Sulfur Process. v. 167, No. 1, January 1966, p. 18.

[33] Chemical Age (London). S.N.P.A. Optimise Sulphur Production at Lacq. v. 96, No. 2459, Aug. 27, 1966, p. 346.

[34] Lipps, Delbert A. (assigned to Freeport Sulfur Company, New York). Process for Heat-Treating Liquid Sulfur Containing Carbonaceous Impurities. U.S. Pat. 3,316,063, Apr. 25, 1967.

parable for the two acids. The three major automobile manufacturers, each a large buyer of pickled sheet, indicated that they could use sheet pickled by either process.[35]

The Ford Motor Company is developing a battery for trial in electric driven automobiles. In the new battery a ceramic electrolyte of about 90 percent aluminum oxide separates liquid sulfur and liquid sodium electrodes. Battery operating temperatures of 250° to 300° C are required to keep the electrodes molten. Heat generated during use is sufficient, and the battery may require cooling during peak loads. It was believed that a model could be developed that could maintain an operating temperature for 2 weeks' inactivity with proper insulation. An energy-density goal of 150 watt-hours per pound is hoped for. This would be 12 to 15 times greater than for conventional lead-acid batteries. A 2 kilowatt model of the sulfur-sodium battery was expected by the end of 1967 but at least an additional year would be needed to produce a 40 kilowatt prototype for automotive use.[36]

[35] Steel. Pickler's Pickle—Sulfuric or Hydrochloric? v. 158, No. 25, June 20, 1966, pp. 58–60.

[36] The Sulphur Institute Journal. Electric Auto Power Concept Uses Sodium-Sulphur System. Autum 1966, p. 18.

Talc, Soapstone, and Pyrophyllite

By J. Robert Wells [1]

The United States mined more crude talc, soapstone, and pyrophyllite in 1967 than in any previous year, establishing alltime records for both tonnage and total value. Marked declines in two of the producing States were more than offset by substantially increased outputs in five others.

The literature on domestic talc resources was increased by the publication of Bureau of Mines Report of Investigations 7045, "Talc and Asbestos at Dadeville, Ala." in completion of a study made in collaboration with the Alabama Geological Survey.

Legislation and Government Programs.—The General Services Administration announced on September 18, 1967, the sale from stockpile surplus of 20,000 pounds of Indian lump steatite talc. The successful bid of $1,600 for this material was placed by the Superior Steatite and Ceramic Corp., Englewood, New Jersey.

Table 1.—Salient talc, soapstone, and pyrophyllite statistics

(Thousand short tons and thousand dollars)

	1963	1964	1965	1966	1967
United States:					
Mine production	804	890	863	895	903
Value	$5,505	$6,218	$6,343	$6,479	$6,871
Sold by producers	794	875	838	r 850	824
Value	$18,420	$19,233	$19,794	r $19,269	$20,488
Exports [1]	57	74	70	70	66
Value [1]	$2,778	$3,391	$3,486	$3,917	$3,450
Imports for consumption	26	23	21	22	15
Value	$1,088	$917	$833	r $827	$653
World: Production	3,411	3,878	3,932	4,031	4,016

r Revised.
[1] Excludes powders—talcum (in package), face, and compact.

DOMESTIC PRODUCTION

In 1967 talc was mined in ten States, soapstone in seven States, and pyrophyllite in three States. Six States produced talc only, four soapstone only, two talc and soapstone, one pyrophyllite only, and one talc and phyrophyllite. Only one State reported production of all three. The leading producers of these crude talc-group minerals were New York, California, and Vermont, in that order, besides which there were two other States that also had outputs for the year of more than 100,000 tons each. Approximately 65 percent of the entire 1967 domestic supply of talc, soapstone, and pyrophyllite was mined by the six largest producing firms. The remainder consisted of the combined contributions of about 35 other companies.

California's talc grinding capacity was materially expanded by the completion of two new processing plants in that State. Discovery was announced of an extensive deposit in St. Lawrence County, N.Y., that contains a micaceous talc ore comparable to laminar western talc and not hitherto known to occur in the east. Proximity to major markets may give this New York mineral an important shipping-

[1] Commodity specialist, Division of Mineral Studies.

Table 2.—Crude talc, soapstone, and pyrophyllite produced in the United States, by States

State	1966 Short tons	1966 Value (thousands)	1967 Short tons	1967 Value (thousands)
California	138,340	$1,847	143,466	$1,945
Georgia	41,000	255	46,150	292
Nevada	4,715	24	2,096	17
North Carolina	113,366	576	109,393	513
Texas	102,399	367	90,836	356
Virginia	3,989	10	W	W
Washington	3,880	22	4,916	26
Other States [1]	487,356	3,378	505,655	3,722
Total	895,045	6,479	902,512	6,871

W Withheld to avoid disclosing individual company confidential data.
[1] Includes Alabama, Arkansas, Maryland, Montana, New York, Oregon, Pennsylvania, Vermont, and data indicated by symbol W.

Table 3.—Talc, soapstone, and pyrophyllite sold by producers in the United States, by classes

Year	Crude		Ground [1]		Total	
	Short tons	Value at shipping point	Short tons	Value at shipping point	Short tons	Value at shipping point
1963	63,924	$310,752	730,087	$18,109,581	794,011	$18,420,333
1964	73,438	370,851	801,587	18,862,560	875,025	19,233,411
1965	63,345	254,681	775,079	19,539,300	838,424	19,793,981
1966	[2] r 110,856	r 492,723	738,736	18,775,841	r 849,592	r 19,268,564
1967	[2] 42,758	279,542	780,998	20,207,990	823,756	20,487,532

r Revised.
[1] Includes crushed and sawed and manufactured material to avoid disclosing individual company confidential data.
[2] Includes exports to grinders in Belgium and Mexico.

cost advantage. In Vermont, Engelhard Minerals & Chemicals Corp. purchased talc mining and milling operations in Lamoille County from Eastern Magnesia Talc Co., Inc. The latter firm will continue its producing and processing activities at talc properties in Windsor County as Windsor Minerals, Inc.

CONSUMPTION AND USES

According to information supplied to the Bureau of Mines by producers and grinders of talc, soapstone, and pyrophyllite, the 1967 end-use pattern for these materials displayed no outstanding changes. Continuing the trend of recent years, however, there was a further, although moderate, decline in the relative share of the talc-group output going into ceramics. This use accounted in 1963 for 34 percent of the total, for 32 percent in 1964 and 1965, for around 28 percent in 1966, and for less than 27 percent in 1967. In absolute figures, this dip has been sharper than is apparent, because there has been a coinciding 4-percent growth in the total-output base to which these percentages apply. Large-volume importing of wall tile has been mentioned as one of the influences contributing to this downward drift in domestic ceramics consumption of the talc-group minerals.

Table 4.—Pyrophyllite [1] produced and sold by producers in the United States

Year	Production short tons	Total sales	
		Short tons	Value
1963	129,018	132,719	$1,664,329
1964	136,108	142,532	1,843,283
1965	126,266	136,308	1,823,946
1966	125,202	126,874	1,627,160
1967	117,457	118,337	1,578,736

[1] Includes sericite schist.

Table 5.—Talc, soapstone, and pyrophyllite sold or used by producers in the United States, by uses

(Short tons)

Uses	Talc and soapstone		Pyrophyllite	
	1966	1967	1966	1967
Ceramics	210,376	203,438	22,205	15,623
Foundry facings	4,596	5,818	---------	---------
Insecticides	36,449	40,759	25,449	27,598
Paint	147,299	151,752	W	W
Paper	42,331	45,046	---------	---------
Roofing	59,346	71,434	---------	---------
Rubber	22,108	27,937	W	W
Textile	8,403	8,384	---------	W
Toilet preparations	25,522	26,996	---------	W
Other	[1] r 166,288	[1] 123,855	[2] 79,220	[2] 75,116
Total	r 722,718	705,419	126,874	118,337

r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Includes asphalt filler, composition floor and wall tile, crayons, exports, grease manufacture, insulated wire and cable, joint cement, plastics, rice polishing, vault manufacturing, and miscellaneous products and items indicated by symbol W.
[2] Includes uses indicated by symbol W and asphalt filler, joint cement, plaster products, refractories, and related products.

PRICES

Total values for 1967 production and sales of talc, soapstone, and pyrophyllite as reported to the Bureau of Mines are listed in table 1. The per-ton averages derived from these data are indicative of current general price ranges, but in 1967 as usual actual sales were arranged at prices established in buyer-seller agreements not publicly recorded. Talc-group quotations in 1967 trade journals were essentially the same as those cited in the 1963 Minerals Yearbook, although early in the year two large eastern producers announced price increases of $2 to $3 per ton for some of their products.

FOREIGN TRADE

In 1967 the United States exported talc-group minerals to 57 countries, foremost of which in terms of quantity were Canada, 46 percent; Belgium-Luxembourg, 18 percent; and Mexico, 10 percent. Canada was first also in total value with 42 percent, followed by Mexico with 11 percent and Belgium-Luxembourg with slightly less than that figure.

Italy, as a source of talc imported by the United States for consumption, even though still in the lead in total value, lost its long-held first place in tonnage, yielding in that respect to both Canada and France.

Table 6.—U.S. exports of talc, steatite, soapstone, and pyrophyllite, crude and ground

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1965	70	$3,486
1966	70	3,917
1967	66	3,450

Table 7.—U.S. imports for consumption of talc, steatite or soapstone, and French chalk, by classes and countries

Year	Crude and unground		Ground, washed, powdered, or pulverized, except toilet preparations		Cut and sawed		Total unmanufactured	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value[1] (thousands)
1965	33	$4	20,835	$739	154	$90	21,022	$833
1966:								
Canada	254	2	3,038	64	9	5	3,301	71
France	4	(2)	5,046	116	1	(2)	5,051	116
India	28	3	84	3	-----	-----	112	6
Italy	-------	---	9,835	451	8	4	9,843	455
Japan	-------	---	--------	------	239	130	239	130
Korea, South	55	3	3,307	46	-----	-----	3,362	49
Total	341	8	21,310	680	257	139	21,908	827
1967:								
Australia	11	1	10	1	-----	-----	21	2
Belgium-Luxembourg	-----	-----	28	6	-----	-----	28	6
Canada	2,850	29	2,147	47	6	1	5,003	77
France	-----	-----	4,985	122	1	(2)	4,986	122
India	20	2	--------	------	-----	-----	20	2
Israel	-----	-----	10	2	-----	-----	10	2
Italy	32	(2)	4,379	281	7	4	4,418	285
Japan	1	(2)	--------	------	200	124	201	124
Korea, South	-----	-----	670	28	1	(2)	671	28
Switzerland	-----	-----	--------	------	3	5	3	5
Total	2,914	32	12,229	487	218	134	15,361	653

[1] Does not include other clay, n.s.p.f.: 1965, $33,764; 1966, $7,131; and 1967, $4,938.
[2] Less than ½ unit.

WORLD REVIEW

Australia.—An open pit mine in Western Australia supplied talc for domestic and foreign markets. In the 6 years since its inception this operation has yielded part of Australia's own talc requirement and more than 20,000 tons for export to European and Australasian consumers.

Belgium.—A new grinding plant in Ghent received its initial shipments of crude talc from the United States. This material, mined in Montana and conveyed to the Belgian mill by rail, ocean steamer, and river barge successively, will be processed to meet the needs of European paper and ceramics manufacturers.

Colombia.—Discovery of talc deposits of potentially commercial importance was reported as one of the results of the first part of a recently undertaken geological reconnaissance of national resources.

Finland.—Lohjan Kalkkitehdas, a major producer of industrial minerals, was weighing the export potential before deciding for or against the construction of a projected talc preparation plant in Sotkamo.

Mexico.—Sierra Talc de Mexico, S.A., opened a new plant at Xalastoc to turn out a wide range of talc and clay products, partly for export and partly for use by domestic industries.

Norway.—In the Norwegian nonmetallic mineral industry, talc, with an annual production of about 85,000 tons, is exceeded in commercial importance only by graphite.

Pakistan.—Scientists of the Geological Survey of Pakistan began an exploration to assess the potential industrial significance of soapstone deposits recently discovered in the Kurram Agency.

Rumania.—The Technical Directorate of the Ministry of Mines estimated that the Rumanian talc production in 1970 would be 140,000 tons or 22 percent greater than in 1965. The intention of expanding surveyed talc reserves more than fivefold was announced.

Table 8.—World production of talc, soapstone, and pyrophyllite, by countries [1]

(Short tons)

Country	1963	1964	1965	1966	1967 p
North America:					
Canada (shipments)	54,250	58,132	52,837	r 70,144	59,389
Mexico e	4,400	4,400	4,400	4,400	NA
United States	804,358	889,949	862,875	895,045	902,512
South America:					
Argentina	30,932	r 27,335	r 28,969	29,873	NA
Brazil	38,487	53,038	r 63,546	e 64,000	NA
Chile	2,846	3,042	r 4,822	r 2,813	NA
Colombia	r 717	805	440	1,317	NA
Paraguay	NA	52	154	66	NA
Peru	2,870	r 4,147	4,935	4,227	NA
Uruguay	1,890	2,341	2,618	2,346	NA
Europe:					
Austria	72,360	79,225	r 83,668	84,110	87,000
Finland	7,447	r 9,062	r 7,716	r 5,516	NA
France	174,298	r 226,414	264,872	r 213,848	215,000
Germany, West (marketable)	26,957	33,604	33,878	r 36,280	35,300
Greece	3,025	3,086	3,858	3,858	NA
Italy	153,590	147,522	131,256	124,207	134,482
Norway	80,537	r 87,536	r 88,185	86,366	e 88,000
Portugal	595	880	783	r 794	NA
Rumania	e 110,000	e 110,000	126,765	e 127,000	e 143,000
Spain	30,317	29,550	r 31,656	NA	NA
Sweden	20,696	18,360	r 20,639	e 21,000	e 21,000
U.S.S.R. e	385,000	385,000	395,000	395,000	408,000
United Kingdom	8,933	11,374	11,174	e 11,000	NA
Africa:					
Botswana	------	------	r 53	------	------
Rhodesia, Southern	21	15	e 90	NA	NA
South Africa, Republic of	7,566	7,294	10,187	9,530	e 11,200
Swaziland	3,052	2,199	1,014	480	NA
United Arab Republic	r 5,280	18,542	43,682	e 44,000	NA
Asia:					
China, mainland e	165,000	165,000	165,000	165,000	165,000
India	133,357	154,203	r 184,998	172,284	NA
Japan	944,551	1,162,646	1,110,908	r 1,222,435	1,509,663
Korea:					
North e	33,000	44,000	55,000	55,000	55,000
South	70,772	99,272	93,306	119,379	135,443
Pakistan	2,061	2,821	3,135	3,618	NA
Philippines	105	108	654	702	NA
Taiwan	16,300	18,718	16,787	31,694	45,542
Oceania: Australia	15,616	r 18,777	r 21,710	r 23,931	NA
Total [2]	r 3,411,186	r 3,878,449	r 3,931,570	r 4,031,263	4,015,531

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Compiled mostly from data available May 1968.
[2] Totals are of listed figures only; no undisclosed data included.

South Africa, Republic of.—Production of wonderstone (block pyrophyllite) was 6,193 short tons in 1966 and about 4,500 tons in 1967. Total exports of this material amounted in 1966 to 6,154 tons, valued at $648,668.

In 1964 the United States received, in terms of both quantity and value, nearly 98 percent of the total exports, but comparable data for subsequent years are not available.

Sweden.—The Swedish Geodetic Survey mentioned the discovery of a large deposit of talcose minerals near the Finnish border and north of the Arctic Circle. Preliminary exploration showed that the ore body may contain over 2 million cubic meters of commercial quality mineral.

Table 9.—Austria, France, and Italy: Exports of talc and soapstone by countries

(Short tons)

Destination	Exporting Countries: Austria 1966	Austria 1967	France 1966	France 1967	Italy 1966	Italy 1967
Algeria	------	------	1,997	1,717	132	NA
Austria	------	------	------	------	1,185	NA
Belgium-Luxembourg	6,031	6,034	4,352	3,866	644	NA
Canada	------	------	------	------	1,058	NA
Cuba	------	------	------	------	1,528	NA
Denmark	362	525	226	205	27	NA
Finland	------	------	r 373	278	------	------
France	1,575	2,020	------	------	r 3,681	4,516
Germany:						
East	5,089	4,304	------	------	------	------
West	32,157	31,550	9,932	9,395	7,099	6,633
Hungary	3,197	2,193	------	------	680	NA
Israel	418	323	679	663	208	NA
Italy	8,904	10,466	r 1,578	2,771	------	------
Ivory Coast	------	------	538	326	------	------
Japan	------	------	------	------	710	NA
Mexico	------	------	------	------	905	1,764
Morocco	------	------	1,299	634	66	NA
Netherlands	3,450	3,878	1,519	1,177	r 460	NA
Poland	967	1,195	808	606	------	------
Portugal	7	26	r 569	777	274	NA
Rumania	44	11	------	------	------	------
Spain	27	58	596	743	r 300	NA
Sweden	57	392	845	860	82	NA
Switzerland	4,205	4,586	6,461	5,917	r 1,458	NA
Tunisia	------	------	360	465	------	------
United Kingdom	184	295	9,535	11,025	7,585	6,685
United States	------	------	5,028	4,933	r 10,059	4,458
Venezuela	------	------	------	------	1,366	NA
Yugoslavia	11	154	------	------	158	NA
Other countries	68	55	r 1,929	3,236	r 3,744	11,618
Total	66,753	68,065	48,624	49,594	r 43,409	35,674

r Revised. NA Not available.

TECHNOLOGY

Talc and pyrophyllite were found to be especially amenable to processing in an attrition microgrinding apparatus developed by Bureau of Mines engineers and described in Bureau publications. At the Calgary meeting of the Canadian Institute of Mining and Metallurgy, it was announced that an equipment manufacturing firm has devised a high-intensity wet magnetic separation process for the elimination of impurities in talc. It has so improved the quality of the talc produced by an associate company that it commands a fourfold higher price.

Compression tests with different pressure-transmitting agents showed that pyrophyllite performs better than talc in high-temperature applications and supporting studies pointed out reasons for this superiority.[2] In a different but allied application, powdered pyrophyllite was specified as an ingredient of a charge mixture used for the production of artificial diamond.[3] A preparation of talc, chalk, and barite was recommended for removing patches of floating oil from water surfaces, as in harbors. The mixture preferentially absorbs the oil and causes it to sink.[4]

Talc with ball clay and talcose rock with ball clay plus wollastonite are two of the premix ceramic tile bodies most frequently furnished to tile manufacturers by a supplier of clays and other ceramic raw materials. This new service involves the grinding, weighing, and blending of

[2] Graf, R. B., and C. O. Hulse. Effect of Temperature on the Mechanical Properties of Solid Pressure-Transmitting Media. J. Appl. Phys., v. 35, No. 12, 1964, pp. 3466–3468, and v. 36, No. 5, 1965, pp. 1593–1596. Abs. in J. Am. Ceram Soc. v. 49, No. 6, June 1966, p. 167.

[3] Giardini, A. A., and J. E. Tydings (assigned to U.S. Secretary of the Army.) Synthesis of Diamond. U.S. Pat. 3,325, 254, June 13, 1967.

[4] Anderson, H. C. British Pat. 1,023,252, Mar. 23, 1966.

ingredients according to customer specifications.[5]

The specific characteristics of articles fabricated from steatite talc for electronic uses as compared with those with different ceramic derivations were tabulated and briefly discussed as criteria for deciding upon optimum materials for individual applications.[6] A description was published of the equipment and technology involved in a highly automated operation maintaining close size and composition tolerances in the mass production of steatite ceramic electrical components.[7]

An exceptionally pure grade of talc from a mine in Montana was found to meet the requirements for human internal toleration and was selected to serve as the carrier for a newly developed oral drug that may someday release diabetes sufferers from the recurring discomforts of syringe-administered insulin.

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[5] Burkley, Richard L. Preblended Tile Bodies. Ceram. Age., v. 82, No. 11, November 1966, pp. 28–30.

[6] Schmidhammer, G. I. Basic Properties Influence Selection of Electronic Ceramics. Ceram. Ind., v. 88, No. 4, April 1967, pp. 114–116.

[7] Allen, Alfred C. Centralab Invests in Facilities for Future Business. Ceram. Ind., v. 87, No. 2, August 1966, pp. 40–42.

Thorium

By Charles T. Baroch [1]

Domestic thorium continued to be produced wholly as a byproduct of the processing of rare-earth elements from monazite. Monazite production in Georgia and Florida increased 50 percent over that of 1966. Imports of monazite were 14 percent less than in 1966. The use of thorium, for both industrial and nuclear purposes, remained fairly steady, but thorium supply was still in excess of demand.

Legislation and Government Programs.—An amendment to the Atomic Energy Commission (AEC) regulations, Part 40, Licensing of Source Material, exempted from licensing requirements the possession and use of finished aircraft parts containing nickel-thoria alloy and provided a general export license in such parts to countries other than Soviet bloc designations and Southern Rhodesia.[2]

The Government stockpile objective of 500,000 pounds of equivalent ThO_2 was covered some seven times over by nearly 8 million pounds of thorium nitrate held in the supplemental stockpile, which contained over 3.6 million pounds of ThO_2. The surplus has been authorized for disposal by Congress, but no plans were announced in 1967.

DOMESTIC PRODUCTION

Mine Production.—Domestic monazite production in 1967 increased about 50 percent over that of 1966 which, in turn, was about three times that of 1965. Most came from operations of Humphreys Mining Co. on property of E. I. du Pont de Nemours & Co., Inc., at Folkston, Ga., and from the Skinner mine of National Lead Co., Jacksonville, Fla. The monazite was a lesser coproduct, tonnagewise, of titanium and zirconium heavy minerals. A small quantity of monazite was recovered as a byproduct of the Climax Molybdenum Co. operation at Climax, Colo. No thorium production was reported from Idaho or Montana. The Union Pacific Railroad Co. continued to investigate deposits of thorite on claims owned by Sawyer Petroleum Co. in the Lemhi Pass district of Beaverhead County, Mont.[3] The thorite deposits in the Montana portion of the district were described in a report issued by the Montana Bureau of Mines and Geology, Butte, Mont. Quartz veins are said to contain significant quantities of thorium, rare-earth elements, and yttrium.[4]

Refinery Production.—Thorium was recovered as a byproduct of monazite processed for its rare-earth elements. American Potash & Chemical Corp. and W. R. Grace & Co. were the only firms to report the reduction of monazite concentrates in 1967, and they supplied both crude and refined products to other processors. Thorium hardener, a master alloy of magnesium with about 40 percent thorium, was imported from England through Magnesium Elektron, Inc., New York.

Table 1.—Principal processors of thorium

Company	Plant location
American Potash & Chemical Corp	West Chicago, Ill.
The Babcock & Wilcox Co	Lynchburg, Va.
The Dow Chemical Co	Midland, Mich.
Gulf General Atomic, Inc	San Diego, Calif.
W. R. Grace & Co	Chattanooga, Tenn.
Kerr-McGee Corp	Oklahoma City, Okla.
Metal Hydrides, Inc	Beverly, Mass.
National Lead Co	Albany, N.Y.
Nuclear Fuel Services, Inc	Erwin, Tenn.
Nuclear Materials & Equipment Corp	Apollo, Pa.
United Nuclear Corp	Hematite, Mo.

[1] Commodity specialist, Division of Mineral Studies.
[2] Atomic Energy Commission. Licensing of Source Material. 32 F.R. 15872, Nov. 18, 1967.
[3] Marsh, James A. Union Pacific's Raw Material Program. Min. Congress J., v. 53, No. 6, June 1967, pp. 20–24.
[4] Geach, Robert D. Thorium Deposits of the Lemhi Pass District, Beaverhead County, Mont. Montana Bureau of Mines and Geol., Special Pub. 41, November 1966, 22 pp.

CONSUMPTION AND USES

Nonenergy Uses.—In 1967 apparent consumption of thorium in nonenergy uses continued the slightly rising trend which started with 1966 and aggregated about 120 tons of equivalent ThO_2. Processors' stocks. however, continued to increase, according to reports received by the Bureau of Mines.

Demand for thorium as thorium nitrate, in its principal use, the manufacture of Welsbach-type incandescent mantles for outdoor gas lights, continued to increase.

Magnesium containing about 3 percent thorium was produced and fabricated by the following:

American Light Alloys, Inc	Little Falls, N.J.
Bendix Foundries	Teterboro, N.J.
Brooks and Perkins, Inc	Detroit, Mich.
Controlled Castings Corp	Plainview, N.Y.
The Dow Chemical Co	Madison, Ill.
Hills-McCanna Co	Carpentersville, Ill.
R. C. Hitchcock and Sons, Inc	Minneapolis, Minn.
Howard Foundry Co	Chicago, Ill.
The Wellman Bronze & Aluminum Co	Bay City, Mich.

Small quantities of thorium were used in structural alloys for aerospace and military projects, which were of sufficient importance to assure that thorium remains on the list of strategic and critical materials. From 1.8 to 3.25 percent thorium contributes higher creep resistance and strength properties to magnesium at elevated temperatures. Electronic uses consumed only small quantities of thorium as thorium oxide, but such uses are of great importance. From 0.8 to 1.2 percent ThO_2 compounded with tungsten makes lamp filaments more ductile and long lasting. Thoriated tungsten filaments also have superior thermionic emission, a desirable property in electronic and X-ray tubes. Thoria was also used in refractories and as a catalyst in the petroleum and chemical industries; however, the latter is not a dissipative use and once a plant is stocked with thoria little replacement is necessary. The use of thoria-dispersed nickel (TD Nickel), cobalt, and chromium alloys remained largely experimental.

Energy Uses.—Thorium demand for nuclear-energy uses was very small and was supplied from a stockpile accumulated by AEC mostly prior to 1962. The five types of nuclear reactors adaptable to the thorium fuel cycle are discussed under Technology. The high-temperature gas-cooled reactor (HTGR) and the light-water breeder reactor (LWBR) are farthest along in development and both have a potential for higher conversion ratios and thermal efficiencies than the present light-water uranium-fueled reactors that are being built and planned. The complete development of thorium breeder reactors is expected to require another 20 years, although an unexpected development could change this. Thorium requirements for nuclear purposes over the next 15 years will probably total no more than a few hundred tons and will at no time reach 100 tons per year, according to an estimate made by AEC.

PRICES

Monazite prices quoted periodically in Metals Week remained unchanged from 1966 at 8 cents per pound for sands containing 55 percent rare-earth oxides (REO) and up to 12 cents for 66 percent REO. The declared value of imports averaged $129.11 per short ton in 1967 against $113.55 in 1966 and $93.11 in 1965. The rising trend was probably caused by increased demand for certain rare-earth elements, such as europium and yttrium for use in television tubes.

Thorium metal, pellets and powder, remained steady at $15 per pound, thorium nitrate was quoted at $3.50 per pound, and thorium oxide ranged from $6.00 to $12.30 per pound, depending on quality. Magnesium-thorium hardener containing about 40 percent thorium closed the year at $11.50 to $12.00 per pound for the contained thorium plus the value of the magnesium (35.25 cents per pound). Thus 40 percent thorium hardener cost about $4.82 per pound. The price of hardener showed a rising trend as the 1966 quotations ranged from $9.18 to $10 per pound of contained thorium.

FOREIGN TRADE

No exports of thorium ores and concentrates were reported in 1967 and 1966 exports contained only 54 pounds of thorium valued at $2,750, most of which went to Italy.

Monazite was the only ore of thorium imported in 1967.

Only 50 pounds of metal valued at $786 was imported in 1967, compared with 75 pounds valued at $1,000 in 1966. Other imports included 1,381 pounds of thorium oxide from France valued at $6,833 and 131 pounds of other thorium compounds from West Germany valued at $14,410.

Table 2.—U.S. imports for consumption of monazite by country

(Short tons and thousand dollars)

	1963	1964	1965	1966	1967
Australia	-----	1,450	1,278	1,542	1,540
Brazil	-----	-----	64	-----	-----
Ceylon	-----	335	141	-----	-----
Germany, West	-----	-----	-----	-----	24
Indonesia	-----	-----	-----	-----	72
Korea, South	-----	-----	22	-----	49
Malaysia	855	320	447	785	273
Nigeria	-----	-----	76	-----	133
South Africa, Republic of	4,791	-----	-----	115	-----
Unidentified country	788	-----	-----	-----	-----
Total: Quantity	6,434	2,105	2,028	2,442	2,091
Value	$771	$186	$189	$277	$270
ThO_2 content [e]	385	130	120	145	125

[e] Estimate.

WORLD REVIEW

World production of monazite is detailed in the "Rare-Earth Minerals and Metals" chapter in this volume.

Brazil.—Comissão Nacional de Energia Nuclear (CNEN) continued to operate its two beach-sand processing plants at Barra de Itabapoana and Cumuruxatiba. All nuclear materials are under strict control of CNEN and none can be exported. The law regarding export was eased somewhat in 1967 by exempting miners from returning equivalent quantities of nuclear material contained as minor associated minerals in ores if its separation was not technically or economically feasible.

Canada.—Rio Tinto Nuclear Products Ltd. (RTNP), (formerly Rio Tinto Dow Ltd.) became a wholly owned subsidiary of Rio Algom Mines Ltd. (RA) in 1966 and was the sole producer of thorium in Canada in 1967. Thorium and yttrium concentrates were recovered from waste leach solutions from its Nordic mill at Elliot Lake, Ontario. Essentially all thorium concentrate production was shipped to Thorium Ltd. in the United Kingdom for refining and processing. Both RA and Thorium Ltd. are subsidiaries of the large international firm, The Rio Tinto-Zinc Corp., Ltd., of London. Thorium Ltd. claimed to have a process for producing a superior grade of magnesium-thorium hardener, and it was a dominant producer of this master alloy.

Malagasy Republic.—The French Atomic Energy Commission has mined monazite and uranothorianite from Madagascar deposits for many years through its own operations and that of affiliated and cooperative companies. Monazite mining became uneconomic in 1966, largely because of increasing Australian production and none was mined in 1967. Uranothorianite mining was continued, but the deposits were being depleted rapidly.

Spain.—A thorium discovery of major proportions in Cordoba Province was reported by the Spanish privately owned mining company, Cia. Minera S.A. The thorium is mixed with uranium, and the discovery may be the largest thorium deposit in Europe.

TECHNOLOGY

The geologic and geographic distribution of monazite in Africa, Asia (except U.S.S.R.), Australia, Antarctica, North America, and South America was reviewed. On the basis of 731 analyses, monazite contains from 0 to 31.50 percent ThO_2 and averages 6 percent. The report presents chemical analyses, resource data, and production figures, where available and discusses how the thorium content of the monazite varies according to geologic origin. For each of the areas discussed, the date of the local discovery of monazite is given and all reports between the discovery date and 1958 (in some cases 1963) are cited and abstracted.[5] A widely used glossary, which is part of a continuing survey of data on uranium and thorium minerals, was updated and republished. This survey consists of collecting authoritative chemical, optical, and X-ray diffraction data from the literature and adding further laboratory research where necessary.[6]

Thorium has great potential as a source of nuclear fuel, because it is a fertile element transmutable into fissionable uranium-233 when exposed to irradiation by neutrons in a reactor. It is possible to design a reactor which can produce energy and simultaneously change fertile material into fissionable fuel. Such reactors are known as breeder reactors when they produce more new fissionable fuel than they consume. Some breeder and converter reactors using thorium are technically feasible, but much development work must be accomplished before they can be competitive with present uranium reactors. The most promising designs are being developed by both AEC and by private industry groups.[7]

The Oak Ridge National Laboratory, headquarters for AEC work on thorium, analyzed five thorium-cycle converter reactor systems that have been proposed: (1) The high-temperature gas-cooled reactor (HTGR) as conceived by Gulf General Atomic, Inc. (formerly General Atomic Division of General Dynamics); (2) the molten-salt converter reactor experiment (MSRE), a prototype of which is in operation at Oak Ridge; (3) the seed blanket or light-water breeder reactor (LWBR), built by AEC's Bettis Atomic Power Laboratory at Shippingport, Pa.; (4) the spectral shift control reactor (SSCR) designed by The Babcock & Wilcox Co.; and (5) the heavy-water reactor (HWR) based on Du Pont's design. The HTGR is the farthest advanced and is represented by a prototype at Peach Bottom, Pa. This 40-megawatt plant started producing power in January 1967. For the first time, a nuclear reactor produced steam at temperature and pressure levels comparable to a modern coal-fired system. The reactor achieved a steam temperature of 1,000° F and a steam pressure of 1,450 pounds per square inch. This is nearly double the temperatures and pressures at which present commercial reactors operate and enables the reactor to use the most advanced and economical turbine generators.[8]

The Peach Bottom plant operated well throughout the year and attained a test objective of 1,000 operating hours at full power. Operational experience from this reactor will provide design data for the 330-megawatt Fort St. Vrain nuclear generating station planned at Platteville, Colo., by Public Service Company of Colorado for operation in 1972. Public Service Company of Colorado is one of 53 utilities comprising High Temperature Reactor Development Associates, Inc., which has participated in the Peach Bottom project. The Peach Bottom fuel core contained 4,400 pounds of thorium and 380 pounds

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[5] Overstreet, W. C. The Geologic Occurrence of Monazite. Geol. Survey Prof. Paper 530, 1967, 327 pp.

[6] Frondel, Judith W., Michael Fleischer, and Robert S. Jones. Glossary of Uranium- and Thorium-Bearing Minerals. Geol. Survey Bul. 1250, 1967, 4th ed., 69 pp.

[7] Atomic Energy Commission. Annual Report to Congress of the Atomic Energy Commission for 1967. Ch. 5, Reactor Development and Technology, pp. 71–110.

[8] Chemical & Engineering News. Atomic Power's Future May Hinge on Breeders. V. 45, No. 24, June 5, 1967, pp. 54–57.

of enriched uranium. The Fort St. Vrain reactor will likely require about 33,000 pounds of thorium and 1,650 pounds of enriched uranium. Success of this type of reactor could lead to a large demand for thorium.[9]

Research on further development of the use of thoria in various alloys continued vigorously, most of it under the sponsorship of the Department of Defense. Sherritt Gordon Mines Ltd., which produces a thoria-strengthened alloy under the trade name DS Nickel, sought to increase the strength of this material, while E. I. du Pont de Nemours & Co., Inc., was developing a manufacturing process for tubing and bar from their alloy, TD Nickel, and were also developing protective coatings for it. Although several dispersoids have been used in nickel, the most effective is thoria, which forms an alloy superior to most superalloys and which is competitive with molybdeneum-base alloys up to 2,500° F. Because of their greater stability at elevated temperature, the thoria alloys are favorable for applications requiring extended periods of loading. Comparisons of strength and tensile properties for TD Nickel are so good that other thoria dispersion-strengthened alloys are being developed using matrices of iron, cobalt, zinc, lead, titanium, zirconium, steel, and others.[10]

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[9] Habush, A. L., and A. M. Harris. 330–Mw(e) Fort Saint Vrain High-Temperature Gas-Cooled Reactor. Gulf General Atomic, Inc., San Diego, Calif., GA–8002, June 9, 1967, 18 pp.

[10] Wolf, S. M. Properties and Applications of Dispersion-Strengthened Metals. J. Metals, v. 19, No. 6, June 1967, pp. 22–28.

Tin

By John G. Parker [1]

U.S. consumption of primary and secondary tin was 6 percent lower than in 1966.

Increased output in Bolivia, Indonesia, and Malaysia, the largest producer, reduced the world deficit between production and consumption to the lowest level since the mid-1950's. Exploration for tin continued in Australia, Indonesia, and the United Kingdom.

Tin prices declined considerably to their lowest point since 1963. General Services Administration (GSA) tried to act as a steadying influence by maintaining surplus stock sale prices virtually the same throughout the year. Meanwhile the International Tin Council (ITC) acquired tin for the buffer stock in an attempt to halt the price drop. The buffer stock at yearend was the highest since March 31, 1961. Four meetings of the ITC, three in London and one in Tokyo, were held during the year; the third London meeting established a new provisional price range owing to devaluation of the pound sterling.

Table 1.—Salient tin statistics

(Long tons)

	1963	1964	1965	1966	1967
United States:					
Production:					
Mine	W	65	47	97	W
Smelter	W	W	3,098	3,825	3,048
Secondary	22,332	23,508	25,076	25,349	22,667
Exports (exports and reexports)	1,625	4,041	2,829	2,847	2,479
Imports for consumption:					
Metal	43,283	32,132	40,816	41,699	50,223
Ore (tin content)	1,650	5,190	4,326	4,372	3,255
Consumption:					
Primary	55,209	58,586	58,550	60,209	57,856
Secondary	23,094	24,304	25,461	25,277	22,790
Price: Straits tin, in New York, average cents per pound	116.64	157.72	178.17	164.02	153.405
World:					
Production:					
Mine	191,051	193,729	201,413	208,577	211,664
Smelter	193,202	191,479	197,766	202,537	221,612

W Withheld to avoid disclosing individual company confidential data.

Legislation and Government Programs.—GSA continued disposing of excess pig tin from the national stockpile. In 1966 the objectives of the stockpile program had been changed to 200,000 long tons in the national stockpile and 26,200 long tons in the nuclear stockpile. Tin disposals in 1967 by GSA of all grades of tin totaled 6,140 long tons. Since the present program was authorized in June 1962, disposals of all grades of tin have totaled 87,378 long tons, of which over 81,000 tons went to commercial users and the rest to the Agency for International Development (AID) programs and governmental agencies. At the end of 1967 an excess of 60,636 long tons of tin was left for disposal by GSA.

At the end of June 1967, after consultations with ITC and various governmental

[1] Commodity specialist, Division of Mineral Studies.

agencies, GSA announced that disposals of tin would be continued until further notice under the terms and conditions set forth in the solicitation of offers, DMS-MET-92 (Revised), dated July 28, 1966. The Department of State, on October 28, 1966, had announced that the United States would, in principle, moderate its tin sales program if it should be inconsistent with the contingent operations authorized under the International Tin Agreement (ITA).

During 1967, under the Export Control Act of 1949, a general license was required to ship tin and manufactured items such as tinplate to any destination in the free world, except for Canada. An individual export license was needed to ship to embargoed areas such as mainland China, Cuba, North Korea, North Viet-Nam, the Pacific region of the U.S.S.R., and Southern Rhodesia. Exports of detinned tinplate and terneplate scrap and detinned cans required licensing, but exports of terneplate and tinplate scrap and old tin cans were exempt from licensing.

The Office of Foreign Assets Control, Treasury Department, administered regulations prohibiting the unlicensed importation from any country of tin of Communist Chinese, North Korean, North Viet-Namese, or Cuban origin. In addition, to prevent the importation of Chinese tin misdescribed as to origin, unlicensed importation was prohibited if the tin had been located in or transported from or through Hong Kong, Macao, Eastern Europe, or the U.S.S.R.

DOMESTIC PRODUCTION

MINE PRODUCTION

Mine production of tin in the United States continued to be an insignificant market factor. Small quantities of tin concentrate were produced in Alaska and California and in Colorado as a byproduct of molybdenum mining.

SMELTER PRODUCTION

The quantity of tin smelted in the United States at the Texas City smelter, which Teledyne, Inc., acquired by absorbing Wah Chang Corp. in June, decreased to 3,048 long tons in 1967. This was 80 percent of that smelted in 1966 and about 5 percent of the U.S. requirements for primary tin in 1967. Practically all of the domestically smelted tin concentrates came from Bolivia.

SECONDARY TIN

Much secondary tin is recovered in the form of chemicals and tin alloys, bronze, white metals, solder, and in other materials, rather than as tin metal.

Few countries other than the United States keep secondary tin statistics, and no others have gathered data over a period of years.

Secondary tin in 1967 was recovered from copper-base scrap at secondary smelters, brass mills, foundries, and some other plants; and from lead-base and tin-base scrap at smelters, refiners, and a few miscellaneous sources. Tinplate scrap is an important source of secondary tin and is treated at detinning plants by special processes.

Table 2.—Secondary tin recovered from scrap processed at detinning plants in the United States

	1966	1967
Tinplate scrap treated [1] ... long tons	783,433	773,605
Tin recovered in the form of—		
Metal ... do	2,614	2,667
Compounds (tin content) ... do	680	486
Total [2] ... do	3,294	3,153
Weight of tin compounds produced ... do	1,288	940
Average quantity of tin recovered per long ton of tinplate scrap used ... pounds	9.42	9.13
Average delivered cost of tinplate scrap ... per long ton	$28.75	$24.18

[1] Tinplate clippings and old tin-coated containers have been combined to avoid disclosing individual company confidential data.
[2] Recovery from tinplate scrap treated only. In addition, detinners recovered 293 long tons (169 tons in 1966) of tin as metal and in compounds from tin-base scrap and residues in 1967.

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

(Long tons)

Form of recovery	1966	1967
Tin metal:		
At detinning plants	2,939	2,939
At other plants	299	237
Total	3,238	3,176
Bronze and brass:		
From copper-base scrap	11,836	10,952
From lead- and tin-base scrap	461	316
Total	12,297	11,268
Solder	5,777	4,775
Type metal	1,714	1,604
Babbitt	1,121	912
Antimonial lead	318	386
Chemical compounds	826	506
Miscellaneous [1]	58	40
Total	9,814	8,223
Grand total	25,349	22,667
Value (thousands)	$93,134	$77,893

[1] Includes foil, cable lead, and terne metal.

CONSUMPTION

Domestic consumption in 1967 was 80,646 long tons of primary and secondary tin, a drop of nearly 6 percent from 1966. Most of the decrease was in secondary tin, which totaled 22,790 tons in 1967 compared with 25,277 tons in 1966. Over half of this decrease was in solder, and another large decrease was in bronze and brass, largely because of company closures due to the copper strike. The consumption of primary tin in tinplate, the principal use, rose over 3 percent. Of total tin consumption, about 37 percent was in tinplate, 25 percent in solder, and 20 percent in bronze and brass. Shipments of steel cans rose from 123.5 to 126.2 million base boxes in 1967; most of the steel cans had a coating of tin.

Table 4.—Shipments of metal cans

(Thousand base boxes)

Product	1966 [r]	1967	Change, percent
Beer	25,965	27,537	+6.1
Vegetables and vegetable juices	20,164	21,972	+9.0
Fruit and fruit juices	15,923	14,301	−10.2
Soft drinks	11,253	14,580	+29.6
Pet foods	5,479	5,796	+5.8
Coffee	4,290	4,163	−3.0
Meat and poultry	3,803	3,801	------
Evaporated and condensed milk	3,789	3,336	−12.0
Fish and seafood	3,030	2,921	−3.6
Lard and shortening	1,842	1,984	+7.7
All other foods	15,272	14,810	−3.0
Total	110,810	115,201	+4.0

[r] Revised.
Source: U.S. Department of Commerce.

Table 5.—Stocks, receipts and consumption of new and old scrap and tin recovered in the United States in 1967

(Long tons)

Type of scrap and class of consumer	Gross weight of scrap						Tin recovered		
	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31			
			New	Old	Total		New	Old	Total
Copper-base scrap:									
Secondary smelters:									
Auto radiators (unsweated)	3,061	48,230	-----	48,412	48,412	2,879	----	2,082	2,082
Brass, composition or red	3,932	78,410	16,016	61,547	77,563	4,779	605	2,289	2,894
Brass, low (silicon bronze)	247	3,943	2,880	832	3,712	478	----	4	4
Brass, yellow	6,665	57,579	8,068	49,724	57,792	6,452	29	469	498
Bronze	2,012	30,862	5,157	24,679	29,836	3,038	404	1,966	2,370
Low-grade scrap and residues	5,570	43,799	35,369	7,917	43,286	6,083	18	----	18
Nickel silver	797	4,979	549	4,364	4,913	863	4	30	34
Railroad-car boxes	142	822	------	778	778	186	----	38	38
Total	22,426	268,624	68,039	198,253	266,292	24,758	1,060	6,878	7,938
Brass mills: [1]									
Brass, low (silicon bronze)	2,666	28,114	28,114	-----	28,114	5,239	1	----	1
Brass, yellow	r 16,877	191,714	191,714	-----	191,714	24,119	194	---	194
Bronze	706	3,457	3,457	-----	3,457	929	168	---	168
Mixed alloy scrap	10,504	5,777	5,777	-----	5,777	6,321	52	---	52
Nickel silver	6,706	19,959	19,959	-----	19,959	8,498	----	---	-----
Total	r 37,459	249,021	249,021	-----	249,021	45,106	415	-----	415
Foundries and other plants: [2]									
Auto radiators (unsweated)	2,360	6,288	------	7,295	7,295	1,353	-----	328	328
Brass, composition or red	704	4,270	1,024	3,379	4,403	571	49	160	209
Brass, low (silicon bronze)	113	724	155	571	726	111	-----	1	1
Brass, yellow	1,127	5,143	2,399	2,982	5,381	889	2	27	29
Bronze	384	1,893	877	958	1,835	442	80	76	156
Low-grade scrap and residues	3,343	7,829	3,462	5,222	8,684	2,488	-----	-----	-----
Nickel silver	4	119	------	119	119	4	-----	-----	-----
Railroad-car boxes	943	23,015	------	22,321	22,321	1,637	-----	1,060	1,060
Total	8,978	49,281	7,917	42,847	50,764	7,495	131	1,652	1,783
Total tin from copper-base scrap	------	------	------	------	------	-----	1,606	8,530	10,136
Lead-base scrap:									
Smelters, refiners, and others:									
Babbitt	311	11,691	------	11,630	11,630	372	-----	565	565
Battery lead plates	24,641	406,093	------	405,036	405,036	25,698	-----	425	425
Drosses and residues	15,133	92,938	90,296	------	90,296	17,775	1,884	-----	1,884
Solder and tinny lead	278	11,402	------	11,430	11,430	250	-----	1,975	1,975
Type metals	2,546	31,829	------	31,159	31,159	3,216	-----	1,480	1,480
Total	42,909	553,953	90,296	459,255	549,551	47,311	1,884	4,445	6,329
Tin-base scrap:									
Smelters, refiners, and others:									
Babbitt	31	333	------	333	333	31	16	279	295
Block-tin pipe	9	191	------	196	196	4	----	193	193
Drosses and residues	746	4,179	4,060	------	4,060	865	2,255	----	2,255
Pewter	4	12	------	15	15	1	-----	13	13
Total	790	4,715	4,060	544	4,604	901	2,271	485	2,756
Tinplate scrap: Detinning plants	-------	------	773,605	------	773,605	-----	3,446	-----	3,446
Grand total	-------	-----	------	------	------	-----	9,207	13,460	22,667

r Revised.

[1] Lines in brass mills and total sections do not balance as stocks include home scrap—purchased scrap assumed to equal receipts.

[2] Omits "machine shop scrap."

Table 6.—Consumption of primary and secondary tin in the United States

(Long tons)

	1963	1964	1965	1966	1967
Stocks Jan. 1[1]	30,876	29,548	32,591	37,277	32,718
Net receipts during year:					
Primary	54,411	62,939	64,302	56,869	56,315
Secondary	2,290	2,524	2,530	2,713	2,884
Scrap	22,041	22,985	24,676	r 23,654	21,492
Total	78,742	88,448	91,508	r 83,236	80,691
Available	109,618	117,996	124,099	r 120,513	113,409
Stocks Dec. 31[1]	29,548	32,591	37,277	r 32,718	30,078
Total processed during year	80,070	85,405	86,822	87,795	83,331
Intercompany transactions in scrap	1,767	2,515	2,811	2,309	2,685
Tin consumed in manufactured products	78,303	82,890	84,011	85,486	80,646
Primary	55,209	58,586	58,550	60,209	57,856
Secondary	23,094	24,304	25,461	25,277	22,790

r Revised.
[1] Stocks shown exclude tin in transit or in other warehouses on Jan. 1, as follows: 1963, 115 tons; 1964, 175 tons; 1965, 220 tons; 1966, 135 tons; 1967, 90 tons, and 1968, 20 tons.

Tabe 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 (long tons)[1]	Tin per short ton of plate (pounds)
1963	174,618	2,188	28.1	4,671,358	26,163	12.6	515,042	5,361,018	28,351	11.9
1964	138,178	1,347	21.8	5,204,541	29,872	12.9	637,481	5,980,200	31,219	11.7
1965	80,645	914	25.4	5,245,642	29,150	12.5	599,400	5,925,687	30,064	11.4
1966	44,290	366	18.5	r 5,154,550	28,218	12.3	675,558	r 5,874,398	28,584	11.0
1967	23,812	230	21.6	5,544,987	29,330	11.9	742,989	6,311,788	29,560	10.5

r Revised.
[1] Includes small tonnage of secondary tin and tin acquired in chemicals.

Table 8.—Consumers receipts of primary tin, by brands

(Long tons)

Year	Banka	English	Katanga	Straits	Thaisarco	Others[1]	Total
1963	3,393	2,708	1,027	36,413	--------	10,870	54,411
1964	1,271	1,441	1,839	38,972	--------	19,416	62,939
1965	3,112	425	850	38,434	1,950	19,531	64,302
1966	709	433	95	30,560	9,815	15,257	56,869
1967	404	704	91	31,980	13,400	9,736	56,315

[1] Includes GSA not reported under specific brands.

Table 9.—Consumption of tin in the United States, by finished products

(Long tons of contained tin)

Product	1966			1967		
	Primary	Secondary	Total	Primary	Secondary	Total
Alloys (miscellaneous)	405	179	584	310	142	452
Babbitt	2,145	1,625	3,770	1,662	1,159	2,821
Bar tin and tin powder	2,035	141	2,176	1,778	40	1,818
Bronze and brass	5,339	12,575	17,914	4,350	12,110	16,460
Chemicals including tin oxide	1,213	1,617	2,830	937	1,837	2,774
Collapsible tubes and foil	1,215	66	1,281	1,071	38	1,109
Pipe and tubing	42	14	56	53	14	67
Solder	15,245	7,497	22,742	14,052	6,070	20,122
Terne metal	357	188	545	264	179	443
Tinning	2,589	67	2,656	2,551	58	2,609
Tinplate[1]	28,584	-------	28,584	29,560	-------	29,560
Type metal	93	1,205	1,298	100	1,019	1,119
White metal [2]	878	51	929	1,094	70	1,164
Other	69	52	121	74	54	128
Total	60,209	25,277	85,486	57,856	22,790	80,646

[1] Includes secondary pig tin and tin acquired in chemicals.
[2] Includes britannia metal, jewelers' metal, and pewter.

STOCKS

Total U.S. industry tin stocks at the end of 1967 were 4 percent under those of 1966 and 12 percent less than those of 1965. The differences lay mostly in the stocks of primary pig tin held by tinplate makers. Tin afloat at yearend was 43 percent greater than tin afloat at the end of 1966.

Table 10.—U.S. industry tin stocks

(Long tons)

	1963	1964	1965	1966	1967
Plant raw materials:					
Pig tin:					
Virgin	17,834	20,926	25,319	20,531	17,044
Secondary	220	247	202	276	283
In process [1]	11,494	11,418	11,756	r 11,911	12,751
Total	29,548	32,591	37,277	r 32,718	30,078
Additional pig tin:					
In transit in United States	175	220	135	90	20
Jobbers-importers	[2] 11,135	[3] 2,950	[4] 2,000	[5] 1,790	[6] 1,315
Afloat to United States	5,060	1,740	1,875	3,415	4,890
Total	16,370	4,910	4,010	5,295	6,225
Grand total	45,918	37,501	41,287	r 38,013	36,303

r Revised.
[1] Tin content, including scrap.
[2] Includes GSA as follows: 10,780 tons end of December (bids rejected plus tonnage to be offered through March 27, 1964).
[3] Includes GSA as follows: 1,590 tons end of December 1964, sold but not delivered.
[4] Includes GSA as follows: 975 tons end of December 1965, sold but not delivered.
[5] Includes GSA as follows: 1,539 tons end of December 1966, sold but not delivered.
[6] Includes GSA as follows: 428 tons end of December 1967, sold but not delivered.

PRICES

In general, monthly prompt prices of Straits tin for delivery in New York declined in 1967 except for a resurgence at midyear and another relatively large rise in November. The average of 153.405 cents per pound for the year contrasted sharply with the average of 164.021 cents per pound for 1966. Other average prices follow: London spot settlement (standard tin of 99.78 percent purity), £1,223 8s. 5d. per long ton (about US$1.50 per pound); and Penang ex-smelter, £1,199 5s. 2d. per long ton (about US$1.47 per pound). GSA prices for grade A tin, which averaged 154.250 cents per pound for the first half of the year, decreased in July and remained at 154.000 cents for the last half. GSA tin sales of all grades, including low-grade material, brought an average price of 123.357 cents per pound.

Table 11.—Monthly prices of Straits tin for prompt delivery in New York

(Cents per pound)

Month	1966 High	1966 Low	1966 Average	1967 High	1967 Low	1967 Average
January	183.000	176.625	178.750	154.125	153.125	153.881
February	180.500	174.500	178.105	155.000	153.875	154.382
March	175.750	171.000	173.984	154.250	153.000	153.710
April	179.750	171.500	174.238	154.250	152.750	153.331
May	173.000	162.500	169.280	154.500	152.250	153.114
June	162.625	158.750	160.767	157.000	152.750	154.943
July	161.750	158.250	159.869	155.000	153.375	154.394
August	158.750	153.500	156.418	153.375	151.875	152.500
September	155.500	153.500	154.125	151.875	150.750	151.013
October	155.250	154.000	154.506	153.500	150.625	151.994
November	154.875	153.750	154.224	156.000	154.000	155.013
December	154.750	153.500	153.989	154.000	151.250	152.588
Total	183.000	153.500	164.021	157.000	150.625	153.405

Source: American Metal Market.

FOREIGN TRADE

Imports of metallic tin and tin concentrates were the most important items in the U.S. foreign trade in the commodity. Those of the former were the highest since 1957 and those of the latter were the lowest since 1963. Significant quantities of tin ingot, compounds, and miscellaneous tin manufactures were exported. Tin contained in imports and exports of babbitt, solder, type metal, and bronze is shown in the "Lead" and "Copper" chapters of the Minerals Yearbook. Ferrous scrap exports including tinplate and terneplate scrap are not classified separately.

Table 12.—U.S. exports of tin; imports for consumption and exports of tinplate and terneplate in various forms

Year	Ingots, pigs, and bars: Exports, Long tons	Ingots, pigs, and bars: Exports, Value (thousands)	Ingots, pigs, and bars: Reexports, Long tons	Ingots, pigs, and bars: Reexports, Value (thousands)	Tinplate and terneplate: Imports, Long tons	Tinplate and terneplate: Exports, Long tons	Tinplate circles, strips, and cobbles: Exports, Long tons	Tinplate scrap: Imports, Long tons
1965	2,605	$10,078	224	$880	108,876	239,034	12,362	16,954
1966	1,866	6,985	981	3,849	111,678	257,140	11,031	14,687
1967	2,050	6,962	429	1,412	139,598	241,873	13,732	12,078

Table 13.—U.S. imports for consumption and exports of miscellaneous tin, tin manufactures, and tin compounds

Year	Miscellaneous tin manufactures				Tin compounds
	Imports			Exports	Imports
	Tinfoil, tin powder, flitters, metallics, tin, and manufactures n.s.p.f., value (thousands)	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
1965	$261	502	$883	$1,220	163
1966	251	108	124	1,957	295
1967	355	449	462	1,490	81

Table 14.—U.S. imports for consumption of tin,[1] by countries

Country	1966		1967	
	Long tons	Value (thousands)	Long tons	Value (thousands)
Belgium-Luxembourg	163	$619	228	$777
Bolivia	118	427	571	1,961
Canada	4	31	1	41
Chile	-----	-------	73	238
Germany, West	(2)	1	80	263
India	-----	-------	10	33
Indonesia	4	12	129	420
Japan	50	166	------	-------
Malaysia	26,008	95,329	30,691	101,802
Netherlands	50	191	25	83
Nigeria	770	2,874	------	-------
Peru	7	23	159	529
Portugal	15	59	275	920
Singapore	55	207	62	217
Thailand	13,416	49,030	16,586	54,786
United Kingdom	1,039	3,792	1,333	4,459
Total	41,699	152,761	50,223	166,529

[1] Bars, blocks, pigs, grain, or granulated.
[2] Less than ½ unit.

Table 15.—U.S. imports for consumption of tin concentrate, by countries

Country	1966		1967	
	Long tons (tin content)	Value (thousands)	Long tons (tin content)	Value (thousands)
Bolivia	4,347	$12,423	3,247	$7,608
Mexico	13	8	-----	------
Peru [1]	12	36	7	24
United Kingdom	-----	-------	1	3
Total	4,372	12,467	3,255	7,635

[1] Reported by the Bureau of the Census as coming from Peru, but believed by the Bureau of Mines to be from Bolivia.

WORLD REVIEW

INTERNATIONAL TIN AGREEMENT

Meetings of the ITC under the Third International Tin Agreement (ITA), which was accepted provisionally on July 1, 1966, and ratified on March 21, 1967, were held in London on January 10–11, 1967, Tokyo on May 29 to June 2, and again in London on October 31 to November 2 and on November 21–22. At the Tokyo meeting, votes of the members were reallocated and a new Committee on Development was created to investigate factors affecting investment and production. Production technology, consumption (including new uses and substitutes), trade in tin (including tariffs and shipping procedures), and the position of tin as a whole were reviewed, including releases of surplus stockpiled tin by GSA. At the second London meeting during the year, the approval of plans to publish a study of factors affecting tin consumption was discussed; at the third London meeting a new provisional price range was fixed which would have to be reviewed within 90 days.

The Third ITA is supported by 17 consuming nations which account for about 50 percent of all tin consumed in the non-Communist countries, and by six nations which produce roughly 93 percent of the free world's tin concentrates. The United States, West Germany, and the U.S.S.R., all large tin consumers, are not members. In the ITC 1,000 votes are held by producers and 1,000 by consumers, distributed among the members in proportion to their production or consumption. At the Tokyo meeting the votes for consumers and producers were reallocated as shown above:

Consuming countries:	Votes
Australia	55
Austria	12
Belgium-Luxembourg	37
Canada	61
Czechoslovakia	38
Denmark	11
France	124
India	48
Israel[1]	6
Italy	71
Japan	208
Korea, South	9
Mexico	19
Netherlands	42
Spain	25
Turkey	14
United Kingdom	220
Total votes	1,000

Producing countries:	
Bolivia	175
Congo (Kinshasa)	51
Indonesia	101
Malaysia	450
Nigeria	72
Thailand	151
Total votes	1,000

[1] Member since October 27, 1967.

Decisions of the Council, except where otherwise provided, are taken by a simple, distributed majority of separately counted producer-consumer votes. Excessive price fluctuations are theoretically to be prevented through the purchase or sale of tin buffer stocks. Excess production may be controlled by imposing export quotas on producing nations. The tin buffer stock, an equivalent of 20,000 long tons of tin metal which is usually tin-in-concentrate, is contributed by the producing nations. For the purpose of the buffer stock, the market price is the price of cash tin on the London Metal Exchange, although other prices such as New York or Penang may be used at the discretion of the ITC. The buffer stock manager was directed to buy or sell fom the stock according to the following schedules, expressed as U.S. dollar equivalent per pound:

	Second ITA[1]	Third ITA
Must buy	1.25	1.375
May buy	1.25 –1.3125	1.375–1.50
Neutral	1.3125–1.4375	1.50 –1.625
May sell	1.4375–1.50	1.625–1.75
Must sell	1.50	1.75

[1] Previous schedule.

At year end, the buffer pool stock of tin metal was said to be 4,755 long tons.

Table 16.—World mine production of tin (content of ore), by countries [1] [2]

(Long tons)

Country	1963	1964	1965	1966	1967p
North America:					
Canada	414	157	168	r 317	237
Mexico	1,055	1,207	503	821	e 662
United States	W	65	47	97	W
South America:					
Argentina	225	343	497	r 458	NA
Bolivia [3]	r 22,209	r 24,319	r 23,036	r 25,626	26,890
Brazil e	1,150	790	1,810	r 1,855	e 1,200
Peru (recoverable)	21	36	49	37	68
Europe:					
Czechoslovakia	[4] 200	[4] 200	[4] 220	[4] 148	150
France	272	486	447	e 418	452
Germany, East [4]	1,000	1,000	1,000	1,000	NA
Portugal [5]	718	676	r 557	r 600	617
Spain	r 158	91	r 111	129	113
U.S.S.R.[6] [7]	r 21,000	r 22,000	r 23,000	r 24,000	25,000
United Kingdom	1,226	1,226	1,313	1,272	1,475
Africa:					
Burundi	16	85	r 100	100	e 100
Cameroon, Republic of	25	40	40	r 45	e 36
Congo (Brazzaville)	43	34	44	48	e 48
Congo (Kinshasa)	6,883	5,108	6,324	5,036	4,664
Morocco	9	14	12	7	6
Niger, Republic of	54	48	53	60	e 60
Nigeria	8,723	8,721	9,547	9,354	9,340
Rhodesia, Southern	498	512	510	600	e 600
Rwanda	1,271	1,360	1,424	r 1,317	1,370
South Africa, Republic of	1,530	1,586	1,671	r 1,555	e 1,769
South-West Africa, Territory of	443	474	416	r 664	e 720
Swaziland	3	3	2	1	e 1
Tanzania	234	287	255	353	353
Uganda	165	217	178	122	104
Zambia	1	8	16	3	------
Asia:					
Burma [5]	1,003	916	677	r 376	e 300
China, mainland [6]	28,000	25,000	25,000	22,000	20,000
Indonesia	12,927	16,345	14,699	12,526	13,597
Japan	857	796	837	971	1,170
Korea, South	-------	-------	-------	32	e 40
Laos	326	336	284	e 340	533
Malaysia	59,947	60,004	63,670	68,886	72,121
Thailand	15,585	15,597	19,047	22,565	22,489
Oceania: Australia	2,860	3,642	r 3,849	r 4,838	5,379
Total [8]	r 191,051	r 193,664	r 201,413	r 208,577	211,664

e Estimate. p Preliminary. r Revised. NA Not available. 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. Negligible amounts of tin were also produced in Mozambique and Surinam during 1963–67.

[2] Compiled mostly from data available May 1968.

[3] Comibol production plus exports by small and medium mines and smelters.

[4] Estimate, according to the 53d annual issue of Metal Statistics (Metallgesellschaft) through 1966.

[5] Includes tin content of mixed concentrates.

[6] Estimated from smelter production.

[7] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[8] Total is of listed figures only; no undisclosed data included.

Table 17.—World smelter production of tin, by countries [1] [2]

(Long tons)

Country	1963	1964	1965	1966	1967 [p]
North America:					
Mexico	1,055	1,145	459	795	[e] 960
United States [3]	[4] 1,650	[4] 5,190	3,098	3,825	3,048
South America:					
Bolivia	2,462	3,610	3,415	1,062	1,018
Brazil	2,051	1,731	1,753	[r] 1,545	[e] 2,100
Europe:					
Belgium	7,044	5,458	4,232	4,978	6,068
Germany:					
East [5]	1,200	1,200	1,200	1,200	1,200
West	1,052	1,178	1,427	1,362	1,622
Netherlands	5,762	15,858	18,114	12,552	13,739
Portugal	663	589	603	[r] 556	619
Spain	1,286	1,774	[r] 1,787	2,957	[e] 1,534
U.S.S.R. [e] [6]	[r] 21,000	[r] 22,000	[r] 23,000	[r] 24,000	25,000
United Kingdom	17,411	16,849	16,494	17,499	23,317
Africa:					
Congo (Kinshasa)	1,441	1,485	1,815	2,002	1,815
Morocco [e]	10	10	12	12	12
Nigeria [7]	9,051	8,749	9,321	9,869	9,131
Rhodesia, Southern	499	511	494	[e] 480	[e] 600
South Africa, Republic of	962	1,016	962	822	659
Asia:					
China (mainland) [e]	28,000	25,000	25,000	22,000	20,000
Indonesia [e]	2,000	1,800	1,800	1,510	1,000
Japan	1,976	1,954	1,610	1,836	1,666
Malaysia [8]	84,001	71,351	72,469	[r] 71,045	76,328
Thailand	-------	-------	5,522	[r] 16,990	26,582
Oceania: Australia	2,626	3,021	[r] 3,179	[r] 3,640	3,594
Total [9]	[r] 193,202	[r] 191,479	[r] 197,766	[r] 202,537	221,612

[e] Estimate. [p] Preliminary. [r] Revised.
1 Data derived in part from the Statistical Bulletin of the International Tin Council, London, England.
2 Compiled mostly from data available May 1968.
3 Includes tin content of alloys made directly from ores.
4 Imports into the United States of tin concentrates (tin content).
5 Estimate, according to the 53d annual issue of Metal Statistics (Metallgesellschaft) through 1966.
6 Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
7 Including a small amount smelted from imported concentrates.
8 Smelter production of tin metal for West Malaysia and Singapore as reported by Dept. of Statistics, Malaysia.
9 Total is of listed figures only; no undisclosed data included.

REVIEW BY COUNTRIES

Australia.—An intensive exploration program was responsible for an upsurge in Australian tin production. New resources were discovered and new deposits opened in the principal tin areas of Tasmania, New South Wales, Western Australia, and Queensland. In 1966 about 30 companies had actively explored for tin in Australia.

Increase in tin production from Tasmania could make Australia self-sufficient in tin and save A$4 million in Australian imports. In northwest Tasmania, particular emphasis was on developing cassiterite-pyrite-pyrrhotite deposits; some exploration was conducted off the coast of Cape Barren in Bass Strait and off King Island, farther to the west. Late in December 1966 Renison Ltd. N.L. commenced commissioning a new concentrator at Renison Bell which had a planned initial throughput of 1,000 tons of ore per day. Renison, the holder of Australia's largest proven tin ore body, also discovered a large reserve containing 1.88 percent tin near the Bassett lode. Estimated tin reserves in the Bassett and Federal lodes are 12 million tons of ore averaging 0.75 percent tin. Near Waratah, Cleveland Tin N.L. continued building a town and concentrator sites at Luina on the west coast and access roads to its old Cleveland mine where new reserves have been indicated.

In January 1967 Oil and Minerals Quest N.L. commenced mining alluvial tin at Walwa, northeast Victoria. It was planned to expand capacity to 50 tons of ore per hour, with resultant concentrates containing 60 to 70 percent tin. Near Irvinebank, North Queensland, an underground development and drilling program was completed in May, with plans for a treatment plant at mine site during 1968.

In early 1967 a new smelter, which now produces the total domestic output of primary refined tin, was commissioned at Alexandria, New South Wales. The smelter is owned by Associated Smelters Pty. Ltd., a joint venture of Australian Iron and Steel Pty. Ltd., O. T. Lempriere and Co., Ltd., and Consolidated Tin Smelters (Australia) Pty. Ltd. with its subsidiary Sydney Smelting Company Pty. Ltd.

Bolivia.—The Estalso consortium, a joint venture of four U.S. firms headed by W. R. Grace & Co., undertook bucket-line dredging of tin-bearing gravels on the Antequera River, east of Lake Poopo and about 150 miles south of La Paz. It was expected that 3.5 million cubic yards of gravel would be mined and processed annually in producing 1,300 metric tons of tin.

After an early summer strike, Corporacion Minera de Bolivia (COMIBOL) had no additional labor troubles. Later in the year, production from Catavi, its largest mine, was considerably higher than the average output for this time period. End-of-year bonuses no doubt led to this increased output in the last quarter. COMIBOL claimed that tin would have to be priced above $1.47 per pound for the company not to lose money. Meanwhile the company continued to ship large tonnages of low-grade concentrate to the Texas City, Tex., tin smelter. Tin recovery because of the complexity of the ores, is generally only about 50 percent by gravity and flotation, and COMIBOL hoped to improve this considerably by using a combination of flotation and volatilization. Tihua Mines has used the process on its low-grade concentrates since July 1967. With this in mind, COMIBOL acquired the use of a small smelter from Empresa Nacional de Fundiciones (ENAF) in December to carry out a 2-year series of trials on industrial-scale volatilization.

Plans were finalized for a tin smelter to be built at Vinto, 5 miles east of Oruro. The West German firm, Klöckner Industrie-Anlagen G.m.b.H. will construct the plant, which will begin smelting tin ore early in 1969. First-year capacity of 7,500 tons probably will be increased eventually to 20,000 tons per year.

Indonesia.—This country was once the world's third largest tin producer, after Malaysia and Bolivia, producing one-sixth of the world's tin. In the last 10 to 15 years, however, its production has fallen from an average of 32,000 tons to about 13,600 tons in 1967.

The Government made efforts to encourage foreign investments in tin mining. For the first time since the Netherlands mining companies were nationalized, some tin prospects, including areas on the shores of Bangka and Belitung (Billiton), were thrown open to foreign investment capital. Offshore tin areas are of great interest, and a number of foreign firms were expected to receive concessions for offshore prospecting and mining. Also, to improve the economy and expand exports, the Indonesian Government allowed tin-mining companies to keep 75 percent of their foreign currency instead of the previous 50 percent.

Production rose, largely due to improved operation of the large new dredge, *Bangka I*. Trial operations at the new Muntok smelter, with an annual capacity of 25,000 tons, on Bangka Island were started early in the year. This smelter was expected eventually to replace the old Puput smelter which shipped tin slag to Singapore.

Malaysia.—Despite serious floods which affected 11 States, especially in the Kelantan area, production was greater than in 1966. Malaysia has rapidly increased its tin output since strict international tin export control ended in the late 1950's. Its increased output has been a major factor in the decline of the international tin trade deficit.

Because of interest shown by a number of local and foreign companies in the tin-mining potential of Malaysia's west coast, the Malaysian Government had a United Nations expert prepare a report on possible terms and conditions interested firms would be granted. Near yearend, approval was expected for a major project on tin exploration in a 50-mile length of Malaysian coastal water off Malacca.

Efforts to discover and outline offshore deposits off the west coast were expected to be facilitated by completion of the 320-ton diesel-electric survey vessel *Bison*. This ship uses an acoustic reflection technique for continuous profiling of seabed and underlying strata (the SONIA method).

South Africa, Republic of.—Large increases in mine output and enlarged smelting facilities were expected to place the country on the road to self-sufficiency. The Rooiberg mine near Warmbaths, Transvaal, is the main source of tin in South Africa. A new smelting plant, owned by Iscor, near Vanderbijlpark, has a monthly capacity of 120 tons of concentrate and, with that owned by the Zaaiplaats mine near Potgietersrus, can supply the nation's requirements.

Thailand.—A backlog excess stock of 4,500 to 5,000 long tons of tin-in-concentrates, collected as a result of production difficulties at the Thailand Smelting & Refining Co., Ltd. (Thaisarco) smelter on Phuket Island in 1966, was smelted in 1967, adding to an expected increase of 1,500 tons over 1966. In April the smelter, owned by Eastern Mining Development Co. Ltd. and Union Carbide Corp., installed a fourth reverberatory furnace. This and a third furnace, operational since November 1966, gave the Phuket plant a top smelting capacity of 40,000 tons of concentrate per year. However, part of the year production was halved when two furnaces were closed for relining and there was a shortage of concentrate for smelting. About 70 percent of concentrate production was said to be obtained from locally based small-scale operators. In the past, foreign-based companies had been restricted to peninsular Thailand, but the "closed" area north of the 11th parallel was opened for prospecting late in 1966. Most Thai production is derived from soft-rock mining operations in the Renong, Phuket, and Songkhla areas, an exception being the Pin Yok hard-rock mine near the Malaysian border.

Owing to lower tin exports, following increased production in Malaysia and Indonesia, Thai Government tin royalties dropped nearly 4 percent below those of 1966.

United Kingdom.—Fifteen firms were said to have started underground development in Cornwall, although critics claimed that there was official indifference regarding tin mining there, in contrast to the recently announced policy of Eire, which is exempting new mines from income tax for 20 years. Exploration has been difficult because diamond drills must probe between the abandoned mines. In addition, old flooded workings can prevent developing and working an area where lode intersections have been indicated during drilling.

One of the most interesting mining activities is the progress made by the South Croft Tin Mines Ltd. in dewatering the old East Pool mine. After dewatering is completed the company was expected to start eastward exploration on a number of lodes. A decision was made to sink a new exploratory shaft in the Pendarves property 1 mile south of Camborne. Thyssen (Great Britain) is doing the drilling; the present project was undertaken by five other firms. Other exploratory diamond drilling was underway near Callington in eastern Cornwall, in the Camborne-Redruth area, at Gwennap, southwest of Truro, and in the area of two old tin mines west of Truro. Lastly, waters by the famous old town of St. Ives were the site of alluvial tin dredging.

Other Producing Countries.—Mine production elsewhere in the free world decreased about 3 percent in 1967 to about 22,800 long tons.

Production from other than major tin mines comes from such sources as byproduct recovery from lead-zinc smelters, tributers in various countries, streamers in Cornwall, and small deposits in Argentina, Mexico, Spain, Portugal, some of the developing African nations, and some Latin American countries

Despite difficulties in shipping tin, some Chinese tin found its way into East Europe countries via exporters in Western Europe. Because of the location of Chinese tin deposites, rail shipments must be made through North Viet-Nam over the Kunming-Hanoi-Nanning railway network, which has been subject to military disruption.

Tin production in the U.S.S.R. can only be estimated, but the country is purchasing increasingly greater quantities of tin in Western markets, indicating insufficient production to satisfy domestic needs Until the Sino-Soviet dispute in 1966, mainland China was the main supplier of tin to the U.S.S.R. It was said that current Soviet reserves probably exceed 500,000 tons, but of these only 9 percent are in placer deposits which are easier to work than lode ore. The U.S.S.R. was said to have three principal reduction and refining plants, one in Siberia and two near Moscow. Reverberatory furnaces were used to produce crude tin of 97-percent purity from low-tin concentrates; electric-arc furnaces were used to produce tin of 99-percent purity from high-tin concentrates.[2]

In Africa, tribal feuding and political difficulties slowed production in the Congo (Kinshasa) and in Nigeria.

TECHNOLOGY

A discussion of the coincidence between the distribution of tin and the evidence for continental drift contributed to the understanding of tin occurrences. Considering ages of tin deposits in the South-West Africa-Nigeria tin belt, it was believed the source of the tin was the crust or the part of the upper mantle adhering to the crust during drifting.[3]

Guidelines to the discovery of tin placer deposits were discussed. Even with a knowledge of onshore geology it was difficult to predict near-shore placers with reasonable certainty.[4]

A number of papers were presented at an International Tin Council meeting in London; subjects included geology and mineralogy of tin deposits, problems concerning their mining and the processing of concentrates, recent dredging innovations, potential new uses, and dissemination of technical information by mines departments and geological surveys in the major tin-producing countries.

In one presentation, the high costs of the Bolivian tin industry were discussed. They were said to be due to declining grade of ore in known bodies, failure to discover new ones (only one small mine has been developed into an important producer since 1931), wastage because of loss in concentration (almost 50 percent in COMIBOL mills in a recent year), and high transport and smelting costs due to distance from sea and world markets and complexity of ore concentrates. Chloride roasting, recently introduced for treating tin concentrates also was discussed.[5]

Details of ore concentration, smelting, refining, secondary recovery, and attempts at developing chemical-metallurgical processes to recover tin from very low grade concentrates were given.[6] Regarding the latter techniques, tin concentration by flotation has been of continuous interest because gravity concentration of lode tin ores, the other alternate and most commonly used method, leads to high losses in slimes created by overgrinding. Accordingly, recent attempts have been made to establish flotation as a supplement to gravity processing. In vacuum and batch flotation test work on complex ores, mostly from Cornwall and Canada, alkyl phosphonic acids provided the most satisfactory collector system for cassiterite.[7]

Tinplate, the largest use for tin, has been receiving increased competition in recent years. Numerous technical developments have been achieved in other canmaking materials and techniques, but there have been innovations in tinplate technology as well. A review article described hot-dip and electrolytic tinning methods and the structure and corrosion of tinplate.[8] Elsewhere, it was stated that the only basic reason for the development of double-reduced plate (lightweight tinplate produced by additional cold reduction before tinning) was the simple economic one of making tinplate cheaper. In the United States tinplate foil is being developed commercially. The first commercial product was said to be material 0.05 millimeter thick with a tin coating of about 3 grams per square meter, but some samples of tin-coated steel foil only 5 microns thick have been produced. When the foil is rolled, the tin coating acts as a built-in rolling lubricant.[9]

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[2] Tesmen, Arthur B. Nonferrous Metals and the Chemical Engineer, Part V: U.S.S.R. Chem. Eng., v. 74, No. 3, Jan. 30, 1967, pp. 139–146.

[3] Schuiling, R. D. Tin Belts on the Continents Around the Atlantic Ocean. Econ. Geol., v. 62, No. 4, June-July 1967, pp. 540–550.

[4] Osberger, R. Prospecting Tin Placers in Indonesia. Min. Mag. (London), v. 117, No. 2, August 1967, pp. 97–103.

[5] World Mining. Tin Geology, Tin Mining, Tin Metallurgy, Outlined and Discussed at London Meeting. V. 3, No. 5, May 1967, pp. 25–27.

Tin International (London). V. 40, April 1967, pp. 87–92.

[6] Wright, P. A. Extractive Metallurgy of Tin. Elsevier Pub. Co., Amsterdam, Netherlands, 1966, 228 pp.

[7] Collins, D. N. Investigation of Collector Systems for the Flotation of Cassiterite. Trans. Inst. Min. and Met. (London), v. 76, No. 727, sec. C, June 1967, pp. C77–C93.

[8] Discombe, John. Tinplate. Steel Times (London), v. 195, No. 5165, July 14, 1967, pp. 53–57.

[9] Hoare, W. E. Tinplate Today. Metal Bull. (London), Spring Tinplate Issue, Spring 1967, pp. 23–26.

Titanium

By John W. Stamper [1]

Rising demand for titanium metal in commerical and military airframes and jet-engines resulted in record shipments of titanium mill products during 1966 and 1967. A new producer of titanium sponge metal began operations in 1966, and the industry announced plans to expand annual production capacity to 31,000 tons by the early 1970's. Imports of titanium sponge metal from Japan, the United Kingdom, and the U.S.S.R. increased markedly and accounted for one-third of consumption in 1967, compared with one-fourth of consumption in 1966.

Domestic rutile production continued to decline drastically and the Government initiated a series of programs under provisions of the Defense Production Act to increase output and to encourage the commercial production and use of substitutes for natural rutile in strategic application. Ilmenite production in the United States dropped slightly in 1967 but world output of both ilmenite and rutile increased significantly.

The planned closing in 1968 of a domestic plant utilizing the sulfate process for making titanuim pigment foreshadowed a continuation of the trend of recent years toward greater utilization of the chloride process for pigment.

Legislation and Government Programs.—On February 14, 1966, the General Services Administration (GSA) announced a plan for the long range disposal of titanium sponge metal from Defense Production Act inventories. A total of 969 short tons was sold during 1966 at average prices per pound ranging from $1.00 to $1.08. However, on November 17, 1966, the Office of Emergency Planning (OEP) increased the stockpile objective for rutile and titanium sponge metal to 200,000 tons and 37,500 tons, respectively. With the establishment of the new objective for titanium sponge metal 10,024 tons of the 30,524 tons on hand at the end of 1966 was determined to be of nonstockpile quality. During 1967,

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Table 1.—Salient titanium statistics

	1963	1964	1965	1966	1967
United States:					
Ilmenite concentrate:					
Mine shipments short tons	890,071	1,003,997	948,832	868,436	882,414
Value thousands	$16,529	$19,178	$18,058	$17,608	$18,519
Imports short tons	200,880	173,219	166,315	186,539	207,906
Consumption do	874,986	980,426	923,304	962,706	919,206
Titanium slag:					
Consumption do	152,416	128,203	148,184	132,233	122,926
Rutile concentrate:					
Mine shipments do	11,311	10,547	W	W	W
Value thousands	$1,262	$1,016	W	W	W
Imports short tons	71,990	110,981	151,748	151,482	167,100
Consumption do	35,189	79,446	117,376	135,883	153,457
Sponge metal:					
Production do	7,879	W	W	W	W
Imports for consumption do	1,468	2,056	3,134	5,675	7,176
Consumption do	8,865	11,131	12,105	19,677	20,062
Price: Dec. 31 per pound	$1.60	$1.32	$1.32	$1.32	$1.32
World production:					
Ilmenite concentrate short tons	2,190,742	2,589,163	2,718,290	2,883,936	e 2,959,965
Rutile concentrate do	221,826	214,755	245,259	279,325	e 317,978

e Estimate.
W Withheld to avoid disclosing individual company confidential data.

794 tons of nonstockpile-grade titanium metal was sold at an average price of about $1.05 per pound. The Government inventory of rutile at the end of 1967 was 47,617 tons.

On January 17, 1967, OEP established a domestic production expansion goal for rutile of 70,000 tons per year. Under provisions of the Defense Production Act the OEP, on June 13, 1967, authorized the Department of the Interior to investigate potential sources of rutile in the United States and to encourage and expedite the production and use of subsitute domestic and other North American titaniferous ores. As part of the program the Geological Survey will test and evaluate ore samples obtained under several exploration programs, to determine if rutile is present in the ores in significant quantities. In addition, a deposit of columbium-bearing rutile in Hot Spring County, Arkansas, will be investigated for the Department's Office of Minerals and Solid Fuels. The Bureau of Mines will investigate the technical and economic factors involved in the production and use of alternate titaniferous materials in place of rutile in strategic applications.

Financial assistance for exploration of rutile deposits, available through the U. S. Geological Survey, Office of Minerals Exploration, was increased in September, 1967, from 50 percent Government participation to 75 percent.

As part of the overall program for improving the mobilization base for rutile the OEP also authorized GSA to develop a domestic rutile purchase program. The Department of Agriculture was authorized to acquire 53,000 tons of rutile by cash or in exchange for agricultural products. A contract was negotiated with Engelhard Minerals & Chemicals Corp. for delivery to the Government of 3,400 tons of Australian rutile by June 30, 1968. However, authorization to acquire additional quantities expired on June 30, 1967.

DOMESTIC PRODUCTION

Concentrates.—Ilmenite concentrate was produced in 1966 and 1967 by E. I. du Pont de Nemours & Co., Inc., Starke and Highland, Fla.; Humphreys Mining Co., Folkston, Ga.; The Glidden Company, Lakehurst, N.J.; National Lead Co. Tahawus, N.Y.; American Cyanamid Co., Piney River, Va.; and M&T Chemicals, Inc., Hanover County, Va. Porter Brothers Corp. shipped a small quantity of ilmenite from stocks at Boise, Idaho, in 1966.

M&T Chemicals, Inc., was the sole producer of rutile in 1966 and 1967. Rutile output at the M&T Chemical mine in Hanover County, Va., decreased markedly in 1967.

Metal.—Output of titanium sponge metal by 3 producers increased for the eighth successive year.

Early in 1967 Armco Steel Corp. acquired a 30-percent interest in Oregon Metallurgical Corp. which had begun production of titanium sponge metal at a new facility in Albany, Oregon, in June 1966.

Table 2.—Production and mine shipments of titanium concentrates from domestic ores in the United States

Year	Production short tons (gross weight)	Shipments		
		Short tons (gross weight)	Short tons TiO_2 content	Value (thousands)
Ilmenite: [1]				
1963	888,400	890,071	470,983	$16,529
1964	1,001,132	1,003,997	526,642	19,178
1965	969,459	948,832	494,353	18,058
1966	965,378	868,436	451,132	17,608
1967	935,091	882,414	463,286	18,519
Rutile:				
1963	11,915	11,311	10,839	1,262
1964	8,062	10,547	10,112	1,016
1965–67	W	W	W	W

W Withheld to avoid disclosing individual company confidential data.
[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite.

Table 3.—Titanium-metal data

(Short tons)

	1963	1964	1965	1966	1967
Sponge metal:					
Production	7,879	W	W	W	W
Imports for consumption	1,468	2,056	3,134	5,675	7,176
Industry stocks	1,100	800	900	800	2,900
Government stocks (DPA inventories)	22,371	22,254	22,339	21,416	20,711
Consumption	8,865	11,131	12,105	19,677	20,062
Scrap-metal consumption	2,335	2,877	3,303	4,857	5,822
Ingot:[1]					
Production	11,138	13,964	15,294	24,253	25,960
Consumption	10,506	13,501	14,694	22,317	25,386
Mill shape production [2]	6,112	7,708	9,358	r 13,996	13,636

r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Includes alloy constituents.
[2] Bureau of the Census and Business and Defense Services Administration, Current Industrial Reports Series BDSAF-263 (67). Net shipments derived by subtracting the sum of producers' receipts of each mill shape from the industry's gross shipments of that shape. Data not comparable with years before 1962.

Ormet planned to expand its sponge metal capacity of about 700 tons per year at the end of 1967 to 6,500 tons by the 1970's.

Titanium Metals Corporation of America (TMCA) and Reactive Metals, Inc. were expanding facilities to produce titanium sponge metal. TMCA planned to increase annual sponge capacity of its Henderson, Nev., plant from 10,000 tons to 16,000 tons by mid-1969. Reactive Metals Inc. was expected to increase annual sponge capacity at Ashtabula, Ohio, from 5,000 tons to 8,500 tons by 1970.

Titanium ingot was produced from sponge metal and alloys by Harvey Aluminum, Inc., Torrance, Calif.; Crucible Steel Company of America, Midland, Pa.; TMCA, Henderson, Nev.; Reactive Metals, Inc., Niles, Ohio; and Oregon Metallurgical Corp., Albany, Ore.

Teledyne Titanium, a subsidiary of Teledyne, Inc., announced plans to produce titanium ingot at a new plant to be constructed at Monroe, N.C. Howmet Corp., was constructing a 2,000-ton-per-year titanium melting facility at Whitehall, Mich.

Pigment.—On a gross weight basis titanium dioxide pigment production in 1966 was 11 percent lower than that of 1965. However, the average TiO_2 content of pigments produced increased and on a TiO_2-content basis output increased by 3 percent. In 1967, the gross weight of production was 2 percent lower than that of 1966 and the TiO_2 content of output dropped 1 percent. In 1967, the first year that the industry reported data on rutile, anatase, and composite types of pigment, the rutile-type pigment was produced by all seven pigment companies and comprised approximately 49 percent of the total on a TiO_2 content basis. The remaining 51 percent was anatase type, produced by five companies, and composite type, produced by one company.

Table 4.—Titanium pigment data (TiO_2 content)

Year	Production (short tons)	Shipments [1]	
		Quantity (short tons)	Value, f.o.b. (thousands)
1963	519,458	528,416	$278,477
1964	558,536	549,329	288,031
1965	r 576,700	r 573,091	r 298,842
1966	r 594,486	593,933	303,902
1967	p 587,995	NA	NA

p Preliminary. r Revised. NA Not available.
[1] Includes interplant transfers.

Source: Bureau of the Census.

Titanium pigments were produced by the following companies: American Cyanamid Co., Piney River, Va., and Savannah, Ga.; American Potash & Chemical Corp., Hamilton, Miss.; Cabot Titania Corp., Ashtabula, Ohio; E. I. du Pont de Nemours & Co., Inc., Edgemoor, Del., Baltimore, Md., Antioch, Calif., and New Johnsonville, Tenn.; SCM Corp., Glidden-Durkee Division, Baltimore, Md.; National Lead Co., St. Louis, Mo., and Sayreville, N.J.; The New Jersey Zinc Co., Gloucester City, N.J.; and American Potash & Chemical Corp., Hamilton, Miss.

During 1967, an agreement was signed between The Sherwin-Williams Co. and E. I. du Pont de Nemours & Co., Inc. whereby Du Pont will build a $20 million plant at Ashtabula, Ohio to make 25,000 tons of titanium dioxide pigment per year. The plant will be owned and operated by Sherwin-Williams, and will utilize a chloride process, licensed from Du Pont.

Late in 1966, PPG Industries, Inc., started construction of an 18,000-ton-per-year titanium pigment plant at Natrium, W. Va. The plant, which will utilize a chloride process developed by PPG, was expected to begin commercial operation early in 1968.

In 1966 the New Jersey Zinc Co., a subsidiary of Gulf & Western Industries, Inc., and longtime producer of titanium pigments by the sulfate process, announced the signing of a joint research and patent licensing agreement with Montecatini Edison S.P.A. of Milan, Italy, relating to development of a new chloride process for production of titanium pigment. The research and development programs under the agreement will be conducted at The New Jersey Zinc laboratories in Palmerton, Pa., and at Montecatini's Donegani Research Institute at Novara, Italy, where a pilot plant reportedly was in operation in 1967.

Du Pont announced that its 40,000-ton-per-year titanium pigment plant at Baltimore, Md. which utilizes the sulfate process, would be phased out by mid-1969.

Welding Rod Coating.—A total of 260,000 tons of welding rods, containing titaniferous materials in their coatings, was produced. Of the total output 51 percent contained rutile; 15 percent, ilmenite; 21 percent, a mixture of rutile and manufactured titanium dioxide; 9 percent, manufactured titanium dioxide; and 4 percent, miscellaneous mixtures and titanium slag.

CONSUMPTION AND USES

Concentrates.—Reflecting the increase in titanium dioxide content of pigment production in 1966 consumption of ilmenite, the principal source of pigment, increased 2 percent over that of 1965. Rutile consumption in 1966 increased 16 percent over that of 1965, mainly because of the increase in making titanium pigment by the chloride process. In 1967, the use of ilmenite and titanium slag decreased slightly reflecting the drop in pigment production; however, rutile consumption, which was mainly for pigment, continued to increase and was 13 percent higher than that in 1966.

Metal.—Sharply increased titanium requirements for commercial and military airframes and jet engines in 1966 led to a 50-percent increase in consumption of titanium metal over that of 1965, as gaged by shipments of mill products. Shipments of titanium mill products in 1967 were slightly lower than that in 1966, reflecting a slowing of demand and a substantial adjustment to excess inventories in the hands of fabricators.

A large producer of titanium metal estimated the end-use distribution of titanium mill products as follows:

	Consumption, percent		
	1965	1966	1967
Jet engines	40	47	54
Airframes	30	28	[1] 34
Space and missiles	15	15	6
Nonaerospace	15	10	6
Total	100	100	100

[1] 26 percent military, 8 percent civilian.

Commercial shipments of titanium mill products for use in producing the giant military transport plane (the C-5A) and the Boeing 747 commercial airliner were initiated in 1967. Although essentially aluminum aircraft, each of these planes will require the purchase of some 45 tons of titanium mill products for engine com-

Table 5.—Consumption of titanium concentrates in the United States, by products

(Short tons)

Year and product	Ilmenite [1]		Titanium slag		Rutile	
	Gross weight	Estimated TiO_2 content	Gross weight	Estimated TiO_2 content	Gross weight	Estimated TiO_2 content
1963	874,986	459,506	152,416	108,645	35,189	33,326
1964	980,426	511,053	128,203	91,868	79,446	76,328
1965	923,304	483,002	148,184	105,483	117,376	113,017
1966:						
Pigments	959,343	505,593	132,233	93,683	(2)	(2)
Titanium metal	-------	---------	---------	---------	(2)	(2)
Welding-rod coatings	(2)	(2)	(3)	(3)	23,904	22,656
Alloys and carbide	2,876	1,500	(3)	(3)	935	869
Ceramics	(2)	(2)	---------	---------	(4)	(4)
Glass fibers	-------	---------	---------	---------	909	884
Miscellaneous	487	287	---------	---------	110,135	105,782
Total	962,706	507,379	132,233	93,683	135,883	130,191
1967:						
Pigments	916,398	486,739	122,926	86,945	96,401	92,795
Titanium metal	-------	---------	---------	---------	(2)	(2)
Welding-rod coatings	(2)	(2)	(3)	(3)	21,190	20,139
Alloys and carbide	2,414	1,265	(3)	(3)	737	697
Ceramics	(2)	(2)	---------	---------	(4)	(4)
Glass fibers	-------	---------	---------	---------	(2)	(2)
Miscellaneous	394	232	---------	---------	35,129	33,527
Total	919,206	488,236	122,926	86,945	153,457	147,158

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite.
[2] Included with "Miscellaneous" to avoid disclosing individual company confidential data.
[3] Included with "Pigments" to avoid disclosing individual company confidential data.
[4] Included with "Alloys and carbide" to avoid disclosing individual company confidential data.

Table 6.—Distribution of titanium-pigment shipments, by industries

(Percent)

Industry	1963	1964	1965	1966	1967
Distribution by gross weight:					
Paints, varnishes, and lacquers	63.3	62.6	62.9	61.6	61.9
Paper	12.5	12.4	12.6	13.9	14.6
Floor coverings	4.3	3.9	3.6	3.4	2.7
Rubber	4.0	3.1	4.2	4.2	2.8
Coated fabrics and textiles (oil cloth, shade cloth, artificial leather, etc.)	2.0	1.2	1.4	1.4	1.4
Printing ink	1.6	1.7	1.8	1.9	2.0
Roofing granules	2.1	1.6	1.3	1.2	1.1
Ceramics	1.2	1.5	1.5	1.7	1.9
Plastics (except floor covering and vinyl-coated fabrics and textiles)	2.9	4.4	3.6	3.8	5.1
Other (including export)	6.1	7.6	7.1	6.9	6.5
Total	100.0	100.0	100.0	100.0	100.0
Distribution by titanium dioxide content:					
Paints, varnishes, and lacquers	57.0	56.8	57.4	56.4	57.5
Paper	15.5	15.2	15.2	16.7	17.2
Floor coverings	5.2	4.7	4.3	3.9	3.1
Rubber	4.9	3.7	5.0	4.9	3.2
Coated fabrics and textiles (oil cloth, shade cloth, artificial leather, etc.)	2.0	1.4	1.6	1.6	1.6
Printing ink	2.0	2.1	2.1	2.2	2.3
Roofing granules	2.6	1.9	1.7	1.5	1.4
Ceramics	1.5	1.9	1.8	2.1	2.2
Plastics (except floor covering and vinyl-coated fabrics and textiles)	3.7	5.4	4.3	4.6	6.0
Other (including export)	5.6	6.9	6.6	6.1	5.5
Total	100.0	100.0	100.0	100.0	100.0

ponents, fasteners, and critical airframe parts. The powerplant for the C-5A is the General Electric TF-39 engine, while the Pratt & Whitney JT9 will be utilized in the 747. Both of these engines reportedly use more titanium than any jet engine produced previously.

According to Oregon Metallurgical Corp. titanium propellers were cast for use on a high-speed hydrofoil gunboat. The blades were 22 inches from hub to tip.

Wyman Gordon, Inc. reportedly forged titanium blades to drive the Navy's 300-ton hydrofoil experiemental craft, Plainview. Each of the four-bladed propellers is 5 feet in diameter and weigh 740 pounds.

New uses for titanium reported in 1966 and 1967 included a sheath for an immersion type heater [2]; an aortic heart valve [3]; a new type prosthetic device,[4] and the boom and upper portion of the mast for the racing sail boat, the Intrepid.

Pigments.—Consumption of titanium pigment in 1967 on a gross weight basis and using shipments as a gage was 4 percent less than that in 1966. Consumption in 1966 on the same basis was 3 percent higher than that in 1965.

STOCKS

Industry stocks of rutile increased 7 percent to 185,000 tons, equivalent to more than a year's supply at the 1967 consumption rate. Ilmenite inventories also increased significantly, but stocks of titanium slag declined. Yearend stocks of titanium sponge metal held by producers, melters, and semifabricators totaled 2,810 tons compared with 826 tons on hand at the end of 1965. Titanium metal scrap held by melters and semifabricators at yearend was 4,894 tons, 645 tons more than that at the end of 1965.

[2] Chemical Age (London). Immersion Heater With Titanium Sheathed Element. v. 96, No. 2452, July 9, 1966, p. 70.

[3] American Metal Market. Aortic Heart Valve Made of Titanium. v. 74, No. 8, Jan. 12, 1967, p. 15.

[4] American Metal Market. Titanium Gets Into the Canine Whirl. v. 74, No. 20. Jan. 30, 1967, p. 2.

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
1966:						
Mine	(1)	(1)	----------	----------	(1)	(1)
Distributor	r 142,440	r 87,562	(2)	(2)	r 16,336	r 15,628
Consumer	r 654,680	r 362,245	137,269	97,022	r 157,107	r 151,111
Total	r 797,120	r 449,807	137,269	97,022	r 173,443	r 166,739
1967:						
Mine	(1)	(1)	----------	----------	(1)	(1)
Distributor	194,994	119,219	(2)	(2)	11,373	10,883
Consumer	660,712	363,443	130,389	92,310	174,099	167,516
Total	855,706	482,662	130,389	92,310	185,472	178,399

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.—The yearend prices, f.o.b. Atlantic ports, quoted in Metals Week for imported ilmenite (54 percent TiO_2) and rutile (96 percent TiO_2), remained unchanged in 1966 and 1967 at $21 to $24 per long ton and $119 to $121 per short ton, respectively. The quoted price for domestic ilmenite (60 percent TiO_2) and titanium slag (70 percent TiO_2) from Canada, remained at $35 per short ton, and $43 per long ton, respectively.

Manufactured Titanium Dioxide.—The base prices of rutile and anatase grades of manufactured titanium dioxide pigment and calcium-rutile base titanium pigments were unchanged in 1966 and 1967. A 2.5-cent-per-pound reduction was quoted for paper grades of anatase titanium dioxide. The following prices were quoted in Oil, Paint and Drug Reporter at the end of 1967.

	Price per pound
Anastase, chalk-resistant, regular and ceramic:	
Carlots, delivered	$0.255
Less than carlots, delivered	.265
Rutile, nonchalking, bags:	
Carlots delivered East	.275
Less than carlots, delivered East	.285
Titanium pigment, calcium-rutile base, 30 percent TiO_2, bags:	
Carlots, delivered	.09375
Less than carlots, delivered	.09875

Metal.—Yearend prices for various grades of titanium sponge metal of domestic and Japanese origin were virtually unchanged in 1966 and 1967, and were quoted in Metals Week at the end of 1967 as follows:

Titanium sponge metals: titanium, 99.3 percent maximum; Brinell hardness number, 115 maximum	$1.32
Japanese titanium sponge	$1.23–$1.25

Russian titanium sponge metal containing a minimum of 99.6 percent titanium was quoted at $0.97 to $1.10 per pound at the end of 1967.

Ferrotitanium.—Nominal prices at yearend for various grades of ferrotitanium were quoted in Metals Week as follows:

	Price
Low-carbon, per pound	$1.35
Medium-carbon, per short ton	375
High-carbon, per short ton	310

FOREIGN TRADE

Titanium dioxide exports in 1966 and 1967 continued the downward trend of recent years. As in past years almost half of the pigment exports went to Canada. The quantity of titanium ores and concentrates exported in 1967 was more than double that exported in 1966. The value of exports in 1967, however, was significantly lower, indicating that most of the material exported under the classification in 1967 was ilmenite. Canada, was the principal recipient of the titanium ores and concentrates.

A decline in exports of titanium metal and alloys, sponge and scrap in 1967 was more than offset by an increase in exports of intermediate titanium mill shapes and mill products, and total exports of titanium was 5 percent higher than that of 1966.

Imports of Australian ilmenite to the United States in 1967 increased substantially, however, imports of rutile from Australia were about the same as in the two previous years. In 1967, a substantial quantity of rutile was imported for the first time from Sierra Leone, bringing total imports of this material, for use chiefly in making titanium metal and pigment, to a record high.

Imports for consumption of unwrought titanium and waste and scrap in 1966 and 1967 totaled 5,675 tons and 7,676 tons, respectively. Material from Japan was vir-

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.[1]		Dioxide and pigments	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1965	1,201	$203	2,132	$2,070	605	$5,144	26,896	$7,249
1966	1,300	213	1,733	1,988	1,371	9,585	26,872	7,501
1967	3,027	167	1,429	1,703	1,811	13,344	25,852	7,165

[1] Not elsewhere classified.

tually all sponge metal and totaled 4,183 and 4,585 tons, respectively, in 1966 and 1967. Most material from the United Kingdom also was sponge metal and in 1966 and 1967 totaled 1,349 tons and 1,022 tons respectively. In 1966 and 1967, 65 tons and 1,313 tons of titanium sponge metal was imported for consumption from the U.S.S.R. The remainder of the imports under this category was titanium scrap and came chiefly from Canada.

Imports of wrought titanium metal in 1966 and 1967 were substantially higher than that of 1965. The 304 tons imported in 1966 was double the total in 1965. In 1967 imports of wrought titanium leveled off at 299 tons. Japan was the principal supplier.

Imports of titanium dioxide in 1966 and 1967 were 47,988 tons and 46,774 tons, respectively, compared with 49,603 tons imported in 1965. As in past years Japan, Finland, France, and West Germany were the principal suppliers.

The tariff on titanium sponge metal, waste, and scrap remained at 20 percent ad valorem. The duty on wrought titanium was 18 percent ad valorem. Duty on titanium waste and scrap was tentatively suspended through June 30, 1969. Presidential Proclamation 3822 authorizing reductions in tariffs in accordance with the Kennedy Round trade agreements was signed in December 1967. The first stage of duty reductions applying to calendar year 1968 and becoming effective June 1, 1968 included titanium sponge metal.

Table 9.—U.S. imports for consumption of titanium concentrates, by countries

(Short tons and thousand dollars)

Country	1965	1966	1967
Ilmenite:			
Australia	49,312	46,245	60,689
Canada [1]	117,003	140,237	147,216
Other countries	---------	57	1
Total:			
Short tons	166,315	186,539	207,906
Value (thousands)	$4,771	$6,698	$5,145
Rutile:			
Australia	151,748	151,463	153,768
Sierra Leone	---------	19	13,129
Other countries	---------	(2)	203
Total:			
Short tons	151,748	151,482	167,100
Value (thousands)	$10,114	$8,494	$11,943

[1] Chiefly titanium slag averaging about 70 percent TiO_2.
[2] Less than ½ unit.

WORLD REVIEW

Sherbro Minterals Ltd., made its first commercial shipment of rutile from its new mine in Sierra Leone. However, its dredge sank late in 1967 and production was expected to be resumed in June 1968.

A new titanium pigment plant utilizing the chloride process was planned in Canada and one was completed in the Republic of West Germany. New and expanded sulfate plants also were planned or completed in Australia, Brazil, France, Mexico, Norway, West Germany, and Yugoslavia.

Table 10.—World production of titanium concentrates (ilmenite and rutile by countries) [1]

(Short tons)

Country	1963	1964	1965	1966	1967 p
Ilmenite:					
Australia (shipments)	r 225,715	340,064	r 493,959	r 574,578	e 600,000
Brazil [2]	6,484	9,117	10,796	14,920	e 15,000
Canada (titanium slag) [3]	379,320	544,721	545,916	524,773	602,455
Ceylon	21,041	50,880	54,222	[4] 45,415	58,573
Finland	103,461	127,937	117,947	129,588	137,789
India	28,619	13,273	33,132	33,253	e 30,000
Japan (titanium slag)	963	2,161	3,190	r 3,867	6,293
Malagasy Republic	4,027	5,291	6,957	6,821	e 6,000
Malaysia [4]	164,656	144,774	136,154	130,364	e 140,000
Mexico	155	----------	----------	----------	----------
Norway	267,040	299,854	311,017	407,546	e 407,855
Portugal	45	63	83	278	e 419
Senegal	13,436	1,455	----------	----------	----------
South Africa, Republic of	31,039	----------	----------	----------	----------
Spain	55,745	48,418	35,458	46,548	20,490
United Arab Republic	596	23	----------	607	----------
United States [5]	888,400	1,001,132	969,459	965,378	935,091
Total ilmenite [6]	r 2,190,742	r 2,589,163	r 2,718,290	r 2,883,936	e 2,959,965
Rutile:					
Australia	205,251	204,256	r 243,410	r 277,200	e 300,578
Brazil	429	315	397	r 37	e 400
India	2,062	2,062	1,452	2,002	e 2,000
Senegal	780	60	----------	----------	----------
South Africa, Republic of	1,385	----------	----------	----------	----------
United Arab Republic	4	----------	----------	37	----------
United States	11,915	8,062	W	W	W
Sierra Leone	----------	----------	----------	e 50	15,000
Total rutile [6]	r 221,826	r 214,755	r 245,259	r 279,325	e 317,978

e Estimate. p Preliminary. r Revised.
W Withheld to avoid disclosing individual company confidential data.
[1] Titanium concentrates are produced in U.S.S.R., but no reliable figures are available.
[2] Production—Comissao Nacional de Energia Nuclear only.
[3] Containing approximately 70 to 72 percent TiO_2.
[4] Exports.
[5] Includes a mixed product containing ilmenite, leucoxene, and rutile.
[6] Total is of listed figures only; no undisclosed data included.

Australia.—A new dry separation plant at Hexham, New South Wales, was started up in 1966 by Associated Minerals Consolidated Ltd., the largest rutile producer. The plant is expected to eventually have an annual capacity of 60,000 tons.

Annual capacity of the Laporte Titanium (Australia) Ltd. titanium dioxide pigment plant at Bunbury, western Australia, was expanded 20 percent in 1966 to 12,000 tons.

Western Titanium N.L., a major producer of ilmenite at Capel in Western Australia, planned to begin early in 1968, semicommercial production of a product containing about 93 percent titanium

Table 11.—Australia: Exports of ilmenite concentrates, by countries

(Short tons)

Destination	1963	1964	1965	1966	1967 p
France	1	45,406	28,947	53,215	90,500
Japan	25,337	55,876	50,884	49,362	69,200
Netherlands	1,127	411	333	7,417	(1)
South Africa, Republic of	-------	20,017	24,640	11,314	(1)
United Kingdom	80,032	136,516	225,912	216,668	186,100
United States	40,430	17,130	72,913	53,923	54,500
Other countries	23,358	227	376	7,338	49,700
Total	170,285	275,583	404,005	399,237	450,000

p Preliminary.
[1] Included with other.

Table 12.—Australia: Exports of rutile concentrates, by countries

(Short tons)

Destination	1963	1964	1965	1966	1967 p
Belgium	3,212	4,287	4,084	2,465	(1)
France	6,938	9,803	12,758	13,642	8,750
Germany, West	4,972	10,625	9,051	10,750	11,300
Italy	7,158	6,851	5,915	6,287	(1)
Japan	12,460	17,832	22,715	24,431	32,900
Netherlands	10,626	15,206	12,601	9,859	21,000
Poland	-------	---------	4,633	NA	(1)
Spain	-------	---------	3,349	NA	(1)
Sweden	4,392	4,454	4,742	3,857	(1)
Switzerland	-------	---------	1,364	NA	(1)
United Kingdom	16,386	17,187	18,923	17,343	17,900
United States	88,234	107,539	152,479	136,556	146,000
Other countries	18,671	23,376	15,574	33,854	52,150
Total	173,049	217,160	268,188	259,044	290,000

p Preliminary.
1 Included with other.

dioxide for use as a substitute for natural rutile. Capacity of the plant, which reportedly cost $500,000, will be about 10,000 tons of the upgraded product per year.

Brazil.—Titanio do Brasil S.A. (TIBRAS began construction of a $25 million sulfate process titanium dioxide plant near Salvador, Bahia, with an annual capacity of 20,000 tons per year. Laporte Industries Ltd., reportedly will provide technical assistance in planning the plant, which is scheduled for completion in mid-1969. SUDENE, the Inter-American Development Bank, and a group of industries from southern Brazil will finance the project.

The Government announced plans to spend several hundred thousand dollars to explore the northeastern and central regions of the country for ilmenite and rutile.

Canada.—Construction of a ninth ilmenite smelting furnace at the Quebec Iron and Titanium Corp. (QIT) plant at Sorel, Quebec was completed early in 1967. The new furnace reportedly has 50 percent greater capacity for producing titanium slag than any of the existing furnaces. The capacity of two of the older furnaces also was increased, raising total titanium slag capacity to about 650,000 tons per year. QIT continued research to develop a competitive substitute for natural rutile.

Canadian Titanium Pigments Ltd., a wholly owned subsidiary of the National Lead Co. was increasing capacity of its titanium pigment plant at Varennes, Quebec from 30,000 tons per year to 40,000 tons. The chloride process was expected to be used for the additional 10,000-ton capacity.

Ceylon.—The state-owned Ceylon Mineral Sands Corp. planned to move its ilmenite concentrating plant from the mine site at Pulmoddai on the northeastern shore, to Trincomalee, about 30 miles south. The port at Trincomalee is open all year. The company produces about 60,000 tons of ilmenite per year, which is exported to Japan, and about 10,000 tons of a mixed product containing equal portions of rutile and zircon. Equipment for separating the rutile and zircon was received from the United States and production of these two minerals at Trincomalee was planned in 1968.

Chile.—A high-grade deposit of rutile was reportedly discovered near La Serena in Northern Chile.

France.—Construction of a new 25,000-ton-per-year titanium dioxide plant at Calais was completed early in the year. The plant, which was built by British Titan Products Co., Ltd., will utilize the sulfate process instead of the chloride process, as originally announced.

Germany, West.—Pigment Chemie G.m.b.H., completed a 6,000-ton expansion of its titanium dioxide plant at Homberg, bringing total annual capacity of 26,000 tons at the end of 1966. A 17,000-ton-per-year unit for producing titanium pigment by the chloride process was reportedly completed at the Titangesellshaft m.b.H. pigment plant at Leverkusen. An equivalent capacity of sulfate pigment plant was expected to be phased out, leaving a total capacity of about 95,000 tons per year.

India.—The Dharahgadrha Chemicals Co. Ltd., reportedly planned to produce a rutile substitute from Travancore ilmenite with technical help from the Wah Chang Corp. of the United States.

Demand for titanium dioxide pigment was said to exceed domestic production and the Birla (private) interest planned to build a titanium pigment plant at Edayar near Alwaye. The only producer of titanium pigment, Travancore Titanium Product, Ltd., with a plant at Kochuveli, Trivandrum, in Kerala, had a capacity of 6,700 tons per year, however, output was reportedy only about 3,000 tons annually.

Japan.—Toho Titanium Co. Ltd., raised annual capacity of its titanium sponge metal plant at Chigasaki, Kanagawa Prefecture, to 4,000 tons early in 1967 and planned an additional capacity increase. Capacity at the Osaka Titanium Co. Ltd. plant in Hyogo Prefecture at the end of the year was believed to be in excess of 4,000 tons annually.

Toho and Osaka produced 8,642 short tons of titanium metal in 1967 compared with 7,090 tons produced in 1966. Hokuetsu Electric Chemical Co. produced 4,961 tons of titanium slag in 1966 and 4,577 tons in 1967.

Toyo-Stauffer Chemical Co. Ltd. planned to build a 400-ton-per-year titanium trichloride plant near Tohyuama. Process and plant design was to be supplied by Stauffer Chemical Co. of the United States.

Malaysia.—Japan continued to be the principal market for ilmenite.

Table 13.—Malaysia: Exports of ilmenite by countries

(Short tons)

Destination	1962	1963	1964	1965	1966
Belgium	-------	19,470	14,663	22,184	(1)
France	34,658	63,194	58,805	27,351	(1)
Japan	77,502	81,537	71,037	86,300	106,832
Other countries	1,696	455	269	319	23,532
Total	113,856	164,656	144,774	136,154	130,364

[1] Belgium and France are included under other countries.

Mexico.—Pigmentos y Productos Quimicos S. A. de C.V. planned to increase the annual capacity of its titanium dioxide pigment plant at Tampico from about 8,000 tons to 15,000 tons.

New Zealand.—The Department of Scientific and Industrial Research was investigating ilmenite resources said to total 45 million tons, near Cape Foulwind in the Buller District of South Island.

Norway.—Titan Co. A/S, a subsidiary of National Lead Co. completed expansion of its titanium dioxide plant at Frederikstad in 1966, raising annual capacity to 15,000 tons. Titania A/S, another National Lead subsidiary which produces ilmenite at Tellnes planned to build a $21 million ilmenite smelter to produce about 200,000 tons of titanium slag per year containing 75 percent TiO_2.

Sierra Leone.—Sherbro Minerals Ltd., made its first commercial shipments of rutile from its new mine in the Gbangbama area in the southwest in June 1967. The company's dredge sank in December and production was not expected to be resumed until June 1968.

South Africa, Republic of.—Progress Minerals (Pty) Ltd., owned by banking firms in Switzerland, planned to begin mining ilmenite and possibly rutile from a deposit at Cape Morgan, 56 miles east of East London near the border of Transkei, early in 1968. The company purchased the entire dry separation plant of Umbgababa Minerals, Ltd., which formerly mined rutile and ilmenite near Durban. Output of 160,000 tons of ilmenite and 20,000 tons of rutile and zircon per year was scheduled.

Spain.—Several small firms reportedly planned to form a jointly owned company to mine ilmenite near Lugo in the northwest. The deposit was believed to be small but virtually chrome-free.

United Kingdom.—A report indicated that the aircraft industry accounted for 94 percent of the market for titanium metal in 1960 compared with 75 percent in 1966.[5]

Yugoslavia.—A 20,000-ton-per-year titanium pigment plant to be built by CINKARNA at Celje was scheduled for completion in 1972. Byproduct sulfuric acid from the zinc smelter of CINKARNA and Egyptain ilmenite reportedly will be utilized.

TECHNOLOGY

Increased demand for rutile to make titanium tetrachloride used in titanium pigment and metal production, coupled with growing concern for the long range availability of an adequate rutile supply, has led to considerable research in recent years on developing methods for utilizing ilmenite in place of rutile in these applications. Processes to produce a high titania content product from ilmenite which would be soluble in sulfuric acid and, thus suitable for use in the sulfate process for making titanium pigment also have been studied. A comprehensive review of the research on chemical beneficiation of ilmenite was reported by Hartley.[6]

The Summit Industrial Corporation through its subsidiary, Oceanic Process Corporation was developing a patented process for making a titanium dioxide concentrate and a high-purity iron oxide or powder from ilmenite.[7] In this process, which was being investigated in 1967 on a pilot plant scale, ilmenite is oxidized by roasting in air or other oxygen-containing gas at 750° to 1,200° C for 20 to 150 minutes, converting the iron in the ilmenite to the ferric state. The iron is then reduced to the metallic state with carbon or other solid reducing agent at 750° to 1,250° C. The metallic iron is then leached from the reduced ilmenite with a ferric chloride solution, leaving a product containing more than 90 percent TiO_2. A portion of the iron contained in the leach solution is oxidized to recover iron oxide and the solution is recycled. The particle size of the TiO_2 product was essentially the same as that of the original ilmenite.

Western Titanium, N.L., a major producer of ilmenite, planned to build a semicommercial plant in 1968 capable of producing 10,000 tons of material containing about 93 percent titanium dioxide annually from ilmenite. The process to be used was developed by Western Titanium and the Commonwealth Scientific and Industrial Research Organization (CSIRO) and involved the reduction of the iron in ilmenite at less than slagging temperatures and subsequent reoxidation of the iron in aerated water and separation of the iron and titanium oxides by decantation. Early development work on the process was described in a report.[8]

The development and operation of a cone-type concntrator for separating the heavy mineral fraction containing ilmenite and rutile from sand deposits was described.[9] One of the principal advantages of the cone concentrator is the relative constancy of recovery regardless of the fairly large changes in grade which are normally encountered in beach sands containing titanium minerals.

Development history, uses, properties, and methods of preparing titanate ceramics, with specific reference to electrical properties were discussed in a report.[10] The piezoelectric property (ability to transform electrical and mechanical energy) of titanate ceramic bodies has led to extensive use of the material to generate ultrasonic vibrations or transform them into electric energy in a number of applications, including underwater communications, gages,

[5] Hodgkinson, Peter. Titanium. Light Metals & Metals Industry, v. 29, No. 332, January 1966, p. 44.

[6] Hartley, R. F. Methods of Producing Titanium Oxide Concentrate From Ilmenite. Eight Commonwealth Min. and Met. Cong., Australia and New Zealand, 1965, Preprint No. 51, 37th Tech. Session, Beach Sands, 399 Little Collins Street, Melbourne, Victoria, Australia, pp. 36–48.

[7] Shiah, Chyn Duog (assigned to Oceanic Process Corporation). Process for Producing Titanium Dioxide Concentrate and Other Useful Products From Ilmenite and Similar Ores. U.S. Pat. 3,252,787, May 24, 1966.

[8] Becker, R. H., R. H. Canning, B. A. Goodheart, and S. Uusna. A New Process for upgrading Ilmenitic Mineral Sands. Mining Paper 3, Pres. at Annual Conf. Australia. I.M.M., Apr. 23, 1964, 21 pp.

[9] Carpenter, J. H. The Reichert Cone Separator. Can. Min. and Met. J., v. 59, No. 656, December 1966 pp. 1413–1417.

[10] Allen, Alfred C. The Titanate Ceramics, Ceramic Industry. V. 87, No. 1, July 1966, pp. 37–44.

and ultrasonic machining. The composition and manufacturing process affects the dielectric property (ability to store electrical charge) which makes titanates good materials for minature capacitance components. Methods for controlling and maintaining raw material purity and particle size and improving the processing of titanate capacitors were discussed in another report.[11]

The properties and growing use of titanium carbide metal cutting tools were described in a number of reports. The advantage of titanium carbide cutting tools was attributed to their resistance to high temperature, which makes them suitable for use at higher cutting speeds. Titanium carbide is susceptible to breaking under impact during discontinuous cutting, hence, under current technology titanium carbide cutting tools are limited to fairly light cutting conditions such as encountered in finishing or semifinishing. The Ford Motor Co. was developing two grades of titanium carbide for roughing cuts.[12]

According to tests made by Adamas Carbide Corp., titanium-carbide-faced dies for stamping electronic-switch vibrating reeds out of 52 alloy nickel were almost twice as efficient as one grade of tungsten carbide.[13]

Titanium carbide made by a new vapor deposition process also was formed into tubing, cylinders, and rectilinear shapes for use as high-temperature bearings, guides for textiles and synthetics, pitot tubes, abrasive fluid transport, sand blast and injection nozzles, and valve seats.[14]

The decrease in toughness of pure titanium carbide at high temperatures was reduced by the addition of a few tenths of a percent of boron.[15] Mixtures of titanium carbide and aluminum powder compacted by explosive and mechanical compaction were compared.[16] Differences in room temperature properties were largely eliminated by immersing the compacts in molten aluminum. However, the explosive bonded compacts retained higher strength at elevated temperatures than the pressed compacts.

Metal.—Detail of the new electrolytic process to produce titanium metal, which will account for part of the 6,000-ton-per-year expansion of TMCA's Henderson, Nev., titanium sponge metal plant were not disclosed. However, two patents concerning the design and operation of electrolytic cells for reducing titanium tetrachloride to titanium metal were assigned to TMCA.[17] The bulk of titanium metal produced by TMCA was made by the reduction of titanium tetrachloride with magnesium.

Oregon Metallurgical Corporation continued expansion of its new titanium sponge metal plant at Albany, Ore., which reportedly utilized a new patented process for removing impurities from the sponge.[18] In this process the titanium sponge metal resulting from the reduction of titanium tetrachloride with magnesium metal is heated in the presence of a stream of inert gas. The contaminants, consisting principally of magnesium chlorides, are evaporated, carried in the stream of inert gas, and separated from the gas by condensation.

The process to make titanium metal used by Reactive Metals Inc. at Ashtabula, Ohio, was described in a report.[19] Reactive used sodium metal to reduce titanium tetrachloride in a two-step process, the first of which involves continuous reaction between sodium and titanium tetrachoride to yield titanium dichloride. The dichloride is subsequently reduced with additional sodium to titanium metal in a batch process.

Large heat-treated titanium alloy plates were required for fabrication tests related to development of the supersonic transport

[11] Hyatt, E. P. and H. R. Laird. Dielectric Titanate Body Improvement. Am. Ceram. Soc. Bull., v. 45, No. 5, May 1966, pp. 541–544.

[12] Iron Age. TiC: A New Era in Cutting Tools. v. 198, No. 24, Dec. 15, 1966, pp. 57–60.

[13] Product Engineering. Brazed-on Facings Improve Tool Life. v. 37, No. 26, Dec. 19, 1966, p. 146.

[14] American Metal Market. Teeg Makes Titanium Carbide Tubes by a New Vapor Deposition Process. v. 73, No. 210, Oct. 28, 1966, p. 11.

[15] William, W. C. Dispersion Hardening of Titanium Carbide by Boron Doping. Trans. AIME, v. 236, No. 2, February 1966, pp. 211–216.

[16] Bergmann, O. R. Aluminum-Bonded Titanium Carbide Cermets. Am. Ceram. Soc. Bull., v. 45, No. 7, July 1966, pp. 639–642.

[17] Priscu, John C. (assigned to Titanium Metals Corporation of America). Electrolytic Cell for the Production of Titanium Metal. U.S. Pat. 3,282,822, Nov. 1, 1966.

Snyder, Linden E. (assigned to Titanium Metals Corporation of America). Electrolytic Production of Titanium. U.S. Pat. 3,274,083, Sept. 20, 1966.

[18] Shelton, Stephen M., Henry G. Poole, and Allen D. Abraham (assigned to Oregon Metallurgical Corporation). Purification of Contaminated Reactive Metal Products. U.S. Pat. 3,356,491, Dec. 5, 1967.

[19] Chemical Engineering. Sodium Proves Cheap Key To Unlock Titanium. v. 74, No. 21, Oct. 9, 1967, pp. 126–128.

(SST) and other advanced aircraft. United States Steel Corp. produced a 1-inch-thick plate, 512 inches long and 64 inches wide, and a 0.75-inch-thick plate 521 inches long and 67 inches wide. Bethlehem Steel Corp. produced five, 0.25-inch-thick plates, 520 inches long and 74 inches wide.

Fried Krupp Schmiede and Giesserei, Essen, West Germany, reported that it had begun melting titanium ingots 1 meter in diameter, 3.5 meters long, and weighing up to 10 tons. The ingot size was believed to be the largest cast in titanium and was produced in a fully automated high-vacuum electric arc furnace drawing 36,000 amperes.

Tungsten

By Richard F. Stevens, Jr.[1]

The tungsten industry during 1967 was marked by higher and relatively stable prices which encouraged the opening or reopening of several idle mines in the free world.

Although domestic demand for tungsten fell approximately 23 percent from the record high reached in 1966, the resulting level was high compared with other years. The major reasons for this rate of consumption, primarily in the form of tungsten carbide, were the demands of the war in Viet-Nam and the increased market for snow-tire studs. Three major factors influenced the improved world tungsten market in 1967: The relative price stability that occurred as a result of the U.S. Government's stockpile sales policy; the absence of significant quantities of tungsten exports from mainland China; and the continued relatively high level of industrial activity in Japan, Western Europe, and the United States.

Legislation and Government Programs.—The long-range tungsten disposal program administered by the General Services Administration (GSA) was revised in March 1966. The tungsten concentrate in the DPA inventory, all of which was declared to be excess, was offered for sale at $43 per short-ton unit adjusted for premiums and penalties, as a "shelf" item on a "first-come, first-serve" basis. During 1967 some 5.9 million pounds, tungsten content, of this material was sold by GSA at an average adjusted price of $39.46 per short ton unit. In addition, GSA sold almost 500,000 pounds, tungsten content, to the U.S. Army Materiel Command at an adjusted average price of $32.44 per short ton unit during the year. Because this material was to be used by a Government subcontractor, GSA sold the tungsten concentrate at a base price of $35.07 per short ton unit rather than the normal $43 per short ton unit ($43 less duty of $7.93 per short ton unit). Because no restrictions on the exportation of this material were

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Table 1.—Salient tungsten statistics

(Thousand pounds of contained tungsten)

	1963	1964	1965	1966	1967
United States:					
Mine production	W	W	W	W	9,250
Mine shipments	5,384	8,798	7,566	8,842	8,649
Releases from Government stocks	418	758	926	8,273	6,393
Exports [1]	51	79	11	101	974
Imports, general	3,882	2,737	3,495	4,203	2,004
Imports for consumption	3,060	3,148	3,618	4,298	1,699
Consumption of concentrate	11,061	12,311	13,868	r 18,058	13,860
Stocks:					
Producer	3,313	580	411	358	975
Consumer and dealer	2,934	2,090	1,434	1,582	1,134
World: Production	59,676	61,924	60,146	64,040	61,862
Consumption p [2]	38,191	41,870	44,219	48,970	38,690

p Preliminary. r Revised.
W Withheld to avoid disclosing individual company confidential data.
[1] Estimated tungsten content.
[2] Excludes some major consuming countries which do not report consumption.

imposed by GSA, approximately 15 percent of the surplus tungsten purchased during the year was shipped by traders to foreign consumers.

Under the amended terms of the "shelf" sale purchase program the purchaser is now allowed 365 days in which to pick up and transfer this material from Government storage sites to his own warehouse. Because of this, some of the material reported as being released from Government inventory has not been physically moved, and, therefore, is not completely reflected in the statistics of industry stocks reported in table 1.

GSA released 72,595 pounds of tungsten in concentrate from the DPA inventory to the Molybdenum Corporation of America (Molycorp) in 1966 as payment-in-kind for the conversion and upgrading of Government-furnished columbium concentrates to ferrocolumbium. During 1966 excess pig tin from the DPA inventory was released as payment-in-kind to Molycorp for the conversion of Government–furnished tungsten concentrates in the national (strategic) stockpile to 148,300 pounds, tungsten content, of ferrotungsten.

A revised national stockpile special instructions for tungsten metal powder (hydrogen–reduced), SI-89-R-2, was prepared during 1966 which provided new instructions to GSA regarding acquisition, storage, and disposal criteria for this material.

Early in 1967 GSA issued bid solicitations on two contracts for converting tungsten concentrates in the Government's strategic stockpile into 250,000 pounds, tungsten content, of hydrogen-reduced metal powder and into 350,000 pounds, tungsten content, of crystalline tungsten carbide powder. The conversion contract for hydrogen-reduced tungsten metal powder was awarded to the General Electric Co. which will receive pig tin from the DPA inventory as payment-in-kind. The bid solicitation for the conversion to crystalline tungsten carbide was canceled.

Table 2.—U.S. Government tungsten materials inventories and objectives

(Thousand pounds, tungsten content)

Material	Objective	Inventory by program, Dec. 31, 1967			Total
		National (strategic) stockpile	DPA	Supplemental stockpile	
Tungsten ore and concentrate:					
Stockpile grade	35,785	[1] 67,823	47,776	3,352	118,951
Nonstockpile grade	------	46,723	15,328	1,153	63,204
Ferrotungsten:					
Stockpile grade	1,800	1,503	------	-----	1,503
Nonstockpile grade	------	638	------	-----	638
Tungsten metal powder, hydrogen reduced:					
Stockpile grade	1,600	1,077	------	-----	1,077
Nonstockpile grade	------	14	------	-----	14
Tungsten metal powder, carbon reduced:					
Stockpile grade	500	499	------	-----	499
Nonstockpile grade	------	171	------	-----	171
Tungsten carbide powder:					
Stockpile grade	2,000	869	1,080	-----	1,949
Nonstockpile grade	------	63	------	-----	63
Tungsten carbide, crystalline:					
Stockpile grade	1,100	------	------	-----	-------

[1] Includes 277,169 pounds, tungsten content, reserved for upgrading.

DOMESTIC PRODUCTION

Ore and Concentrate.—As a result of the Government's continuing disposal program, tungsten prices remained high and stabilized during 1967 and stimulated domestic mine production. Production as measured by mine shipments increased 2 percent. The stabilized tungsten market and the absence of significant amounts of tungsten concentrates from mainland China prompted the reactivation of several mines and the opening of at least one new mine. Of the 49 domestic mines which reported production and/or shipments of tungsten concentrates during 1967, only the Pine Creek mine of the Mining and Metals Division of Union Carbide Corp., near Bishop, Calif., and the Climax mine of Climax Molybdenum Co., a division of American Metal Climax, Inc. near Leadville, Colo., were operated continuously. Both of these mines obtained tungsten as a coproduct or byproduct. At Pine Creek, tungsten was the main metal value recovered along with minor amounts of molybdenum, copper, and gold. At Climax, molybdenum was the main metal value recovered while tungsten, tin, and pyrite were recovered as byproducts.

Intermittent tungsten production and shipments were also reported from Pima County, Ariz.; Fresno, Inyo, Kern, Madera, Riverside, San Bernardino, Tulare, and Tuolomne Counties, Calif.; Boulder and Lake Counties, Colo.; Custer and Valley Counties, Idaho; Beaverhead, Deer Lodge, and Silver Bow Counties, Montana; Churchill, Nye, and Pershing Counties, Nevada; Emery County, Utah; and Okanogan County, Wash. Because of the high elevation at some of these operations, production was limited to about 6 months per year when the mining areas were clear of snow.

Ranchers Exploration and Development Corp., Albuquerque, N. Mex., obtained an option from the Howmet Corp. to purchase the former Hamme tungsten mine near Henderson, N. C. This mine which contains proven and probable reserves of about 1 million tons of WO_3 ore, was closed February 14, 1963, and allowed to fill with water. Since the mill facilities were sold at auction, new milling equipment must be acquired and the mine is not expected to go onstream until late 1968.

Minerals Engineering Co. announced that, with assistance from the General Electric Co., it would reopen its Calvert Creek tungsten mine in Montana. In connection with this operation, the capacity of the mill will be increased to 250 tons per day (tpd) and a chemical plant will be constructed to process the concentrate to ammonium paratungstate. This operation is scheduled to go onstream in 1968 and most of the output will be shipped to General Electric.

Production at the Strawberry tungsten mine of the New Idria Mining & Chemical Co. near Bass Lake, Calif., which had been reopened in mid-1966 after increasing its mill capacity from 100 to 250 tpd, continued to be limited by heavy snows to only 5 to 6 months' operation during the year. A highway under construction in the area will extend to within 3 miles of the mine and permit expansion of the present limited operating season.

A 100-tpd concentrator was constructed by the Barrett Investment Co., which holds a sublease on the Salmon River Scheelite Corp. mine at Thompson Creek Canyon, Clayton, Idaho. Full production from this reopened mine was scheduled to begin early in 1967. Late in 1966, the mill, operating at 60 percent efficiency, concentrated some tungsten ores which were shipped to Union Carbide's Pine Creek mine for further processing.

W. R. Grace & Co. obtained an option to purchase the Silver Hill tin-tungsten prospect 4 miles south of Spokane, Wash., and conducted exploratory drilling of the property. A 150-tpd gravity concentrator that was built on the site in 1960 has been idle since 1962 but, it is believed

Table 3.—Tungsten concentrate shipped from mines in the United States

Year	Quantity			Reported value f.o.b. mines [1]		
	Short tons, 60 percent WO_3 basis	Short-ton units WO_3 [2]	Tungsten content (thousand pounds)	Total (thousands)	Average per unit of WO_3	Average per pound of tungsten
1963	5,657	339,402	5,384	$7,202	$21.22	$1.34
1964	9,244	554,676	8,798	11,251	20.28	1.28
1965	7,949	476,979	7,566	13,028	27.32	1.72
1966	8,912	534,727	8,482	17,620	32.95	2.08
1967	9,088	545,269	8,649	20,895	38.32	2.42

[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.

that with a minor amount of repair, the milling equipment can be used.

Buckeye Mining Co., Tulare County, Calif., announced plans to reactivate the company's Buckeye tungsten mine and to construct a plant to concentrate and process tungsten ore. During the year, Mines Exploration, Inc., reported production of tungsten concentrates from the company's Atolia tungsten mine, Atolia, Calif.

A new producer, Canyon Mining Co., Boulder, Colo., began mining tungsten in 1966 and operated at a capacity of about 1,500 short–ton units (approximately 24,000 pounds contained tungsten) per month.

Metal, Alloys, and Compounds.—Sylvania Electric Products, Inc., formally opened a new plant in Towanda, Pa., which is one of the largest facilities in the world devoted to manufacturing tungsten and molybdenum wire and which has a capacity to produce fine wire of 0.00015 inch diameter.

During the year, the Wah Chang Corp. was purchased by Teledyne, Inc., and became an operating subsidiary of that company.

M&R Refractory Metals, Inc. completed a new $1 million facility in Winslow, N.J., for the pyrometallurgical and chemical treatment of tungsten, molybdenum, and vanadium concentrates. This new facility will feed M&R's main plant in Springfield, N.J., which recently more than doubled its reduction facilities for the production of tungsten and molybdenum powder and pellets.

During 1967, Firth Sterling, Inc., began construction of a new chemical plant at West Elizabeth, N.J., to process ore to ammonium paratungstate and subsequently to hydrogen-reduced tungsten metal powder.

VR/Wesson Division, Fansteel Metallurgical Corp., announced plans to double capacity at its factory in Ferndale, Mich. A sintering facility will be installed for the manufacture of tungsten carbide inserts, blanks, rods and wear parts.

The ferroalloy producer, Mercer Alloys Corp., expanded its production facilities at Greenville, Pa., to include additional crushing and screening equipment, reaction vessels, and induction melting furnaces used in the preparation of ferrotungsten and nickel-base alloys.

To provide improved tungsten carbide products, Adamas Carbide Corp. completed a new quality control laboratory at its Kenilworth, N.J., plant.

The scrap tungsten carbide recovery plant of Shwayder Chemical Metallurgy Corp., Detroit, Mich., was enlarged to a capacity of 1 million pounds annually.

A new $4 million plant, laboratory, and office facility was being constructed by Metallurgical International, Inc., New Shrewsbury, N.J., to provide additional capacity to process tungsten and tungsten carbide powder by the company's "coldstream impact process."

CONSUMPTION AND USES

Tungsten carbide (WC) continued to represent the major individual end use of tungsten and accounted for 43 percent of the total consumption. Much of this was due to the increasing use of tungsten carbide as studs in snow tires, as balls in ballpoint pens, and in other wear resistant applications. Consumption of ferrotungsten, primarily in steels, represented 12 percent of the total consumption.

A unique lubricant commercially available from Miniature Precision Bearings, Inc., Keene, N.H., utilizes a modified 0.005-inch-thick, tungsten disulfide (WS_2) coating which is fusion bonded to solid metal surfaces. This increases the service life of the coated surfaces by a factor of at least three. Because the process involves no temperature curing it can be used on heat-treated components and fusion is achieved without the necessity of a carrier or adhesive.

Metco, Inc., Westbury, N.Y., developed a commercial plasma flame spraying technique with which a self-fusing, self-bonding, thin tungsten carbide coating could be applied to a variety of substrate surfaces.

Thin-wall, small-diameter tungsten tubing produced by vapor deposition of tungsten hexafluoride (WF_6) and designated GE–10, became available on a developmental basis from the General Electric Co., Euclid, Ohio. This tubing, which is virtually impossible to form by conventional fabrication techniques, can be made by vapor deposition in sizes from 0.060 to 0.750 inch outside diameter and in wall thickness from 0.004 to 0.040 inch.

Union Carbide Corp. developed an inexpensive continuous chemical process for producing fine tungsten wire which, while having the strength of drawn wire, possesses sufficient flexibility to allow the wire fiber to be woven. This "yarn" material is now commercially available.

Studebaker Corp. and Kennametal, Inc., both producers of tungsten carbide studs for use in snow tires, announced that Kennametal had signed a sublicensing agreement with Studebaker to manufacture tire studs under the original patent assigned to Kovametalli, Helsinki, Finland, and licensed to Studebaker. Studebaker also announced that it was dismissing its patent infringement action against Kennametal.

Several special reviews of tungsten were published that discussed and evaluated the supply–demand (consumption) patterns, and the high-temperature aerospace applications for this refractory metal.[2] Two

[2] Ruth, John P. Tungsten Section. American Metal Market, sec. 2, Jan. 29, 1968, 12 pp.;
———. Tungsten Section. American Metal Market, sec. 2, Mar. 20, 1967, 12 pp.;
———. Space Age Metals Section. American Metal Market, sec. 2, June 26, 1967, 24 pp.

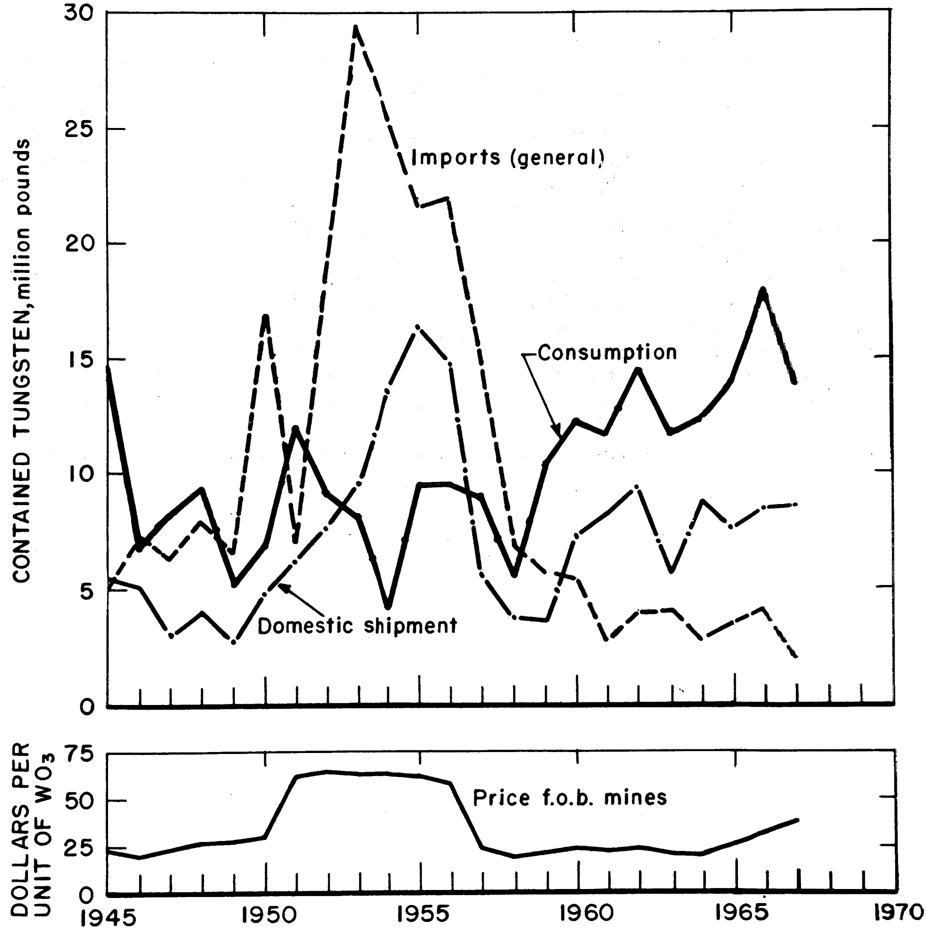

Figure 1.—Domestic shipments, imports, consumption, and average price of tungsten ore and concentrate.

detailed reports on ferroalloys were published that discussed the use of tungsten in alloy steels, and included a directory of free world companies in the ferroalloy industry, their products, programs, and capacities.[3]

PRICE AND SPECIFICATIONS

Throughout most of 1967 the world price of tungsten ore and concentrate as quoted in the Metal Bulletin (London) and in Metals Week remained near the GSA sales price of $43 per short–ton unit. This sales policy had the effect of stabilizing the tungsten price which previously had been subject to extremely wide fluctuations.

In the United States the price of tungsten ores and concentrate, 65 percent tungsten trioxide (WO_3), as quoted in Metals Week continued to remain at $43 (nominal) per short-ton unit, duty included, throughout the year. This price reflected the GSA "shelf" sales price announced March 9, 1966. There continued to be no quotations on tungsten concentrate produced domestically during the year. Quotations of the price of foreign concentrates, c.i.f. U.S. ports, 65 percent WO_3 basis, duty ($7.93 per s.t.u.) extra, which were discontinued in mid–March 1966 were also not reported in 1967.

The price of ammonium paratungstate delivered to contract customers ranged from $38 to $46 per short-ton unit during 1967 while ammonium paratungstate processed from GSA material reportedly sold for about $48.75 per short-ton unit.

The quoted prices of tungsten products increased only slightly during the year, reflecting the stable price of the concentrate starting material. Carbon-reduced tungsten metal powder (99.8 percent in 1,000-pound lots) continued to be quoted at the 1962–66 price of $2.75 per pound by Metals Week. The quoted price of hydrogen-reduced tungsten metal powder (99.99 percent) increased from $4.38 to $5.22 at the beginning of the year to $4.60 to $5.44 per pound at yearend. The domestic price of ferrotungsten sold by merchants was essentially unchanged during the year and ranged from $3.30 to $3.50 per pound of contained tungsten (in lots of 5,000 pounds or more, ¼-inch lump, packed, f.o.b. destination, continental United States, 70 to 80 percent tungsten). UCAR, Union Carbide's high-grade ferrotungsten, continued to be $2.03 per pound throughout the year.

[3] Metal Bulletin. Ferro-Alloys, A Metal Bulletin Special Issue. London, July 1966, 158 pp.
Metals Week. Ferro-Alloys—Review and Outlook. V. 38, No. 7, Feb. 13, 1967, pp. 13–36.

Table 4.—Production, shipments, and stocks of tungsten products in the United States

(Thousand pounds of contained tungsten)

	Hydrogen- and carbon-reduced metal powder	Tungsten carbide powder: Made from metal powder	Tungsten carbide powder: Crushed cast	Chemicals	Other [1]	Total [2]
1966:						
Received from other producers	5,304	100	16	4,975	1,798	12,193
Gross production during year	r 10,669	r 5,740	1,485	13,164	3,867	r 34,925
Used to make other products listed here	r 7,140	-----	-----	11,139	1,535	r 19,814
Net production	3,529	r 5,740	1,485	2,025	2,332	r 15,111
Shipments [3]	8,883	r 5,780	1,713	6,971	4,308	r 27,655
Producer stocks, December 31	2,160	r 294	23	1,415	768	r 4,660
1967:						
Received from other producers	4,953	48	-----	5,439	1,624	12,063
Gross production during year	9,256	5,549	1,256	11,606	3,243	30,910
Used to make other products listed here	6,725	-----	----	10,246	1,334	18,306
Net production	2,531	5,549	1,256	1,360	1,908	12,604
Shipments [3]	7,487	5,690	1,259	6,436	3,252	24,124
Producer stocks, December 31	2,125	201	18	1,777	1,047	5,168

r Revised.
[1] Includes ferrotungsten, tungsten carbide powder (crystalline), scheelite (produced from scrap), nickel-tungsten, self-reducing oxide, pellets, and scrap.
[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.

A report, submitted as a doctoral thesis, was published that discussed the economic implications behind the price fluctuations of tungsten.[4] A second report recommended the elimination of the U.S. import duty as a method of stabilizing the price of tungsten.[5]

[4] Barbier, Claude. La Formation Du Prix Du Tungstene Sur Le Marche Mondial (The Formation of the Price of Tungsten on the World Market). University of Paris, Paris, France, 1966, 294 pp.

[5] Belous, Walter T. The Tungsten Price Problem. M.B.A. Thesis, New York Univ., 1967, 121 pp.

Table 5.—Consumption of tungsten products, by end uses, in the United States in 1967

(Thousand pounds, contained tungsten)

	Ferro-tungsten melting-base-self-reducing tungsten, tungsten-sponge mix, etc.	Carbon reduced tungsten powder [1]	Hydrogen reduced tungsten powder [2]	Tungsten carbide powder [3]	Chemicals	Scheelite (natural or synthetic)	Scrap and other	Total [4]
Steel:								
High-speed steel	793	W	-----	-----	---	659	189	1,641
Hot-work-tool steel	168	---	-----	-----	---	417	18	603
Other	7	---	-----	-----	---	321	W	328
Alloy (other than tool steel) [5]	455	(6)	(6)	57	---	27	116	655
Gray and malleable castings	10	---	-----	-----	---	-----	40	50
High-temperature nonferrous alloys [7]	104	434	30	(6)	---	118	225	913
Other nonferrous alloys [8]	22	9	101	207	10	W	51	400
Tungsten metal: Wire, rod, sheet, other	(6)	3	1,681	29	4	-----	(6)	1,718
Carbides:								
Cemented and sintered	-----	---	521	4,009	---	-----	91	4,621
Other [9]	-----	250	284	471	---	-----	211	1,217
Chemicals [10]	-----	---	W	-----	164	-----	---	164
Unspecified	71	51	548	560	63	5	57	1,355
Total [4]	1,631	748	3,166	5,334	240	1,546	998	13,663
Stocks Dec. 31	338	99	486	808	106	206	475	2,518

W Data withheld to avoid disclosing individual company confidential data; withheld data included in unspecified.
[1] Includes tungsten metal pellets that may be hydrogen or carbon reduced or scrap.
[2] Does not include quantities consumed in making tungsten carbide powder.
[3] Includes tungsten carbide made from metal powder and crystalline and crushed cast.
[4] Data may not add to totals due to rounding.
[5] Includes stainless steel and other alloy steel.
[6] Less than ½ unit.
[7] Includes cutting and wear resistance materials.
[8] Includes welding rods, alloy hard facing rods and materials, copper and nickel-base alloys, metal to glass seal materials, electrical contact materials, electrical resistance alloys, and anodes.
[9] Includes diamond bit matrices or abrasives, hard facing rods and materials and cast carbide dies or parts.
[10] Includes inorganic and organic pigments fluorescent powder, catalysts, and other (specify).

Table 6.—Monthly price quotations of tungsten concentrate in 1967

Month	London market, shillings per long-ton unit of WO_3 60 percent basis — Wolfram and Scheelite: Low	High	Equivalent quotation, dollars per short-ton unit of WO_3: Low	High	Average [1]
January	330s	362½s	$41.25	$45.31	$43.28
February	352½	362½	44.06	45.31	44.68
March	342½	362½	42.81	45.31	44.06
April	325	350	40.63	43.75	42.19
May	325	362½	40.63	45.31	42.97
June	355	377½	44.38	47.19	45.78
July	365	377½	45.63	47.19	46.41
August	315	375	39.38	46.88	43.13
September	315	347½	39.38	43.44	41.41
October	325	352½	40.63	44.06	42.34
November	345	[2] 405	43.13	43.41	43.27
December	[2] 402½	[2] 422½	43.14	45.28	44.21

[1] Arithmetic average of weekly quotations. Average price $43.64; duty $7.93; average price, duty paid, $51.57.
[2] Result of devaluation of the pound (£) from equivalent of $2.80 to $2.40 by United Kingdom.

FOREIGN TRADE

Exports of tungsten concentrate during 1967, primarily to the Republic of South Africa (25 pecent), the Netherlands (24 percent), Japan (16 percent), and the United Kingdom (13 percent), increased substantially and represented material purchased from the GSA stockpile. Because official tungsten concentrate export statistics are reported only in gross weight, the tungsten content was estimated by multiplying the gross weight by a factor of 0.516 equal to 0.65 (to convert from 65 percent WO_3 basis) times 0.7931 (to convert from WO_3 to W basis). Reexports of tungsten ore and concentrate totaled 538,917 gross weight valued at $576,016 and were destined primarily for the United Kingdom (46 percent), Belgium and Luxembourg (31 percent), and Japan (23 percent). Ferrotungsten exports are no longer separately classified and data on these exports are not available.

Exports of unwrought tungsten metal and alloys in crude form, waste, and scrap, primarily to West Germany increased substantially in 1967 to 671,129 pounds gross weight, valued at $890,482 from the 196,005 pounds (gross weight) valued at $222,643 reported in 1966. Tungsten and tungsten alloy powder totaling 51,178 pounds gross weight valued at $236,515 was exported primarily to West Germany (45 percent) and Canada (20 percent) in 1967 compared with 40,021 pounds gross weight valued at $178,466 exported in 1966.

Tungsten and tungsten alloy wire exports, primarily to Canada (30 percent), Italy (29 percent), and Mexico (13 percent), increased to 36,450 pounds, gross weight, valued at $1,207,681, compared with the 30,264 pounds valued at $1,049,338 reported in 1966. Exports of wrought tungsten in 1967, primarily to Canada (39 percent), West Germany (22 percent), and France (11 percent), decreased to 44,310 pounds, gross weight, valued at $645,094 from the 55,237 pounds valued at $649,087 exported in 1966.

During the year general imports of tungsten concentrate decreased 48 percent and imports for consumption decreased 60 percent. As in the previous 3 years, there were no duty-free imports of tungsten ore and concentrate for the U.S. Government in 1967.

Imports of tungsten carbide during the year primarily from West Germany (32 percent), Sweden (31 percent), and Canada (25 percent), decreased to 1,766 pounds, tungsten content, valued at $9,368 from the 1966 imports of 3,768 pounds, tungsten content, valued at $16,970.

While there were no imports of semifabricated tungsten in ingots and shot in 1967, 20,100 pounds valued at $69,158, all from West Germany, was imported under this category in 1966.

Imports of tungsten waste and scrap containing over 50 percent tungsten decreased during the year and totaled 123,853 pounds, tungsten content, valued at $246,329, compared with the 244,085 pounds, tungsten content, valued at $363,077, imported in 1966. In 1967 this material came primarily from the Netherlands (23 percent), the United Kingdom (18 percent), France (14 percent), West Germany (12 percent), Brazil (9 percent), and Sweden (8 percent).

In 1967, imports of unwrought tungsten in lump, grains, and powder fell substantially to 8,932 pounds of contained tungsten valued at $54,169 from the 1966 figures of 47,255 pounds, tungsten content, valued at $153,355. These imports came primarily from Sweden (83 percent) and France (11 percent).

Imports of wrought tungsten during the year totaled 5,222 pounds valued at $275,947 primarily from Austria (50 percent), Japan (31 percent), and the Netherlands (14 percent). While the amount of these imports decreased substantially from the 39,790 pounds reported in 1966, the value was approximately 1.5 times greater than the $182,302 reported in 1966. This discrepancy was caused primarily by imports from the Netherlands which reportedly had an extremely high average value of almost $300 per pound.

During 1967, 10,731 pounds, tungsten content, of calcium tungstate valued at $77,884 was imported from the United Kingdom and West Germany. This represented a decrease from the 16,199 pounds, tungsten content, valued at $104,160 from the same sources reported in 1966.

Imports of material classified as "Other Metal-Bearing Materials in Chief Value Tungsten," during the year totaled 73,998 pounds, tungsten content, valued at

$59,448 and believed to represent primarily synthetic scheelite, were obtained from South Korea (85 percent), and Japan (15 percent). Imports under this classification in 1966 totaled 168,609 pounds, tungsten content, valued at $189,993 from South Korea (94 percent) and Portugal (6 percent).

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 in 1967.

In accordance with the Kennedy Round Tariff Negotiations which were completed during the year, the import duties on all forms of tungsten were to be reduced in stages by 50 percent over the 5-year period 1968–72. The reduced duties which became effective January 1, 1968, in the first stage of these tariff reductions are reported in table 12.

Table 7.—U.S. exports of tungsten ore and concentrates, by countries

(Thousand pounds and thousand dollars)

Country	1966			1967		
	Gross weight	Estimated tungsten content	Value	Gross weight	Estimated tungsten content	Value
Austria	(1)	(1)	$1	-----	---	-----
Belgium-Luxembourg	---	---	---	107	55	$161
Canada	---	---	---	16	8	13
France	119	61	98	153	79	247
Germany, West	48	25	62	127	66	262
Japan	2	1	9	304	157	393
Netherlands	---	---	---	458	236	749
South Africa, Republic of	---	---	---	477	246	744
Spain	1	(1)	2	-----	----	-----
United Kingdom	26	14	51	246	127	363
Total	196	101	223	1,888	974	2,932

[1] Less than ½ unit.

Table 8.—U.S. imports [1] of tungsten ore and concentrates, by countries

(Thousand pounds and thousand dollars)

Country	1966			1967		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Australia	784	455	$1,069	336	195	$508
Bolivia	1,211	680	937	156	90	206
Brazil	55	32	47	-----	-----	-----
Burundi and Rwanda	66	35	57	-----	-----	-----
Canada	1,772	996	1,076	739	463	871
Congo (Kinshasa)	167	90	145	132	68	138
Hong Kong	11	6	10	-----	-----	-----
Korea, South	756	430	686	560	316	639
Mexico	124	71	96	23	12	16
Netherlands [2]	99	58	85	-----	-----	-----
New Zealand	-----	-----	-----	20	11	35
Peru	1,059	606	1,207	635	369	848
Portugal	851	500	1,022	806	480	1,175
Sweden	4	2	3	-----	-----	-----
United Kingdom [2]	415	239	346	-----	-----	-----
Total	7,374	4,200	6,786	3,407	2,004	4,436

[1] Data are "general imports" that is, they include tungsten imported for immediate consumption plus material entering the country under bond.

[2] Represents transshipment, rather than country of origin.

Table 9.—U.S. imports for consumption of tungsten ore and concentrates, by countries

(Thousand pounds and thousand dollars)

Country	1966			1967		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Argentina	33	17	$34	-----	-----	-----
Australia	1,089	632	1,256	296	172	$445
Bolivia	1,038	623	871	156	90	206
Brazil	55	32	47	-----	-----	-----
Burma	26	14	42	-----	-----	-----
Burundi and Rwanda	66	35	57	-----	-----	-----
Canada	2,040	1,087	1,209	739	463	871
Congo (Kinshasa)	178	96	152	132	68	138
Hong Kong	11	6	10	-----	-----	-----
Korea, South	534	307	405	60	34	50
Mexico	144	73	149	23	12	16
Netherlands [1]	48	29	49	-----	-----	-----
New Zealand	-----	-----	-----	20	11	35
Peru	1,059	606	1,207	635	369	848
Portugal	851	500	1,022	806	480	1,175
Sweden	4	2	3	-----	-----	-----
United Kingdom [1]	415	239	346	-----	-----	-----
Total	7,591	4,298	6,859	2,867	1,699	3,784

[1] Represents transshipments, rather than country of origin.

Table 10.—U.S. imports for consumption of ferrotungsten, by countries [1]

(Thousand pounds and thousand dollars)

Country	1966		
	Gross weight	Tungsten content	Value
Austria	291	233	$362
France	79	64	148
United Kingdom	102	82	186
Total	472	379	696

[1] No transactions in 1967.

Table 11.—U.S. imports for consumption of tungsten or tungsten carbide forms

(Thousand pounds and thousand dollars)

Year	Ingots, shot, bars, and scrap		Wire, sheets, or other forms, n.s.p.f.		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1965	61	$83	26	$176	87	$259
1966	292	432	r 49	r 208	r 341	r 640
1967	138	246	5	277	143	523

r Revised.

Table 12.—U.S. import duties

(Per pound contained tungsten)

Tariff classification	Articles	Rate of duty [1]	
		Through Dec. 31, 1967	Effective Jan. 1, 1968
601.54	Tungsten ore (tungsten content)	$0.50 per pound tungsten (W).	$0.45.
603.45	Other metal bearing materials in chief value tungsten (tungsten content).	$0.42 plus 20 percent ad valorem.	$0.375 plus 18 percent ad valorem.
607.65	Ferrotungsten (tungsten content)	$0.42 plus 12.5 percent ad valorem.	$0.378 pus 11 percent ad valorem.
629.25	Waste and scrap containing by weight not over 50 percent tungsten (tungsten content).	do	Do.
629.26	Waste and scrap containing by weight over 50 percent of tungsten (tungsten content).	21 percent ad valorem.	18.5 percent ad valorem.
629.28	Unwrought tungsten, except alloys, in lump, grain, and powder (tungsten content).	$0.42 plus 25 percent ad valorem.	$0.37 plus 22.5 percent ad valorem.
629.29	Unwrought tungsten ingots and shot (tungsten content).	21 percent ad valorem.	18.5 percent ad valorem.
629.30	Unwrought tungsten, n.e.c. (tungsten content)	25.5 percent ad valorem.	22.5 percent ad valorem.
629.32	Tungsten alloys, unwrought, containing by weight not over 50 percent tungsten (tungsten content).	$0.42 plus 12.5 percent ad valorem.	$0.378 plus 11 percent ad valorem.
629.33	Tungsten alloys, unwrought, containing by weight over 50 percent tungsten (tungsten content).	25.5 percent ad valorem.	22.5 percent ad valorem.
629.35	Wrought tungsten (tungsten content)	do	Do.
416.40	Tungstic acid (tungsten content)	$0.42 plus 20 percent ad valorem.	$0.37 plus 18 percent ad valorem.
417.40	Ammonium tungstate (tungsten content)	do	Do.
418.30	Calcium tungstate (tungsten content)	do	Do.
420.32	Potassium tungstate (tungsten content)	do	Do.
421.56	Sodium tungstate (tungsten content)	do	Do.
422.40	Tungsten carbide (tungsten content)	$0.42 plus 25 percent ad valorem.	$0.378 plus 22 percent ad valorem.
422.42	Other tungsten compounds, n.e.c. (tungsten content).	$0.42 plus 20 percent ad valorem.	$0.37 plus 18 percent ad valorem.
423.92	Mixtures of two or more inorganic compounds in chief value tungsten (tungsten content).	do	Do.

[1] Not applicable to Communist countries.

WORLD REVIEW

The eight-member Working Group of the United Nations (U.N.) Committee on Tungsten met in New York City early in 1967 to prepare a report on the prevailing tungsten situation. The Working Group, consisting of representatives of Australia, Austria, Bolivia, Portugal, South Korea, Sweden, the United States, and West Germany, also reviewed the U.N. statistical bulletin, "Tungsten Statistics," which became available for general distribution on a quarterly basis in the fall of the year. Interested parties desiring to receive this publication should request it from the United Nations Committee on Trade and Development (UNCTAD), Distribution Section, Palais des Nations, Geneva, Switzerland. During September a meeting was held in Geneva to resolve problems associated primarily with tungsten consumption statistics. This meeting was attended by representatives and technical advisors from Australia, Austria, Canada, France, Italy, the Netherlands, Peru, Poland, Portugal, South Korea, Sweden, the United States, and West Germany.

Australia.—King Island Scheelite (1947) Ltd., on King Island approximately 50 miles northwest of Tasmania, continued an economic study on deepening its open pit operation compared with underground mining of the scheelite deposits which extend to a depth of 110 feet or more below sea level. Continued exploration confirmed the existence of some 1 million tons of additional scheelite ore containing approximately 1 percent WO_3.

Table 13.—World production of tungsten ore and concentrate, by countries [1]

(Thousand pounds of contained tungsten) [2]

Country	1963	1964	1965	1966	1967 [p]
North America:					
Canada [3]	------	840	2,964	3,318	NA
Guatemala	------	------	------	9	88
Mexico	36	8	192	150	214
United States (shipments)	5,384	8,798	7,566	8,482	8,649
South America:					
Argentina	174	64	152	174	236
Bolivia	2,300	2,106	1,912	3,760	3,494
Brazil	582	402	402	[e] 420	628
Peru	542	676	836	762	564
Europe:					
Austria	234	110	206	144	252
Portugal	1,698	1,854	1,724	2,096	2,428
Spain	154	40	46	102	166
U.S.S.R. [e]	11,000	11,400	12,600	13,000	13,600
Africa:					
Congo (Kinshasa)	212	244	224	198	116
Rwanda	14	156	288	432	340
South-West Africa, Territory of	228	198	178	186	NA
Tanzania	------	------	------	7	50
Uganda	2	------	50	74	84
Asia:					
Burma [e]	780	600	360	240	200
China	23,600	21,400	17,600	17,600	17,600
Japan	816	910	758	724	862
Korea:					
North [e]	4,200	4,200	4,720	4,720	4,720
South	5,798	5,698	4,698	4,530	4,464
Malaysia	------	------	------	4	25
Thailand	216	452	580	586	974
Oceania:					
Australia	1,706	1,768	2,090	2,322	2,108
Total [4]	59,676	61,924	60,146	64,040	61,862

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

[1] France, Sweden, and Yugoslavia are no longer tungsten producers. In addition the following countries also produce tungsten (only 1 to 15 short tons of contained tungsten yearly each): India, Hong Kong, Italy, Nigeria, Republic of South Africa, Southern Rhodesia, and New Zealand.

[2] Conversion factors: W to WO_3 equals 0.7931; in converting 60 percent WO_3 concentrate to W, multiply by 0.4758.

[3] Only producer was shut down in December 1966 and was reopened in December 1967.

[4] Total is of listed figures only; no undisclosed data included.

Storeys Creek Tin Mining Co. continued to recover wolframite and coproduct cassiterite at its mine in northeastern Tasmania. Approximately 0.5 ton of tin concentrate was obtained per ton of tungsten oxide in concentrate recovered.

The third and smallest producer, Aberfoyle Tin, N.L., also of Tasmania, recovered tungsten concentrate as a byproduct of tin mining.

Belgium.—Société Génèral de Belgique of Brussels was licensed by Metallurgical International, Inc., New Shrewsbury, N.J., to use Metallurgical's "coldstream impact process" on a pilot-plant basis and to represent Metallurgical International for tungsten carbide powder conversion sales in Europe.

Brazil.—The demand for tungsten both overseas and to meet domestic requirements resulted in increased activities at the Borborema area scheelite mines. The Brejui mine at Currais Novos produced 25 to 30 tons of tungsten concentrate containing 70 percent WO_3 per month and an extension of the Brejui mine at Barre Verde produced between 10 and 12 tons per month.

Canada.—Late in December 1966 an extensive fire destroyed the Flat River, Northwest Territories mill and other processing facilities of Canada Tungsten Mining Corp. Ltd. (CTMC), the sole Canadian tungsten producer. While reconstruction of the damaged facilities began promptly, CTMC was not expected to resume production before early 1968. All material shipped by CTMC during 1967 came from accumulated stocks.

France.—A new tungsten ore mining firm, La Société Minière d'Anglade was

Table 14.—World consumption of tungsten ore and concentrate, by countries [1]

(Thousand pounds, tungsten content)

Country	1963	1964	1965	1966	1967p
Actual consumption:					
Australia e	110	110	110	110	110
Austria	2 r 3,454	2 r 3,909	3,982	4,189	3,140
Canada	563	286	447	449	450
Japan	4,112	4,910	3,236	4,002	4,070
Portugal	246	651	433	341	370
United Kingdom	2 6,303	2 7,447	7,515	6,633	4,880
United States	11,061	12,311	13,868	r 18,058	13,860
Apparent consumption, including stock variations:					
France	2,517	1,846	2,636	3,038	2,320
Sweden	1,450	1,549	2,162	2,072	1,350
Apparent consumption, excluding stock variations:					
Argentina	3 13	r 59	117	147	180
Belgium-Luxembourg	13	2	44	90	55
Germany, West	4,024	4,992	6,266	5,467	4,410
Italy	141	106	15	42	45
Netherlands	26	79	319	574	290
Poland	3,623	3,124	2,721	r 3,430	2,900
Spain	502	139	150	r 194	125
Yugoslavia	33	350	198	134	135
Total	r 38,191	r 41,870	44,219	r 48,970	38,690

p Preliminary. e Estimate. r Revised.
[1] In addition, the following countries are known or believed to consume tungsten but specific data are not available: Brazil, Bulgaria, Chile, China (mainland), Czechoslovakia, Denmark, Finland, Germany (East), Hungary, India, Israel, Korea (North), Norway, Republc of South Africa, Rumania, Switzerland, and U.S.S.R.
[2] Apparent consumption.
[3] Actural consumption.
Primary source: United Nations Committee on Tungsten.

recently established in Toulouse for exploitation of a scheelite deposit at Salau, Ariége, in southern France. The deposit, which contains an estimated 500,000 tons of ore averaging about 1.81 percent WO_3, was first discovered in 1962.

Sté des Poudres Metalliques et des Alliages Spéciaux Ugine-Carbone, the French producer of tungsten carbide powder, entered an agreement with Nuove Utensileria Italiania (UA) to supply WC powder to the Italian company.

India.—A study of the tungsten occurrences in India indicated that while deposits were scattered throughout the country, the major productive deposits were located at Rewat Hill northeast of Jodhpur, at Agargaon south of Nagpur, and at the Chhendapathar Group northwest of Calcutta.[6] The Rewat Hill tungsten mine which was recently reopened is expected to yield approximately 50 tons of 66 percent WO_3 concentrate annually.

Korea, South.—Production of tungsten concentrate by the country's major producer, the Korea Tungsten Mining Co. Ltd. (KTMC), primarily from the Sangdong mine (81 percent), the Okbang mine (9 percent), the Talsong mine (3 percent), and the Wollak mine (2 percent), decreased as KTMC encountered lower grade ore.

Netherlands.—The facilities of the Arnhem tin smelter, operated by NV Hollandse Metallurgische Industrie Billiton, were expanded appreciably to provide more capacity for the processing and recovery of tungsten-containing raw materials. During 1967, the metal trading company, Grondmet NV, Rotterdam, began construction of a smelting plant in the port areas of Bergen-op-Zoom to refine imported tungsten residues and scrap.

New Zealand.—Although only about 15 tons of scheelite concentrate was mined from deposits in the Glenorchy district of Otago Province, the elevated prices during 1967 stimulated evaluation of the high-grade tungsten deposits of this and of the Macreas scheelite fields on South Island.

Peru.—Cerro de Pasco Corp. became the major Peruvian tungsten producer when its new concentrator and recovery unit began operation early in 1967. Built at Cerro's Mahr Tunnel plant, the new

[6] DeKate, Y. G. Tungsten Occurrences in India and Their Genesis. Econ. Geol., V. 62, No. 4, June–July 1967, pp. 556–561.

facilities process about 5,500 tons of silver-containing scheelite ore and recovered between 600 and 700 tons of tungsten concentrate per month. Ore is shipped to the plant over a 10-mile aerial tramway from the San Cristobal mine. Cerro also recovers about 250 tons of wolframite concentrate annually from its Morococha mine.

Portugal.—Beralt Tin and Wolfram Limited, the country's major tungsten producer, announced that it was stepping up underground mechanization in an aggressive development program to ease the continual labor problem.

Rhodesia, Southern.—The Tact scheelite mine operated by Rhodesian Selective Development Co. 10 miles north of Filabusi produced tungsten at a rate of 6 tons of scheelite concentrate per month when a second five-stamp mill began operation in 1967. A second scheelite operation, the Killarney mine in Filabusi, was reopened early in 1967 and produced between 3 and 4 tons of scheelite per month.

South Africa, Republic of.—Carbide Diamond Industries, Pty., became the country's fourth producer of tungsten carbide. Carbide entered into a 10-year licensing agreement with Adamas Carbide Corp., Kenilworth, N.J., in which Adamas will supply building plans, specialized equipment, technical aid, and ready-to-press tungsten carbide powders. The new tungsten carbide plant will be located in Cape Town.

South-West Africa.—Production of tungsten from the Brandberg West tin-tungsten mine of the South-West Africa Co., Ltd., continued during the year and the milled concentrates from this mine averaged about 34.20 percent tin and 18.31 percent WO_3.

Sweden.—A large high-grade scheelite deposit was discovered at Elgfalt near Kopparberg in Bergslagen province. A consortium comprised of Sweden's six largest steel producers was formed to conduct further exploration. It was expected that mining activities would begin in late 1967.

Turkey.—Although tungsten has been found in significant amounts in seven areas of Turkey, the only tungsten ore body of commercial significance was the deposit on the southern slopes of Mount Uladag, 60 miles from Istanbul, which reportedly contains approximately 10 million tons of scheelite ore averaging 0.42 percent WO_3.[7]

United Kingdom.—The Hard Metals Division, Wickman Wimet Ltd., Coventry, a fully integrated producer of tungsten carbide powder made from ammonium paratungstate, began construction of a new metal powder plant in 1967 which will allow the company to increase production of hydrogen reduced tungsten metal powder by 80 percent. Wickman used tungsten ores, residues, and reprocessed carbide scrap as starting material for the production of tungsten metal.

TECHNOLOGY

An English language translation of a Soviet book on the metallurgy associated with rare metals became available which described the mineralogy of tungsten, its properties and uses, methods of processing tungsten concentrates, methods of recovering and producing metallic tungsten, and methods of producing solid tungsten bars and sheet materials.[8]

Because tungsten and cobalt are major components in several superalloys that have been developed for uses requiring high-temperature hardness, strength, and resistance to oxidation and corrosion, continued studies of the tungsten-cobalt (W-Co) system were conducted by Bureau metallurgists. In one comprehensive investigation the W-Co phase diagram was refined, the solid solubility of cobalt in tungsten was found to be extremely low (maximum 0.9 atomic percent (a/o) cobalt), and the only intermediate phases determined were W_6Co_7 and WCo_3.[9] A second study of this system was conducted to determine the oxidation behavior of

[7] Bureau of Mines. Mineral Trade Notes. V. 64, No. 6, June 1967, pp. 24–29.

[8] Zelikman, A. N., O. E. Krein, and G. V. Samsonov. Metallurgy of Rare Metals. NASA Tech. Trans. F-359, U.S. Department of Commerce, Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., 1966, pp. 1–59.

[9] Neumeier, L. A., and J. L. Holman. The Tungsten-Cobalt System for Compositions to 85 Atomic Percent Cobalt. BuMines Rept. of Inv. 6956, 1967, 73 pp.

selected W-Co alloys.[10] Specimens of W-Co alloys containing 0.7, 1.7, 3.4, and 9.7 weight-percent Co developed WO_3 and $CoWO_4$ oxide coatings at a constant rate, indicating the formation of scales of constant porosity that were essentially independent of the cobalt concentration. A cobalt-rich outer scale of Co_3O_4 protected the tungsten, from further oxidation.

Bureau engineers continued studies of a significant method of preparing ultrafine, extremely homogeneous, and finely mixed tungsten-rhenium powders with closely controllable compositions by the hydrogen coreduction of the freeze-dried ammonium compounds obtained from an aqueous solution.

Investigations of vapor-deposited tungsten were continued as the significant effects of process variables on grain size, grain type, and microhardness were etsablished, and the optimum parameters and the efficacy for the vapor deposition process were determined.[11] Continuous deposition was successfully conducted at atmospheric pressure, a deposition rate of 2 mils thickness per square inch of substrate area per hour, a temperature of 550°C, and a hydrogen-to-WF_6 gas ratio of 4 to 1. During the vapor deposition of molybdenum-tungsten alloys dense, homogeneous Mo-W alloys were successfully codeposited from a gaseous mixture of hydrogen, molybdenum hexafluoride (MoF_6), and tungsten hexafluoride (WF_6) at temperatures between 650° and 750° C[12] Tungsten-rhenium alloys produced by vapor-deposition of mixed rhenium and tungsten hexafluorides showed significant nonhomogeneity due to the wide variation in optimum hydrogen-reduction temperatures of the two hexafluorides (250° C for ReF_6 and 550° C for WF_6).[13]

In other vapor-deposition studies methods of purifying the gaseous tungsten hexachloride (WCl_6) starting material to remove low-level metallic impurities were evaluated.[14] The purification techniques studied included distillation, fused-salt scrubbing, zone refining, and adsorption. Of these, fractional distillation and fused-salt scrubbing were found to be the best, resulting in a tungsten halide sample containing a total of less than 10 parts per million (ppm) detectable metallic impurities.

Using high energy-rate (Dynapak) techniques, compacted tungsten billets were successfully extruded into sound, high-density rods and sheet bars at reduction ratios of 6.25:1 and 9:1 at 1,800° C.[15] Yield strength obtained were higher than those of tungsten produced by conventional powder-metallurgy techniques, and considerable grain refinement was achieved by careful temperature control.

Tungsten-rhenium ingots and uranium dioxide-tungsten dispersions were also successfully compacted and formed by the Dynapak high-energy, high-velocity forming process.

Because of their excellent high-temperature, high-strength properties, tungsten and tungsten-base alloys were studied for use as structural materials and tungsten-uranium oxide alloys were studied for use as cladding materials in nuclear reactors by evaluating the effects of reactor environments such as nuclear radiation, corrosion, resistance, and compatibility with alkali liquid metal coolants on these materials.[16]

A process was successfully developed for recovering tungsten in the form of ammonium paratungstate (APT) from

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[10] Doerr, Robert M., L. A. Neumeier, and J. W. Jensen. Reaction of Tungsten-Cobalt Alloys With Oxygen at 1,000° and 1,100° K. BuMines Rept. of Inv. 6998, 1967, 22 pp.

[11] Berkeley, Jean F., Abner Brenner, and Walter E. Reid, Jr. Vapor Deposition of Tungsten by Hydrogen Reduction of Tungsten Hexafluoride: Process Variables and Properties of the Deposit. J. Electrochem. Soc., vol. 114, No. 6, June 1967, pp. 561–568.

Hoertel, F. W. Effect of Certain Process Variables on Vapor Deposited Tungsten. BuMines Rept. of Inv. 6731, 1966, 15 pp.

[12] Donaldson, J. G., and H. Kenworthy. Vapor Deposition of Molybdenum-Tungsten Alloys. BuMines Rept. of Inv. 6853, 1966, 12 pp.

[13] Harin, Jr., C. E. (assigned to the U.S. Atomic Energy Commission). Method for Depositing a Tungsten-Rhenium Metal Alloy on a Substrate. U.S. Pat. 3,343,979, Sept. 26, 1967.

Hoertel, F. W., and J. G. Donaldson. Rhenium and Rhenium Tungsten Deposition by Thermochemical Reduction of the Hexafluorides—A Preliminary Study. BuMines Rept. of Inv. 6915, 1967, 14 pp.

[14] Skirvin, F. A., T. T. Campbell, and F. E. Block. Purification of Tungsten Hexachloride. BuMines Rept. of Inv. 6984, 1967, 17 pp.

[15] Croeni, Jack G., John S. Howe, Jr., and H. Kato. High-Energy-Rate Extrusion of Low-Density Tungsten Powder Billets. BuMines Rept. of Inv. 6817, 1966, 12 pp.

Croeni, Jack G., John S. Howe, Jr., and H. Kato. High Energy-Rate Forging and Extrusion and the Effect on Structure and Properties. BuMines Rept. of Inv. 6757, 1966, 31 pp.

[16] U.S. Atomic Energy Commission. Fundamental Nuclear Energy Research—1967. January 1968. 368 pp.

low-grade tungsten concentrates by solvent extraction and methods were developed for recovering extremely pure tungsten metal by electrowinning.[17]

[17] Churchwood, P. E., and D. W. Bridges. Tungsten Recovery From Low-Grade Concentrates by Amine Solvent Extraction. BuMines Rept. of Inv. 6845, 17 pp.
Gomes, John M., Kenji Uchida, and Don H. Baker, Jr. Electrowinning Tungsten in Halide and Phosphate Electrolytes. BuMines Rept. of Inv. 6742, 1966, 9 pp.
Gomes, John M., Kenji Uchida, and Don H. Baker, Jr. Electrolyte Life in Winning Tungsten From Scheelite. BuMines Rept. of Inv. 6805, 1966, 9 pp.

Uranium

By Charles T. Baroch [1]

Uranium ore production showed the first increase since 1961; however, the ore grade was lower and an increase in ore stockpiles and uranium in process more than absorbed the increase, leaving the mill output of concentrates at its lowest since 1960. Public utility companies continued a trend started in 1965 and ordered or planned 30 nuclear powerplants with a capacity of 24,424 megawatts (Mw) compared with 21 plants with a capacity of 16,709 Mw in 1966. When completed, 89 plants will have a capacity of almost 60,000 Mw, compared with 2,810 Mw operable on December 31, 1967. These reactors will not be completed until the period 1970–75, hence increased demand for uranium will not be felt appreciably before 1970, although contracts for substantial quantities of uranium concentrate (U_3O_8) were made for future delivery.

The rising need for electric power, which appears to be doubling about every 11years (nearly twice the rate of the entire energy market), and the sudden acceptance of nuclear powerplants, caused the Atomic Energy Commission (AEC) to revise upwards by about 50 percent their 1966 estimates of 1980 uranium requirements. Their 1967 estimate was for a range of 120,000 to 170,000 Mw of installed nuclear power by 1980, leading to an annual requirement which might be in the range of 35,000 to 40,000 tons of U_3O_8 and a cumulative requirement through 1980 of about 250,000 tons of U_3O_8.

The prospect of steeply rising demand, inspired an increase in prospecting. Surface exploration and development drilling rose to a new high for the industry in 1967, reaching a total of 10.8 million feet, compared with the previous high of 9.2 million feet in 1957. The price trend also stiffened appreciably during the year. U_3O_8 concentrates, which sold as low as $4 per pound in 1965, rose to a range of $6 to $7 per pound. Unless economic breeder reactors or more efficient converter reactors are developed by the early 1980's, many experts believed that a shortage of low-cost uranium may develop around the turn of the century.

Table 1.—Salient uranium statistics

(Short tons)

	1963	1964	1965	1966	1967
United States:					
Mine ore shipments	5,613,570	5,359,653	4,385,995	4,352,651	5,276,038
Concentrate (U_3O_8 content):					
AEC procurement	14,218	11,847	10,442	r 9,487	8,425
Private industry sales e	---------	---------	---------	r 100	700
Imports: Concentrate (U_3O_8)	8,802	5,297	2,650	2,049	1,309
Free world:					
Production (U_3O_8 content)	31,025	26,782	21,115	18,993	p 17,458

e Estimate. r Revised. p Preliminary.

Legislation and Government Regulations.—AEC contracted with milling companies serving isolated areas for the purchase in 1967 and 1968 of concentrate derived from ores produced at eligible small mining properties which were not served by mills having a stretchout contract through 1970. This provided a market for small operators

[1] Commodity specialist, Division of Mineral Studies.

whose annual allocations were less than 20,000 pounds of U_3O_8 and that had produced and delivered ore to a mill during the 1962–66 period. Many small mines and a few mills thus were enabled to stay in business, pending the development of private sales of uranium.

In 1967 the Congressional Joint Committee on Atomic Energy held public hearings on radiation exposure of uranium miners. High concentrations of daughter decay products of radon, itself a decay product of the ever-present radium, can often be found in underground mines having poor ventilation. Miners who have worked in such areas reportedly have a higher incidence of lung cancer than that of the general population. AEC, the Bureau of Mines, and the Public Health Service joined in a cooperative research and development effort each, respectively, to improve surveillance-monitoring equipment; improve mine air and personal protection; and conduct epidemiological studies and study the bioeffects of alpha radiation. The Federal Radiation Council (FRC), an advisory body to the President on radiation matters, recommended guides for radiation protection in underground mines which the President approved.[2] These guides established exposure levels that shall not exceed those which a worker would receive at the working level if, in any 12 consecutive months of employment, he were exposed to 3.6 months of 40-hour workweeks at such level. The working level was defined as an environment which exposes the worker to the equivalent of 100 picocuries of radon per liter of air (100 pc/1).[3]

AEC established a set of policies that will be followed after 1968: (1) on the schedule of charges for lease and sale of enriched uranium, the natural uranium component will continue to be based upon a price of $8 per pound of U_3O_8 in concentrate, at least through June 30, 1973; (2) toll enrichment will be the preferred method of distributing enriched uranium; (3) beginning January 1, 1971, enriched uranium on lease may be converted to private ownership by toll enriching, under which the lessee would furnish to AEC the specified quantities of uranium feed and pay certain charges, thereby acquiring ownership of the leased material; and (4) the transition to private ownership of all material held by licensees for power reactor use will be accomplished by AEC terminating the distribution of such material on December 31, 1970, and terminating outstanding leases for such material on June 30, 1973. AEC also established a policy of toll enriching only domestic ore for domestic users, but stated that it would remove the restriction on foreign uranium for domestic use as soon as they had reasonable assurance of the viability of the domestic uranium industry as a whole, possibly some time after 1970.

Toll enrichment is a service by which a customer delivers privately owned uranium to AEC, pays for the enrichment services desired, and receives an appropriate quantity of uranium containing the higher concentration (enrichment) of the fissionable isotope, U^{235}. AEC established criteria for toll enrichment services and use charges in 1966 and 1967. Among other things, AEC agreed to sign contracts for specified periods of time up to 30 years and established a toll enrichment charge for privately owned uranium of $26 per kilogram unit of separative work, which is a measurement of the work done, not a quantity of material. At the same time, the AEC lowered the tails assay of U^{235} in the depleted uranium to 0.2 percent, from the former figure of 0.2531 percent. This means that lesser quantities of feed material (natural uranium) will be used as the 0.2 percent tails assay will require about 5.5 pounds of fresh feed material to produce 1 pound of 3 percent enriched uranium, whereas the tails assay of 0.2531 percent would have required about 6 pounds of feed.[4]

AEC signed its first contract to provide toll enrichment services for a reactor in a foreign country. The 30-year contract with Oskarshamnsverkets Kraft Grupp Aktiebolag is for a 400-Mw boiling-water reactor being built in Sweden. During the contract period approximately 10,000 kilograms of U^{235}, contained in slightly enriched uranium, will be required.

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[2] Federal Radiation Council. Guidance for the Control of Radiation Hazards in Uranium Mining. Report No. 8 (revised), September 1967, 60 pp.

———. Radiation Protection Guidance for Federal Agencies. 32 F.R. 11183, Aug. 1, 1967.

[3] Dworshak, Henry. Radiation Standards Set for Uranium Mining. Min. Cong. J., v. 53, No. 6, June 1967, pp. 88–89.

Mining Congress Journal. Radiation Protection Guides Approved by President. V. 53, No. 8, August 1967, p. 111.

[4] Atomic Energy Commission. Uranium Enrichment Services. F.R. 16478, Dec. 23, 1966.

———. Plutonium and Uranium Enriched in U^{235}. F.R. 16289, Nov. 29, 1967.

AEC approved agreements in 1967 with Louisiana and Arizona under which these States assume part of the regulatory authority over the uses of radioactive materials within their borders. This brings to 17 the total of States with which similar agreements exist. Others are Alabama, Arkansas, California, Florida, Kansas, Kentucky, Mississippi, Nebraska, New Hampshire, New York, North Carolina, Oregon, Tennessee, Texas, and Washington. Other States were moving toward similar agreements.

DOMESTIC PRODUCTION

Mine and Mill Production.—Approximately 500 mining operations in 8 States produced nearly 5.3 million tons of ore, 21 percent more than was produced by 600 operations in 12 States in 1966. New Mexico led by producing 54 percent of the total recoverable uranium; followed by Wyoming, 23 percent; Colorado, 12 percent; and Utah, 6 percent. The average ore grade dropped to 0.20 percent U_3O_8 from 0.23 percent in 1966.

Uranium ore was processed at 16 mills which shipped to AEC concentrates containing 8,450 tons of U_3O_8, compared with

Table 2.—Uranium mine and mill production in 1967, by States

State	Ore shipped				Concentrate purchased by AEC	
	Short tons	Value (thousands)	Recoverable U_3O_8, content			
			Percent	Thousand pounds	Number of mills	U_3O_8, thousand pounds
Arizona	15,723	$350	0.28	83	--	------
Colorado	615,585	10,803	.22	2,537	4	1,680
New Mexico	2,754,225	43,298	.21	11,202	4	9,395
Utah	254,538	5,505	.26	1,287	--	------
Wyoming	1,345,919	16,829	.18	4,655	5	3,410
Other States [1]	290,048	3,665	.15	889	3	2,365
Total	5,276,038	80,450	.20	20,653	16	16,850

[1] Ore shipments: North Dakota, South Dakota, and Texas. Concentrates: South Dakota, Texas, and Utah.

Table 3.—Uranium ore-processing plants, December 31, 1967

State and company	Plant location	Tons U_3O_8 deliverable to AEC under contracts, 1968–70
Colorado:		
American Metal Climax, Inc	Grand Junction	------
Cotter Corp	Canon City	------
Union Carbide Corp	Rifle	2,660
Do	Uravan	
New Mexico		
The Anaconda Company	Bluewater	2,220
Homestake-Sapin Partners	Grants	[1] 6,200
Kerr-McGee Corp	do	4,470
Foote Mineral Co	Shiprock	990
South Dakota: Mines Development, Inc	Edgemont	------
Texas: Susquehanna-Western, Inc	Falls City	-----
Utah: Atlas Corp	Moab	2,590
Wyoming:		
Federal-Radorock-Gas Hills Partners	Gas Hills	1,040
Petrotomics Co	Shirley Basin	--------
Union Carbide Corp	Gas Hills	560
Utah Construction & Mining Co	do	1,580
Western Nuclear, Inc	Jeffrey City	1,570

[1] Includes 2,930 tons under contract to United Nuclear Corp., which is treated in the Homestake-Sapin Partners mill under a tolling agreement.

9,487 tons in 1966. For the second year, uranium in significant quantities was sold to private industry. It was estimated that 700 tons was sold in 1967 compared with 100 tons in 1966. Contracts for future deliveries of 46,500 tons of U_3O_8 were announced by domestic producers, some to be implemented as far into the future as 1977.

Contracts for delivery of concentrates to AEC were in effect with 10 companies operating 11 mills which, under the stretchout program, permitted deliveries aggregating 23,880 tons of U_3O_8 through 1970. The other five mills operated largely to fill private orders, although some produced concentrate for AEC from ore mined by eligible small mining companies, Most of the milling companies negotiated contracts during 1966 and 1967 to supply uranium concentrates to reactor manufacturers and public utilities. Delivery on these contracts will start between 1968 and 1970 and some will extend through 1975.

Kerr-McGee Corp., the largest uranium producer, began developing its sixth underground uranium mine in the Ambrosia Lake area near Grants, N. Mex., and it was scheduled for production in 1969. Petrotomics Co. awarded a $1.5 million contract to double the size of its Shirley Basin mill to 1,000 tons per day. Western Nuclear, Inc., began engineering studies to develop a mining and milling system for uranium ore deposits on the Spokane Indian Reservation where 10 million pounds of U_3O_8 were outlined by drilling. A 3,000 to 4,000-ton-per-day operation was the ultimate goal. Mining of uraniferous lignite in Harding County, S. Dak., ceased as the operation was no longer profitable. Mining of sandstone ores also declined, and Mines Development, Inc., a subsidiary of Susquehanna Corp., conducted extensive exploration in the Dakotas and Wyoming in an effort to find additional ore for their mill. The plan of Continental Mining & Milling Co. to reactivate the Lakeview, Oreg., mill of Lakeview Mining Co., reported in 1966, failed to materialize. Cotter Corp. purchased the Schwartzwalder uranium mine near Golden, Colo., and reopened its mill in 1966 to fulfill contracts with several domestic and one foreign user. Foote Mineral Co. acquired the Vanadium Corporation of America including the uranium operations near Shiprock, N. Mex.

The upsurge in commercial sales of uranium and higher prices caused a great increase in exploration activity beginning in 1966. Surface exploration and development drilling totaled 10.8 million feet in 1967, up from 4.2 million in 1966, and set a new record since 1957 when the industry drilled 9.2 million feet. After 1957 drilling declined steadily to slightly over 2.0 million feet in 1965. The 1967 total was about equally divided between exploration for new deposits and development drilling. Almost 55 percent was conducted in Wyoming, 23 percent in New Mexico, 7 percent in Colorado, and the balance in Texas, Utah, Arizona, California, Nevada, Oregon South Dakota, and Washington. Prospecting was also vigorous and thousands of claims were filed, particularly in Wyoming and Utah.

Several Canadian mining companies became active in the Western United States. Rio Algom Mines Ltd. was exploring in Utah and Wyoming with Mitsubishi Metal Mining Co. Ltd., and both Faraday and Denison examined properties in Colorado.

Refining and Enrichment.—AEC production of enriched uranium continued at a reduced rate. The level of electric power usage at the Portsmouth, Ohio, gaseous diffusion plant was reduced by 320,000 electrical kilowatts (ekw), as part of the plan to reduce total power usage at the three gaseous diffusion plants (Oak Ridge, Tenn., Paducah, Ky., and Portsmouth, Ohio) to 2 million ekw by January 1, 1969. The "D" plutonium production reactor at Hanford, Wash., was shut down in June 1967 after 22 years of operation, the fifth to be shut down since 1964. The remaining reactors, four each at Hanford and Savannah River, set new records for operating efficiency. In addition to weapon-grade plutonium, these reactors produced significant quantities of nondefense plutonium, U^{233}, and many special isotopes. AEC announced that two more reactors, one each at Hanford and Savannah River, will be shut down in 1968.

Allied Chemical Corp., Metropolis, Ill., owned the only commerical plant for converting U_3O_8 into gaseous uranium hexafluoride, UF_6, the compound required in gaseous diffusion plants for producing uranium enriched in U^{235}. The plant, closed in 1964 was maintained in a state of readiness and in 1967 Allied began construction to double its size to an ultimate capacity in 1969 of 10,000 tons of U_3O_8 per year. Kerr-McGee Corp. also initiated plans for a UF_6 conversion plant to be ready in 1970 with a capacity of 5,000 to 10,000 tons of U_3O_8 annually. Both General Electric Co. and Westinghouse Electric Corp. had plants for fabricating nuclear fuel elements but announced plans for new ones. General Electric operated its facility at San Jose, Calif., and started construction on a new plant on a 1,600-acre site near Wilmington, N.C.[5] Westinghouse fabricated fuel elements at its plant at Cheswick, Pa., and was doubling capacity there. In addition, the company broke ground for a new $20 million facility at Columbia, S.C., planned for operation in 1969. Both companies stated that the large volume of new orders for nuclear plants had strained the capacities of their fabrication facilities.

CONSUMPTION AND USES

Practically all uranium production went to the AEC stockpile and unspecified quantities were used for producing special nuclear materials for military and civilian programs.

Weapon and Explosives Applications.—Plutonium production continued at both the Hanford Works, Richland, Wash., and the Savannah River plant, near Aiken, S.C., at a slightly lower rate. The "N" reactor at Hanford performed satisfactorily as the first dual-purpose—plutonium production and electricity generation—reactor. It produced over 2 million megawatt (Mw) hours of electricity in spite of being shut down from September 1 through December 15 as a result of a strike.

A total of 25 underground nuclear-explosion tests were announced in 1967, compared with 40 in 1966. In addition a nuclear explosive was detonated 4,240 feet deep in the San Juan basin of New Mexico as part of Project Gasbuggy. A segment of the Plowshare Program, designed to test the application of nuclear explosives to peaceful uses, Gasbuggy was expected to stimulate gas flow in a tight rock formation.

Civilian Reactors.—The trend by electric utilities toward nuclear powerplant installations, which started late in 1965, continued in 1967 at an accelerated rate. As the result of technical improvements which made nuclear power generation competitive with other power sources, commitments for the construction of nuclear plants increased beyond expectations and were much greater than was foreseen when AEC made its 1962 report to the President. This report predicted that 40,000 Mw of nuclear power would be installed by 1980, The estimate was revised in 1964 to a range of between 60,000 and 90,000 Mw and again in 1966 to a range of 80,000 to 110,000 Mw. The continuing high rate of commitments caused AEC in 1967 again to revise upward its forecast. The new projection was for a range of 120,000 to 170,000 Mw in 1980, with the most likely figure near the middle of the range. During 1967, electric utilities made known plans for 32 nuclear power plants, compared with 28 in 1966. Actually ordered in 1967 were 30 plants with a total capacity of 24,424 Mw, compared with 21 plants with a total capacity of 16,709 Mw in 1966.

Table 4 is a summary of all domestic nuclear powerplants announced to the end of 1967, arranged by groups according to the anticipated startup year. From this arrangement, the future annual demand for uranium can be estimated, as present reactor types require for the initial charge from 0.6 to 0.9 ton of U_3O_8 (as concentrate) per Mw of electrical capacity. Uranium concentrates need not be purchased until approximately 1 year before planned startup time. Thus, since it requires from 3 to 6 years to complete a reactor after a contract is awarded, uranium producers can quite accurately predict future demand for several years ahead. After a few years, makeup requirements, ranging from 0.11 to 0.20 ton of U_3O_8 per Mw-year of operation, also will have to be considered.

Many contracts for future delivery of U_3O_8 were made in 1966 and 1967. Approximate total tonnage of such contracts with the years of delivery were as follows:

Year	*Tons* U_3O_8	*Year*	*Tons* U_3O_8
1968	4,900	1972	7,900
1969	5,000	1973	6,200
1970	5,900	1974	4,400
1971	7,200	Later	4,200
		Total	45,700

In addition to the above, 2,400 tons was contracted for delivery to foreign buyers.

The 16 operable plants, most of which are relatively small powerplant prototypes,

[5] American Metal Market. General Electric Building Atomic Fuel Plant in Wilmington, N.C. V. 74, No. 120, June 23, 1967, p. 12.

Table 4.—Status of central-station nuclear powerplants, December 31, 1967

Plant status	Number of plants	Electrical capacity, Mw	Startup year
Operable	16	2,810	1957–67
Under construction	3	1,824	1968
Do	4	2,651	1969
Do	8	5,234	1970
Under construction and planned	16	12,119	1971
Planned and ordered	11	9,086	1972
Do	12	10,393	1973
Do	7	5,561	1974–77
Planned but not ordered	12	10,100	1974–?
Total	89	59,778	

produced 7.2 billions of kilowatt-hours of electricity during 1967, compared with 5.5 billions of kilowatt-hours produced by 14 plants in 1966. Seven plants started producing electricity in 1966 or 1967. All, except the "N" Reactor, were built under the AEC Power Reactor Demonstration Program in which AEC and industry share the costs. Brief descriptions and highlights of the newest reactors follow:[6]

1. AEC's "N" Reactor, Richland, Wash., produced its first electricity in April 1966 and reached full power (800 Mw) in December. The byproduct steam of this production reactor is provided to a generating station operated by Washington Public Power Supply System. The failure of a high-voltage transformer the day after reaching full-power level, made it necessary to reduce power output to 400 Mw.

2. Pathfinder Atomic Power Plant, Northern States Power Co., Sioux Falls, S. Dak., a 59Mw boiling-water reactor, produced its first electricity July 1966 and reached design power in September 1967. The plant shut down in October because of broken vanes in a steam separator.

3. Enrico Fermi Atomic Plant, Power Reactor Development Co., Lagoona, Mich., a 61–Mw fast-breeder reactor, started producing electricity in August 1966 but closed down in October 1966, because of a fuel failure. A piece of zirconium sheathing, part of a conical flow guide, fell from place and plugged a coolant channel, causing overheating and meltdown ot several fuel subassemblies.

4. Peach Bottom Atomic Power Station, Unit 1, Philadelphia Electric Co., Peach Bottom, Pa., a 40–Mw high-temperature gas-cooled reactor, produced electricity January 1967 and reached full power in May 1967. The fuel core contains thorium, and it is the first nuclear power system to achieve the high-efficiency steam conditions of 1,000° F and pressures up to 1,450 pounds per square inch. By yearend, the plant had operated for more than 158 days at full-power equivalent. Data from this plant will be used to design a 330–Mw reactor at Fort St. Vrain, Colo., to be built for the Public Service Company of Colorado.

5. San Onofre Nuclear Generating Station, Southern California Edison and San Diego Gas & Electric Co., San Clemente, Calif., a 430–Mw pressurized-water reactor, started producing electricity in July 1967 and reached an output of 405 Mw by December 26.

6. Connecticut Yankee Atomic Power Plant, Connecticut Yankee Atomic Power Co., Haddam Neck, Conn., a 462–Mw pressurized-water reactor, first produced electricity in August 1967 and reached full power in December.

7. La Crosse Boiling-Water Reactor, Dairyland Power Cooperative, Genoa, Wis., 50 Mw, started producing electricity in December 1967, and at yearend it had been operated at power levels up to 12.5 Mw. Startup tests should be completed by March 1968.

The Carolinas-Virginia Tube Reactor at Parr, S.C., was closed down in June 1967. This 17–Mw heavy-water prototype powerplant had operated as a training and research facility since 1963. The Hallam Nuclear Power Facility, Hallam, Nebr., which was shut down in 1964, was ordered to be decontaminated and dismantled. This was a sodium-cooled, graphite-moderated reactor prototype of 75–Mw capacity. Tech-

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[6] U.S. Atomic Energy Commission. Annual Report to Congress for 1967—Major Activities in the Atomic Energy Programs. January 1968, pp. 71–97; 325–339.

nical problems proved to be excessive and AEC discontinued pursuing this reactor concept. Much was learned from this reactor, and the information gained has been applied to improving the reliability and performance of other sodium-cooled reactors. The Southwest Experimental Fast Oxide Reactor at Cove Creek, Ark., to be used for research on fast-breeder reactors and planned for operation in 1968, is a good example.

The Piqua (Ohio) Nuclear Power Facility, an 11-Mw heavy-water, organic-cooled reactor, (HWOCR) was inoperative during 1967 because of technical problems. AEC terminated its contract for the operation of Piqua in December 1967, and it was uncertain whether or not the cooperating agency, the City of Piqua, would resume operation on its own.

The Tennessee Valley Authority (TVA) completed a detailed study of costs of coal-fired and nuclear powerplants, based on twin units totaling around 2,000 Mw.[7] The estimated costs of power were 2.39 mills per kilowatt-hour for a boiling-water reactor plant, 2.56 mills for a pressurized-water reactor plant, and 2.90 mills for a coal-fired plant. As a result TVA ordered twin units of the boiling-water reactor plant, each with a capacity of 1,064 Mw, to be ready for operation in 1971 and 1972.

Allis-Chalmers Manufacturing Co. withdrew from the nuclear-reactor field in 1966, leaving The Babcock & Wilcox Co., Combustion Engineering Co., and Westinghouse Electric Corp. (pressurized-water reactors); General Electric Co. (boiling-water reactors); and Gulf General Atomic, Inc. (high-temperature gas-cooled reactors) as the principal domestic builders of complete nuclear reactor plants. These and other principal firms engaged in major segments of the nuclear-fuel business are listed in table 5. The General Atomic Division of General Dynamics Corp. became a wholly owned subsidiary of the Gulf Oil Corp. in 1967, and its name was changed to Gulf General Atomic, Inc. North American Aviation, Inc., and Rockwell-Standard Corp. merged in 1967 to form the North American Rockwell Corp., and Atomics International is now an operating division of the new company.

Military Reactors.—Of 107 nuclear-powered submarines authorized by Congress, 74, including all 41 Polaris missile-launching types, were in operation. The aircraft carrier *Enterprise*, the guided-missile cruiser *Long Beach*, and the guided-missile frigates *Bainbridge* and *Truxton* (commissioned May 1967), were in operation and aggregated over 10 million miles of travel without a failure in the reactor plant. The Navy's next attack aircraft carrier, the *Nimitz*, will have the highest powered reactors developed so far in the naval reactors program, and will be able to steam for 13 years without refueling.

Reactors for Export.—U.S. firms had contracts for eight other reactors being built throughout the world. Locations are at Tarapur, India (380 Mw); Tsuruga, Japan (310 Mw); Niu, Japan (340 Mw); Fatuba, Japan (440 Mw); Zorita, Spain (153 Mw); Santa Maria de Garona, Spain (440 Mw); Beznau, Switzerland (350 Mw); and Bern, Switzerland (306 Mw). Most of these were planned for operation by 1970.

[7] Tennessee Valley Authority. Comparison of Coal-Fired and Nuclear Power Plants for the TVA System. June 1966, 36 pp.

Table 5.—Principal producers and fabricators of nuclear fuels

Company and principal location	Producers of uranium fuels	Fabricators of uranium fuels	Plutonium capability
Aerojet General Nucleonics, San Ramon, Calif	----------	X	----------
Atomics International, Canoga Park, Calif	----------	X	X
The Babcock & Wilcox Co., Lynchburg, Va	----------	X	X
Combustion Engineering, Inc., Windsor, Conn	----------	X	----------
Gulf General Atomic, Inc., San Diego, Calif	X	X	----------
General Electric Co., San Jose, Calif	X	X	X
Kerr-McGee Corp., Oklahoma City, Okla	X	----------	----------
National Carbon Co., Lawrenceburg, Tenn	X	----------	----------
National Lead Co., Albany, N.Y	X	X	----------
Nuclear Fuel Services, Inc., Erwin, Tenn	X	X	X
Nuclear Materials & Equipment Corp., Apollo, Pa	X	X	X
United Nuclear Corp., New Haven, Conn	X	X	X
Westinghouse Electric Corp., Pittsburgh, Pa	----------	X	----------

Source: AEC, The Nuclear Industry 1967, Nov. 6, 1967, pp. 45–47.

Two other reactors were in the planning stage for 1972 operation: Unit 2 at Niu, Japan (500 Mw), and Unit 2 at Beznau, Switzerland (350 Mw).

A total of 52 test, research, and teaching reactors, built by U.S. firms, were operable throughout the free world, and 4 others were being built.

Radioisotopes.—Although AEC was still a principal domestic producer and distributor of radioisotopes, it withdrew from the routine production and sale of 20 radioisotopes in 1966 and 1967 and a total of 37 since 1961. AEC ceases production when radioisotopes became available from private industry. Late in 1967 AEC proposed to withdraw from the production and distribution of cobalt-60 of 45 curies per gram specific activity or less. General Electric Co. was said to have production capacity of at least 1 million curies annually and Neutron Products, Inc., a capacity of about 2 million curies of cobalt-60 annually. AEC sold 2.3 million curies of cobalt-60 in 1967, valued at $422,000, and will continue to meet requirements on a custom order basis in minimum quantities of 100,000 curies, when the purchaser certifies need for material that is not commercially available. A total of over 3.1 million curies of radioisotopes was distributed by Oak Ridge National Laboratory during the first 11 months of 1967, an increase of about 27 percent over the same 1966 period. The final packaging and distribution was performed almost entirely by industry, and the total domestic market in 1967 was estimated at $18 million to $22 million. About 20 firms are engaged in processing radiochemicals and radiopharmaceuticals.[8]

The uses for radioisotopes continued to expand at such a rate that a current listing could not be obtained. The business is estimated to be growing about 10 percent per year in dollar value. One of the most widespread uses is in measurement. Automated systems can weigh a product or gage its thickness, level, or density without touching it, then actuate necessary changes in the manufacturing process.

Tritium, the mass-3 isotope of hydrogen, sometimes called radioactive hydrogen, is one of the least expensive radioisotopes, and this makes large-scale tracer experiments possible. It has been available from AEC for peaceful purposes since 1959. The physical properties of tritium and full direction for its use in all phases of research in biochemistry, agricultural chemistry, and physics were described in a book containing many references in each chapter.[9]

Depleted Uranium.—The use of U_3O_8 as a catalyst in making acrylonitrile and methacrylonitrile may prove to be the first major commercial use for depleted uranium. Standard Oil Co. of Ohio has built a plant to produce 3.5 million pounds of the organics, which are classed as improved monomer intermediates for polymers. Nuclear Materials & Equipment Corp. of Apollo, Pa., received a 2-year contract for producing U_3O_8 from depleted uranium hexafluoride, byproduct of the AEC enrichment plants.[10]

PRICES AND SPECIFICATIONS

Ore and Concentrate.—Uranium ore-processing mills owned or controlled an estimated 90 percent of ore reserves and production, and any ore purchased from independently owned mines was under individually negotiated contracts. Ore prices were not disclosed, but most mills claimed to adhere to prices similar to those of AEC Circular 5, which expired in 1962. These prices ranged from $1.50 per pound of contained U_3O_8 on ore grade of 0.10 percent to $3.50 per pound on ore containing 0.20 percent U_3O_8 or more.

The AEC contract price for specification-grade concentrates continued to be $8 per pound of contained U_3O_8, and this price will continue through 1968. During 1969 and 1970, AEC will pay $1.60 per pound of U_3O_8, plus 85 percent of the allowable production costs during the prior 6 years, subject to a maximum of $6.70 per pound. The average AEC contract price for all U_3O_8 delivered in 1969 and 1970 is expected to be between $5.50 and $6.00 per pound. Canadian uranium concentrate was contracted to the Canadian Government stockpile at $4.90 per pound of contained U_3O_8 and to the United Kingdom Atomic

[8] U.S. Atomic Energy Commission. The Nuclear Industry. 1967, 184 pp.

[9] Evans, E. Anthony. Tritium and Its Compounds. D. Van Nostrand Co., Inc., Princeton, N.J., 1966, 441 pp.

[10] Chemical & Engineering News. Industry Concentrates. V. 44, No. 46, Nov. 7, 1966, p. 39.

Energy Authority (UKAEA) at $5.03. These contracts are for limited quantities aggregating about 4,000 tons per year through 1969.

Prices of U_3O_8 sales under private contracts were seldom made public by either seller or purchaser. Such contracts call for deliveries after 1970 and as far in advance as 1977. A few disclosures made in financial prospectuses and annual reports indicate that future delivery prices ranged from about $5.40 per pound of U_3O_8 for delivery prior to 1970 to an average of about $6.40 per pound for delivery after 1970. Canadian sales contracts were reported at prices as high as Can $7.14 (US $6.57). Many of these contracts contain escalation clauses to cover rising labor and supply costs.

Refined Uranium.—Normal uranium metal continued to be quoted periodically at $18 to $24 per pound in American Metal Market. Depleted uranium, in the form of uranium hexafluoride (67.6 percent uranium), was quoted at $2.50 per kilogram ($1.14 per pound) of contained uranium.

Special Nuclear Materials.—Base charges by AEC for enriched uranium remained unchanged since 1962 and varied with the degree of enrichment from $4.77, $8.48, and $9.59 per gram of U^{235} content for 1.0, 2.0 and 5 percent U^{235}, respectively. The new lowered charge by AEC of $26 (formerly $30) per kilogram unit of separative work and the lowering of "tails" assay in deriving the feed and separative components to 0.2 percent U^{235} (formerly 2.531 percent) will reduce the cost of enriched uranium after January 1, 1968, by 5 to 7 percent.

FOREIGN TRADE

No uranium ores and concentrates were exported in 1967 compared with 45,921 pound of U_3O_8 content valued at $160,984 exported to West Germany in 1966. Exports of uranium and thorium and their alloys, wrought or unwrought, totaled 543 pounds valued at $21,963 in 1967 and 3,505 pounds valued at $135,514 in 1966, over half in each year going to Canada and the rest mainly to France, West Germany, and Italy. Exports of uranium and thorium compounds totaled 50,353 pounds valued at $140,615 in 1967 and 153,494 pounds valued at $295,757 in 1966, with United Kingdom, Japan, West Germany, and Hong Kong being the principal recipients.

Special nuclear materials (enriched uranium, plutonium, and U^{233}, principally) totaling $44.0 million in value were shipped to 13 countries in 1967; 55.7 percent going to West Germany, 16.5 percent to India, 16.1 percent to France, and 6.7 percent to Spain. This compared with shipments valued at $41.9 million to 19 countries in 1966, with 56.1, 13.7, 6.5, 6.4, and 4.4 percent, respectively, going to West Germany, Italy, Belgium-Luxembourg, United Kingdom, and Canada. The large shipments to West Germany were enriched uranium for four projects in West Germany and one in the Netherlands, and were in the form of UF_6 for fabrication abroad into the first cores for the five projects. In late 1967, 30 kilograms (66 pounds) of plutonium were sold to Euratom for use in the Rhapsodie reactor at Cadarache, France.

Radioactive isotopes, compounds, and mixtures, radium included, enjoyed an extensive world trade and were exported to 85 countries in 1967 and were valued at $3.1 million, compared with shipments in 1966 to 79 countries, valued at $15.6 million.

No uranium concentrates were imported for the AEC stockpile in 1967, but imports for private industry contained 1,045 tons of U_3O_8 from the Republic of South Africa, 158 tons from Spain, and 106 tons from Canada, a total of 1,309 tons valued at $12,592,769. Imports of concentrates in 1966 were all for AEC procurement and consisted of 1,329 tons of U_3O_8 from the Republic of South Africa and 720 tons from Canada.

Radioactive isotopes, elements, and compounds imported in 1967 from 16 countries were valued at nearly $2 million, compared with $1.3 million in 1966. In addition, imports of Co^{60}, which is classified separately by the Bureau of the Census, were 379,575 curies valued at $1.0 million, compared with 197,543 curies valued at $0.8 million in 1966.

WORLD REVIEW

Australia.—Known uranium resources were not deemed to be adequate to support even a modest nuclear power program, and the Minister for National Development announced a policy to limit uranium exportation to safeguard the national interest. Uranium reserves recoverable up to $10 per pound consist of 8,080 short tons of reasonably assured U_3O_8 and another 2,580 tons possible but not proved. Another 3,540 tons are reasonably assured as economically recoverable up to $30 per pound. Permissible exports will vary with the size of the uranium ore deposits but, in general, not more than 50 percent of the predicted reserves from a property may be exported.[11] Despite this ban, Conzinc Riotinto of Australia Ltd. received permission to export during the 1970's the 2,000 tons of developed uranium in the Mary Kathleen open-pit mine. Before the mine was closed in 1963, it produced $100 million worth of uranium, which was all sold to UKAEA.[12]

Table 6.—Free world production of uranium oxide (U_3O_8), by countries [1] [2]

(Short tons)

Country [1]	1963	1964	1965	1966	1967 [p]
Argentina	[r] 10	37	[r] 50	[e] [r] 8	NA
Australia [e]	1,200	[r] 370	370	330	330
Canada	8,352	7,285	4,443	[r] 3,761	3,753
France	1,987	1,911	1,887	[r] 1,260	NA
Gabon	582	586	724	[e] 600	[e] 500
Malagasy Republic [e] [3]	123	169	65	65	NA
Portugal	11	22	[r] 42	[r] 46	NA
South Africa, Republic of	4,532	4,445	2,942	3,286	[e] 3,300
Spain [e]	([r])	[r] 100	[r] 130	NA	NA
Sweden [e]	10	10	[r] 20	[r] 50	50
United States	14,218	11,847	10,442	[r] 9,587	9,125
Total [4]	[r] 31,025	[r] 26,782	[r] 21,115	[r] 18,993	17,058

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] Uranium is also believed to be produced in Czechoslovakia, East Germany, West Germany, Hungary, India, Italy, Japan, and U.S.S.R., but production data are not available.
[2] Compiled from data available March 1968.
[3] Contained in uranium ore.
[4] Totals are of listed figures only; no undisclosed data included.

Belgium.—Belgonucléaire, founded by Belgian firms interested in nuclear energy, announced an international consortium for developing fast-breeder reactors. Other members are Siemens-Interatom (German) and Neratoom (Dutch).[13]

Brazil.—Brazil has kept uranium and thorium under strict export control since 1951, because of their nuclear properties. Exporters of minerals, such as zircon and pyrochlore, containing small quantities of associated nuclear material had to return equivalent quantities of such nuclear material to Comissão Nacional de Energia Nuclear. This law was eased in 1967 and exempted miners from the obligation of returning equivalent nuclear material if its separation was not technically or economically feasible. In processing pyrochlore, for instance, the small quantities of uranium and thorium present go into a slag and are not economically recoverable.

Canada.—Uranium production in 1967 was little changed from 1966, but was only 24 percent of the 1959 peak. Only the Nordic mine of Rio Algom Mines Ltd., Elliot Lake, operated at full capacity. Denison Mines Ltd., also at Elliot Lake, operated at about 50 percent capacity, and Eldorado Mining & Refining Ltd., at Beaverlodge, operated at about 80 percent capacity. Stanrock Uranium Mines Ltd., Elliot Lake, continued to produce about 13,000 pounds of U_3O_8 per month solely by underground bacterial leaching.[14] Rio Algom started developing a new mine, the Quirke No.

[11] Bureau of Mines. Mineral Trade Notes. V. 64, No. 8, August 1967, pp. 11–14.
[12] Mining Journal (London). Re-Opening in Sight. V. 268, No. 6,880, June 30, 1967, p. 533.
[13] Bureau of Mines. Mineral Trade Notes. V. 65, No. 2, February 1968, pp. 31–32.
[14] Williams, R. M. Uranium. Mineral Resources Division, Department of Energy, Mines and Resources, Ottawa, Canada, 16 pp.; Canadian Min. J., v. 89, No. 2, February 1968, pp. 129–133.

2, about 10 miles north of the Nordic mine, which it will gradually replace. The mine and the rehabilitated Quirke mill will increase the company's capacity from 3,300 to 3,700 tons per day.

Although the bulk of Canadian uranium has been marketed in the past through the Government-owned Eldorado Mining & Refining Ltd., producers since 1965 were at liberty to negotiate their own sales contracts. All four producers had contracts to deliver maximum quantities to the Canadian Government stockpile at a basic price of $4.90 per pound of U_3O_8 until 1970. Deliveries to this stockpile did not approach maximum permissible quantities in 1967, largely because producers anticipated early deliveries under commercial contracts at higher prices.

Commercial contracts grew markedly in 1967 and uranium sales commitments through 1980 aggregated over 42,000 tons, an average of 3,300 tons per year. Among the major contracts consummated were the following: Rio Algom to deliver up to 11,500 tons of U_3O_8 to the United Kingdom Atomic Energy Authority over an 8-year period beginning in 1973; the Hydro-Electric Power Commission of Ontario ordered 6,500 tons of U_3O_8 from Eldorado and Rio Algom for delivery between 1970 and 1980; The Tokyo Electric Power Co., Inc., The Kansai Electric Power Co., Inc., and six other Japanese electrical utilities ordered, over a 10-year period beginning in 1969, 10,500 tons from Denison and 5,000 tons from Rio Algom; Eldorado will supply 500 tons to Tokyo Electric over a 5-year period beginning in 1969; and Eldorado will supply about 1,000 tons of U_3O_8 to Kernkraftwerk Obrigheim, West Germany, beginning in 1969.

These substantial assurances of continuing demand caused a resurgence of uranium prospecting and exploration reaching boom proportions in some areas. Large areas of land were being explored, mostly by large companies in three areas: Beaverlodge, northern Saskatchewan; Elliot Lake, Ontario, and eastern Quebec and Labrador.[15] In addition to the Canadian firms, several foreign organizations were actively exploring. American firms participating included American Metal Climax, Inc., Federal Resources Corp., Homestake Mining Co., Kerr-McGee Corp., Newmont Mining Corp., Phelps Dodge Corp., and Western Nuclear, Inc. Federal Resources of Salt Lake City, Utah, optioned the mine and 1,500-ton mill of Canadian Faraday Corp. Ltd. which produced from 1957 to 1964.[16]

A French firm, Mokta Explorations (Quebec) Ltd. had concessions on 700 square miles and reportedly found enough ore to consider opening a mine. British Newfoundland Exploration Ltd. and four West German firms entered into a uranium exploration program in Labrador. Mitsui Mining and Smelting Co. Ltd., a Japanese firm, is cooperating with Tobe Mines Ltd. of Edmonton in exploration near Uranium City, Saskatchewan.[17]

The 200-Mw Douglas Point Nuclear Power Station, in the east shore of Lake Huron, went into operation in January 1967, but pump difficulties prevented reaching full capacity. This is Canada's first full-scale reactor to be fueled with natural uranium and cooled and moderated with heavy water, the so-called CANDU type.

France.—Commissariat a l'Energie Atomique (CEA) prospecting teams found a reportedly large uranium deposit in Niger and expected to exploit the deposit with initial output scheduled for 1970. CEA also entered into a contract with the Mexican Government for the construction of a uranium milling plant at Nasas, State of Coahuila.

The French mining company, Dong Trieu, found promising new uranium deposits at St. Suplice-les-Feuilles in south central France. The uranium deposit at Mounana, Gabon, was an important French source of uranium. Compagnie des Mines d'Uranium de Franceville operated the mine and a concentration plant.

The French national power corporation, Electricité de France (EDF) contracted to build a 500-Mw nuclear powerplant at Vandellos on the Mediterranean coast in northeast Spain. This, Spain's third reactor, will be fueled with natural uranium, graphite moderated, and gas cooled. France provided a 15-year loan of about $70 mil-

[15] Beck, L. S. Uranium Developments in Saskatchewan. Canadian Min. J. (Gardenvale, Quebec), v. 88, No. 4, April 1967, pp. 126–129.
Robertson, James A. Recent Geological Investigations in the Elliot Lake-Blind River Uranium Area, Ontario. Canadian Min. J. (Gardenvale, Quebec), v. 88, No. 4, April 1967, pp. 120–126.

[16] Engineering and Mining Journal. Federal Resources to Develop Uranium Facility in Ontario. V. 168, No. 3, March 1967, p. 110.

[17] Bureau of Mines. Mineral Trade Notes. V. 64, No. 11, November 1967, pp. 39–41.

lion at 4.5 percent interest. EDF will buy from 25 to 50 percent of the power and will own 25 percent of a company to be known as Hispano-Francesa de Energía Nuclear, and four Spanish concerns will own the balance.[18] France had two nuclear-power complexes in operation at the end of the year: Three reactors at Marcoule totaling 85 Mw and EDF-1, EDF-2, EDF-3 at Chinon totaling 750 Mw.

Gabon.—The uranium deposit at Mounana continued as an important source of uranium for France. Originally operated as an open-pit, underground operations began in 1965, and since then the deposit was found to be considerably larger than originally believed. The life of the operation may extend to 1980, 10 years longer than first estimated. The underground ore reportedly contains 0.3 to 0.4 percent uranium, compared with an average of 0.5 percent in the open pit. The ore is leached with sulfuric acid at Mounana, and a 20 to 30 percent uranium concentrate is shipped to France. Production reportedly equals around 400 tons of elemental uranium annually.

India.—In January 91,500 pounds of enriched uranium was shipped by boat from Alameda, Calif. to India for the first core loading of the No. 1 reactor of the 380-Mw twin boiling-water reactor station being built at Tarapur. A similar shipment for the No. 2 reactor followed in September. The total value of the two cores was $14.4 million. Reactor startup was expected by mid-1968.

Japan.—The cabinet formally approved private ownership of enriched fuel as proposed by the Japanese AEC. Previously only natural uranium could be owned privately. The ruling permits the negotiation of a new agreement with the United States to provide toll enrichment to supply Japan's future needs.[19]

Japan has two reactors in operation. One is a 12.5-Mw power-demonstration reactor of the boiling-water type and the other is a 154-Mw British Magnox type, using natural uranium. Nuclear power is particularly attractive to Japan because of her dependence on imported fuels. Hence, she expects to build nearly 10,000 Mw by 1980. Three reactors totaling 1,091 Mw ordered from the United States are under construction for 1969 and 1970 operation, and a fourth of 500-Mw capacity was planned for 1972 operation.

Japan is deficient in economic uranium deposits and, well aware that uranium requirements over the next 20 years may reach over 100,000 tons of U_3O_8, an aggressive worldwide search for uranium was initiated. Part of their needs has been assured by orders placed with Canadian firms for 16,000 tons of U_3O_8 deliverable over the next 10 years, and negotiations for purchasing uranium were also conducted with South African mines. A number of Japanese firms also sent technical missions to Australia, Canada, and the United States which were authorized to engage in exploration activities.[20]

Mexico.—The French Atomic Energy Commission (CEA) entered into a contract with the Government of Mexico for the construction of a uranium mill at Nasas, Coahuila. An initial investment equivalent to about $2 million was mentioned, and the plant was planned for completion in 1968.

Mexico's Nuclear Energy Commission (CNEN) claims to have found about 3 million tons of ore containing 2,300 tons of U_3O_8 in the States of Chihuahua, Sonora, Durango, and Oaxaca. A pilot plant was planned for Villa Aldama, near Chihuahua, to treat about 25 tons of ore per day.[21]

Niger.—The French Atomic Energy Commission (CEA) has held prospecting rights on over 350,000 square kilometers in three areas of this former French colony. Approximately 20,000 tons of U_3O_8 have been developed in a few square kilometers of desert near Arlit. By agreement with the Niger Government, CEA planned to develop these deposits, and expected to produce about 200 tons of U_3O_8 in 1970 and 1,000 tons annually by 1973. An investment equivalent to about $45 million will be required, about one-half contributed by the French Government. CEA will take the entire uranium output at an agreed price stated to be equivalent to $8 per pound of U_3O_8.[22]

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[18] Mining Journal (London). Franco-Spanish Nuclear Power Project. V. 267, No. 6848, Nov. 18, 1966, p. 371.

[19] Nuclear Engineering. Private Ownership of Enriched Fuel for Japan. V. 11, No. 127, December 1966, pp. 915–917.

[20] Mining Journal (London). Japan—Pre-Empting Future Uranium Supplies. V. 268, No. 6855, Jan. 6, 1967, p. 2.

[21] Engineering and Mining Journal. V. 168, No. 7, July 1967, p. 140.

[22] Engineering and Mining Journal. France, Niger, to Develop 20,000-Ton Arlit Uranium Deposit. V. 168, No. 8, August 1967, p. 106.

South Africa, Republic of.—Thirteen mines produced uranium in 1967, but only one—West Rand Consolidated—was a primary producer, gold being the byproduct.[23] A new process using solvent extraction was started by Harmony Gold Mining in 1966, which improves recovery and produces high-purity uranium concentrates which find a readier market. Sale of full production was assured Harmony through 1972 by the 5-year renewal of a French contract.[24]

The Minister of Mines announced that a reassessment of South African uranium reserves indicate that 205,000 tons of U_3O_8 are available at under $10 per pound. Estimates made by the Organization for Economic Co-Operation and Development in 1965 gave a figure of 140,000 tons.[25] Another 15,000 tons was possible at the same price. At a cost of $10 to $15 per pound another 65,000 tons would be available with a further 35,000 tons possibly available. In the price range of $15 to $30, another 55,000 tons can be added to accumulated reserves. The established total was estimated at 325,000 tons, with another 70,000 tons possible.[26]

Spain.—Construction on Spain's first nuclear powerplant, the 153-Mw station at Zorita, east of Madrid, neared completion at the end of 1967 with operation planned for mid-1968. The first core loading of about 41,000 pounds of uranium enriched to an average of about 3.0 percent U^{235}, valued at $4.6 million, was shipped in October. Construction was also about 20 percent complete on the 440-Mw Santa Maria de Garona plant, which was in the market for 388 tons of U_3O_8 and was scheduled for operation in 1970.[27] Work continued on the Vandellos 500-Mw plant, a joint venture between France and Spain for operation in 1971. Three other nuclear powerplants were being planned for operation around 1975.

Sweden.—The Ranstad uranium mill near Skovde operated throughout 1966 and 1967 with many stoppages and was operating at about 40 percent capacity at the end of 1967. Production cost was estimated at $10 to $15 per pound of U_3O_8, considerably in excess of world prices. Yield from the ore is less than three-fourths pound per ton of slate.[28]

Oskarshamnsverkets Kraftgrupp Aktiebolag, a group of Swedish utilities, signed a 30-year contract with AEC to provide toll enrichment services for a nuclear powerplant. The contract will provide the initial inventory and replacement fuel necessary for the 400-Mw boiling-water reactor over the term of the contract. This will require approximately 22,000 pounds of U^{235} in enriched uranium and will cost more than $40 million in total.

Switzerland.—The Nordostschweizerische Kraftwerke A.G. Baden (NOK) 350-Mw reactor was on schedule for 1969 startup. Located at Beznau, it will supply about 25 percent of total Swiss energy needs at a cost of 6 to 7 mills per kilowatt-hour, about half the cost of hydraulic power. AEC approved a barter request for 370 tons of enriched uranium for the plant, and Anaconda Sales Co. received a contract in 1966 to supply uranium concentrate as part of a barter contract. A 306-Mw reactor was announced by Bernische Kraftwerk A.G. (BKW) to be built near Muehleberg, 8 miles west of Berne, probably for 1972 startup.

U.S.S.R.—A dual purpose nuclear reactor for both heat and power was being erected at Biblibino in the Chukotsk region and is the first Soviet reactor north of the Arctic Circle. Its power will be 48 Mw and is expected to be completed during 1970.[29]

United Kingdom.—Britain, with 11 operating nuclear-power stations using 24 nuclear reactors totaling slightly over 4,000 Mw, far outranked any other country in nuclear capacity. Nuclear electricity generated totaled nearly 30 million Mw-hours, compared with 21 million in 1966. To provide a future supply of uranium, a contract was made with Rio Algom Mines of Canada, for 8,000 to 11,500 tons of U_3O_8 to be delivered through 1980. To meet its requirements for enriched uranium without dependence on the United States,

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[23] Canadian Mining Journal (Gardenvale, Quebec). South Africa. V. 88, No. 6, June 1967, pp. 31, 33.
[24] Metal Bulletin (London). South African Uranium. No. 5250, Nov. 21, 1967, p. 21.
[25] Baroch, Charles T. Uranium in Minerals Yearbook, 1965. V. I, Metals and Minerals (Except Fuels), 1966, p. 987.
[26] Bureau of Mines. Mineral Trade Notes. V. 65, No. 2, February 1968, pp. 31–32.
[27] Engineering and Mining Journal. Spain Set to Buy 388 Tons of U_3O_8 in the Foreign Market. V. 186, No. 8, August 1967, p. 116.
[28] Bureau of Mines. Mineral Trade Notes. V. 64, No. 4, April 1967, p. 26.
Chemical Engineering, Sweden's Uranium Mill Will Continue to Operate. V. 74, No. 3, Jan. 30, 1967, p. 50.
[29] Bureau of Mines. Mineral Trade Notes. V. 64, No. 1 January 1967, p. 41.

UKAEA initiated a $38-million modernization of its inactive Capenhurst gaseous-diffusion plant. Enriched uranium from this plant is expected to be more expensive initially than that from the United States, but the discrepancy is expected to narrow by 1970 with larger demand.

Venezuela.—A new uranium deposit was discovered in eastern Venezuela, near the Brazilian border in Bolivar State. Preliminary assay reports show 0.3 to 0.5 percent U_3O_8.[30]

WORLD RESERVES

Domestic uranium ore reserves estimated by AEC at the end of 1967, recoverable at $8 per pound of U_3O_8 in concentrates, aggregated 64 million tons of ore containing 0.2 percent U_3O_8 or 148,000 tons of U_3O_8, compared with 61 million tons of ore and 141,000 tons of U_3O_8 at the end of 1966. For the first time since 1959, development of new ore reserves exceeded the quantity mined. Reserves available at $10 per pound of U_3O_8 were estimated to be 190,000 tons of U_3O_8 plus another 120,000 tons available as a byproduct of copper and phosphate operations through the year 2000. In addition, approximately 3,550 tons of U_3O_8 were in ore stockpiles and 4,580 tons in process and finished product stocks, both up from 1,850 and 3,150, at the end of 1966. In general domestic reserves were considered to be adequate for the lifetime needs of all reactors operating or ordered to the end of 1967, and uranium needed to fuel reactors ordered in the future will have to come largely from deposits yet to be discovered.[31]

The estimated total of reasonably assured free world uranium resources available at under $10 per pound of U_3O_8 was estimated at 821,000 tons of U_3O_8 compared with 642,000 tons at the end of 1965. The increase was due mainly to increases in the estimate of reserves in the United States and the Republic of South Africa.

TECHNOLOGY

As usual, all phases of nuclear science and technology were covered by Nuclear Science Abstracts,[32] which listed 47,055 items in 1967, compared with 47,096 items in 1966 and 48,118 in 1965. AEC also reported the scope of its fundamental and basic research programs.[33] Concise summaries of current nuclear-energy developments continued to be published in a series of Technical Progress Reviews which evaluated the latest findings in four specific areas of nuclear technology and science.[34]

The Geological Survey completed a number of reports on uranium geology prepared on behalf of AEC. One report is a comprehensive geological study of a 535-square-mile area mostly in Valencia County, N. Mex., which includes the very productive Jackpile mine owned and operated by The Anaconda Company.[35] The uranium deposits of the Ralston Buttes district, 12 miles west of Denver, and the most productive vein deposits in the United States, exemplified by the Schwartzwalder mine, were mapped and described in detail, with emphasis on the economic geology of the 57-square-mile area.[36] Another report reviewed the geology of uranium deposits in sandstone, based on geologic studies and explorations from 1943 to 1959 by industry, educational,

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[30] Bureau of Mines. Mineral Trade Notes. V. 64, No. 11, November 1967, p. 41.

[31] Butler, Arthur P., Jr. Uranium Reserves and Progress in Exploration and Development. Geol. Survey Circ. 547, 1967, 8 pp.

[32] U.S. Atomic Energy Commission, Division of Technical Information. Nuclear Science Abstracts, v. 21, Nos. 1–24, issued semimonthly, 1967, 4,880 pp.

[33] U.S. Atomic Energy Commission. Fundamental Nuclear Energy Research—1967. January 1968, 368 pp.

[34] Argonne National Laboratory. Power Reactor Technology. V. 10, Nos. 1–4, 1967, 190 pp.

Baker, P. S., A. F. Rupp, and Associates (Oak Ridge National Laboratory). Isotopes and Radiation Technology. V. 4, Nos. 1–4, 1967, 446 pp.

Cottrell, W. B., W. H. Jordan, and J. P. Blakely (Oak Ridge National Laboratory). Nuclear Safety. V. 8, Nos. 1–6, 1967, 683 pp.

Simons, E. M., S. W. Porembka, Jr., and D. L. Keller (Battelle Memorial Institute). Reactor Materials. V. 10, Nos. 1–4, 1967, 288 pp.

[35] Moench, R. H., and J. S. Schlee. Geology and Uranium Deposits of the Laguna District, New Mexico. Geol. Survey Prof. Paper 519, 1967, 117 pp.

[36] Sheridan, D. M., C. H. Maxwell, and A. L. Albee. Geology and Uranium Deposits of the Ralston Buttes District, Jefferson County, Colorado. Geol. Survey Prof. Paper 520, 1967, 121 pp.

and government scientists, and contains an extensive bibliography.[37]

A publication on the uranium deposits around Moab and adjacent districts of Utah described the primary sedimentary features of pinchouts, facies changes, channel systems and scours, and thick sandstone lenses.[38] The geology and uranium deposits of South Dakota were amplified by two reports, one of which covered the Hot Springs quadrangle on the southeast flank of the Black Hills,[39] and the other described the Cascade Springs quadrangle on the southern tip of the Black Hills.[40] The geology was mapped and described of the rugged and picturesque 660-square-mile area east of Bryce Canyon and the High Plateaus of southeastern Utah, where 8,500 feet of sedimentary rocks ranging from Permian to Late Cretaceous age are exposed. Uranium minerals are concentrated principally in the Chinle and Morrison Formations.[41]

A widely used glossary of uranium minerals was republished.[42] A mineral inventory briefly described 124 deposits of uranium and thorium in the Blind River and Bancroft areas of southern Ontario.[43] A much more detailed and comprehensive report gave complete data on the history, geology, mining and milling technology, and production of each past and present Canadian uranium producer; altogether 28 mining operations were described.[44]

The Chattanooga Shale formation, which is found in large areas from Kentucky through Tennessee and into Alabama, is a potential low-grade source of uranium. In 1952, the Bureau of Mines and Geological Survey entered into a cooperative agreement with AEC to explore by core drilling some of the most favorable areas. A total of approximately 12,000 feet of test drilling in 72 holes was done by the Bureau and large samples were mined for extractive and metallurgical testing. Mineral reserves in five blocks, covering nearly 3,000 square miles underlain by Chattanooga Shale, gave measured reserves of 928 million tons and inferred reserves of nearly 85,000 million tons of material containing 0.006 percent uranium or slightly more.[45]

The proceedings of an international panel on processing of low-grade uranium ores, held in Vienna June 27 to July 1, 1966, were published in 1967. The series of papers included status reports from Australia, Canada, Czechoslovakia, France, India, Portugal, South Africa, Spain, Sweden, U.S.S.R., United Kingdom, United States, and Yugoslavia. These reported on the scientific research, experimental work, and industrial practice in the processing of low-grade uranium ores. Also included were 13 technical reports by experts from most of the countries.[46]

Bureau of Mines metallurgists presented a paper at the above-mentioned IAEA symposium, which disclosed that about 200 pounds of U_3O_8 per day was recovered by ion exchange from New Mexico mine waters containing from 5 to 15 parts per million of U_3O_8. Uranium had also been found in solutions resulting from the leaching of copper-mine waste rock at most of the major copper mines in the Western United States. While uranium was not being recovered from these solutions currently, a potential production of up to 6,000 pounds per day appeared to be possible.[47]

Solution mining of underground uranium ore in formations below the water table was tested in the Shirley basin in Wyoming. Average production was 500 pounds of U_3O_8 per day. The method involves the introduction of nitric acid

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[37] Finch, Warren I. Geology of Epigenetic Uranium Deposits in Sandstone in the United States. Geol. Survey Prof. Paper 538, 1967, 121 pp.

[38] Johnson, H. S., Jr. Uranium Deposits of the Moab, Monticello, White Canyon, and Monument Valley Districts, Utah and Arizona. Geol. Survey Bull. 1222-H, 1967, 53 pp.

[39] Wolcott, D. E. Geology of the Hot Springs Quadrangle, Fall River and Custer Counties, S. Dak. Geol. Survey Bull. 1063-K, 1967, pp. 427–442.

[40] Post, E. V. Geology of the Cascade Springs Quadrangle, Fall River County, S. Dak. Geol. Survey Bull. 1063-L, 1967, pp. 443–504.

[41] Davidson, E. S. Geology of the Circle Cliffs Area, Garfield and Kane Counties, Utah. Geol. Survey Bull. 1229, 1967, 140 pp.

[42] Frondel, J. W., Michael Fleischer, and R. S. Jones. Glossary of Uranium- and Thorium-Bearing Minerals. Geol. Survey Bull. 1250, 1967, 4th ed., 69 pp.

[43] Hewitt, D. F. Uranium and Thorium Deposits of Southern Ontario. Ontario Dept. of Mines, Mineral Resources Circ. No. 4, 1967, 76 pp.

[44] Griffith, J. W. The Uranium Industry—Its History, Technology, and Prospects. Mineral Resources Division, Dept. of Energy, Mines, and Resources, Ottawa, Canada, Min. Rept. 12, 1967, 335 pp.

[45] Hickman, R. C., and V. J. Lynch. Chattanooga Shale Investigations. BuMines Rept. of Inv. 6932, 1967, 55 pp.

[46] International Atomic Energy Agency. Proceedings of a Panel on Processing of Low-Grade Uranium Ores. Vienna, Austria. 1967. 247 pp. (Available from National Agency for International Publications, Inc., New York.)

[47] George, D. R., and J. R. Ross. Proc. Panel on Processing of Low-Grade Uranium Ores, Vienna. June 27–July 1, 1966. International Atomic Agency, Vienna, Austria, 1967, pp. 227–234.

solution through a cluster of injection wells drilled into the ore zone and pumping water and solution from a centrally located recovery well. A controlled pressure gradient is maintained between the injection wells and the recovery well. Uranium was recovered from pumped solution by solvent extraction.[48]

In France, at the Ecarpière deposit, Department of the Vendée, uranium recovery from mine waters was accelerated by recirculation and artificial watering of fractured country rock and caved and filled stopes. About 35 metric tons of uranium is recovered annually.[49]

The rapid acceptance of nuclear powerplants has accelerated interest in the development of fast-breeder reactors. Current reactors utilize only about 1 percent of the uranium, and greater efficiency of utilization will be necessary to meet the world's future power requirements. Breeder reactors would extend our energy resources almost indefinitely. AEC has given top priority to developing the liquid-metal fast-breeder reactor, which it considers to be the prime contender for producing power at competitive costs. Problem areas are many, of which fuels and materials constitute major ones. Work in this field was conducted at the Argonne and Oak Ridge National Laboratories and at the Experimental Breeder Reactor-II (EBR-II) at the National Reactor Testing Station in Idaho, which was operated at 45 thermal megawatts. While much data had been accumulated, in-pile performance data were inadequate as yet. Culmination of all the studies, developments, experiments, and testing is expected to permit the design of a prototype plant sometime in the 1970's.[50]

The historic Experimental Boiling Water Reactor (EBWR) at Argonne National Laboratory, near Chicago, Ill., was retired after 11 years of service. It was the first boiling water reactor to operate with a plutonium core which contained 31 pounds of plutonium. If future power reactors can use plutonium, world reserves of fissionable fuel will increase vastly.[51]

Technologic advances in peaceful uses for nuclear energy, besides those for nuclear power, continued throughout 1967. Five groups of projects came closer to fruition during the year: (1) A nuclear explosion for Project Gasbuggy, designed to stimulate gas flow in a tight rock formation, was detonated on December 10; (2) two similar proposals were in the planning stage—Project Dragon Trial, proposed by Continental Oil Co., and Project Rulison, proposed by Austral Oil Co.; (3) Project Bronco, proposed by CER Geonuclear Corp., Las Vegas, Nev., acting for 18 oil companies, to conduct a nuclear test in oil shale aimed at developing an economical *in situ* oil recovery process; (4) Project Sloop, a scheme proposed by Kennecott Copper Corp. to fracture a low-grade ore body and permit copper recovery by inplace leaching; and (5) Project Ketch, a proposal by Columbia Gas System Service Corp. of New York City, to use nuclear explosives to create underground storage for natural gas.[52]

Gasbuggy was the first joint Government-industry experiment in the Plowshare program. Final results will not be available for about 2 years, but the initial results were encouraging.[53] The objective is to obtain data to determine whether nuclear explosives can be used to stimulate recovery of gas from formations where the gas is not presently recoverable economically. The explosive charge was placed at a depth of 4,240 feet and released energy equivalent to 26 kilotons of TNT (1 kiloton approximates 1×10^{12} calories). A chimney of broken rock 333 feet high was formed, almost exactly as expected. Instruments indicated that fractures in the rock around the chimney extended out about 440 feet. The Bureau of Mines has estimated that successful nuclear stimulation could more than double the known reserves of nearly 300 trillion cubic feet of natural gas.

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48 Engineering and Mining Journal. New Method Suggested for Leaching Uranium Ore in Place. V. 168, No. 5, May 1967, pp. 106–107.

49 Mining Magazine (London). Recovery of Uranium From Ore by Solution at Sites. V. 116, No. 5, May 1967, pp. 373, 375.

50 Strauss, Sheldon D. Our Fast Breeder Program—Where it Stands and Where it is Going. Nucleonics, v. 24, No. 12, December 1966, pp. 41–47.

51 Chemical & Engineering News. Pu Fuels Boiling Water Reactor. V. 44, No. 50, Dec. 5, 1966, pp. 21–22.

52 Chemical & Engineering News. Oil, Gas Projects Perk Up AEC's Plowshare. V. 45, No. 6, Feb. 6, 1967, pp. 44–46.

53 Chemical & Engineering News. Initial Results Encouraging for Project Gasbuggy. V. 45, No. 53, p. 26.

Vanadium

By Gilbert L. DeHuff [1]

The strong demand and high production that characterized the vanadium industry through 1966 eased somewhat in 1967. The overall supply situation was greatly improved relative to demand by yearend, both at home and abroad. Prices for the pentoxide dropped back to the levels of the latter half of 1965, after having increased in 1966.

Legislation and Government Programs.—Early in January the Office of Emergency Planning (OEP) increased the conventional war stockpile objective for vanadium, from 1,400 to 1,500 short tons of contained vanadium. The portion contained in ferrovanadium remained at 1,200 tons so that the entire increase was in pentoxide. At approximately the same time, OEP announced a nuclear war objective for vanadium of 60 tons. However, all vanadium stockpiling actions are controlled by the higher objective.

There were no sales or offerings of surplus Government stocks in 1967. In late February 1966, the last of the Atomic Energy Commission (AEC) stocks (1,971 tons of vanadium pentoxide containing 1,104 tons of vanadium) was sold by General Services Administration (GSA) on a competitive bid basis. In May, President Johnson authorized disposal of the surplus vanadium in the national stockpile—approximately 6,450 tons contained in vanadium pentoxide. Of this quantity, 2,242 tons (4,003 tons of pentoxide) was sold before the end of 1966. A condition of all sales was that the purchased oxide would be consumed domestically within a specified time.

As of December 31, 1967, the national stockpile inventory totaled 5,609 tons of vanadium, of which 1,200 tons was contained in ferrovanadium and the remainder in vanadium pentoxide.

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Table 1.—Salient vanadium statistics

(Short tons of contained vanadium)

	1963	1964	1965	1966	1967
United States:					
Production:					
Ore and concentrate:					
Recoverable vanadium [1]	3,862	4,362	5,226	5,166	4,963
Value ..... thousands	$13,788	$13,061	$18,284	$22,210	$21,331
Vanadium pentoxide recovered	3,897	5,049	6,160	6,496	5,921
Consumption	2,906	3,550	4,708	5,481	5,170
Exports:					
Ferrovanadium and other vanadium alloying materials (gross weight)	183	103	220	482	351
Vanadium ores, concentrate, oxides, and vanadates	536	1,231	928	886	788
Imports (general):					
Ferrovanadium (gross weight)	442	466	51	8	14
Ore and concentrate	-------	12	-------	72	42
World: Production	7,917	8,573	9,834	10,029	10,595

[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

Western uranium-vanadium ores continued to be the principal source of supply for the vanadium recovered in the United States. Recovery was principally in the form of technical-grade vanadium pentoxide, but there was some direct recovery of ammonium metavanadate. Although contributing significantly to the high production of 1966, the vanadiferous sludges and other uranium-vanadium mill intermediates, accumulated when demand for uranium was high and that for vanadium was low, were virtually exhausted by that yearend and were not a factor in 1967. A renewed interest in uranium probably helped to keep production of vanadium at a higher level than would otherwise have been the case. Recovery of vanadium from Idaho phosphate rock continued to increase, and it was an appreciable portion of the total in 1967. Some fly ash, boiler scrapings, oil residues, spent catalysts, and other waste materials were included in the feed at western processing plants.

Table 2.—Recoverable vanadium of domestic origin produced in the United States, by States

(Short tons of contained vanadium)

State	1963	1964	1965	1966	1967
Colorado	3,047	3,312	4,017	3,697	3,317
Utah	382	405	387	353	471
Arizona and other States [1]	433	645	822	1,116	1,175
Total	3,862	4,362	5,226	5,166	4,963

[1] Includes Idaho, 1963–67; New Mexico, 1963–67; North Dakota, 1965; Oregon, 1964; South Dakota, 1963–67; Wyoming, 1963–67.

Table 3.—Mine production and recoverable vanadium of domestic origin produced in the United States

(Short tons)

Year	Mine production [1]	Recoverable vanadium [2]
1963	6,047	3,862
1964	5,184	4,362
1965	5,641	5,226
1966	5,685	5,166
1967	5,088	4,963

[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
1963	7,347	6,959
1964	9,775	9,013
1965	11,498	10,996
1966	11,955	11,595
1967	10,915	10,569

[1] Includes vanadium pentoxide and metavanadate produced directly from all domestic sources mentioned on this page, plus small byproduct quantities from imported chromium ores.

Vanadium Corporation of America merged with Foote Mineral Co. on August 31, 1967, to become the latter's Vancoram Operations. Its mill at Shiprock, N. Mex., together with those of American Metal Climax, Inc., Grand Junction, Colo.; Susquehanna-Western, Inc. (formerly Mines Development, Inc.), Edgemont, S. Dak.; and Union Carbide Corp., Rifle, Colo., continued to recover vanadium from uranium-vanadium and vanadium-uranium ores. In March, they were joined by Atlas Minerals, Division of Atlas Corp., when a new vanadium circuit at its Moab, Utah, uranium mill began to turn out technical-grade pentoxide with possibilities for ammonium metavanadate production later.

Union Carbide Corp. dedicated its new vanadium mill at Wilson Springs, Ark., on May 20, but delays were experienced in bringing the project (see "Technology" Section) into production. The company's vanadium-uranium mine, north of Rifle, Colo., continued to operate primarily as a vanadium mine.

CONSUMPTION AND USES

Domestic consumption of vanadium contained in ferrovanadium, other vanadium alloys, metal, and some chemicals failed to increase in 1967 for the first time since 1961. This was in keeping with a decline in steel production and a general softening of the economy. Consumption for nonferrous alloys however was still well above the 1965 level, although down somewhat from 1966. Greatly increased use of titanium in air and space applications was responsible for the increase in nonferrous alloys. It has been estimated that more than half of the titanium mill products made in the United States are composed of alloy containing 6 percent aluminum and 4 percent vanadium. Vanadium-aluminum master alloys continued to be the principal vehicle for adding vanadium to titanium. Use of vanadium for continuously cast steel appeared to have leveled off in 1967. The future importance of this use remained unsettled, and probably dependent in large part on vanadium's future cost. Columbium competed for this and other applications in the steel industry, particularly for line pipe and high-strength low-alloy constructional steels. The chemical industry continued to consume vanadium compounds in quantity, in large part in the form of catalysts for production of sulfuric acid, ethlyene-propylene synthetic rubber, plastics, and various organic compounds.

Consumption of technical-grade vanadium oxide by producers of ferrovanadium, Carvan, master alloys, metal, and some vanadium chemicals was 4,396 short tons of contained vanadium, compared with 8,282 tons in 1966. Both figures include a

Table 5.—Vanadium consumed and in stock in the United States in 1967, by type of material

(Short tons of vanadium)

Type of material	Stocks at consumer plants Dec. 31, 1966	Consumption p	Stocks at consumer plants Dec. 31, 1967 p
Ferrovanadium [1]	1,696	4,243	1,001
Oxide	47	142	25
Ammonium metavanadate	58	112	15
Other [2]	168	673	129
Total	1,969	5,170	1,170

p Preliminary.
[1] Includes other vanadium-carbon-iron alloys.
[2] Consists principally of vanadium-aluminum alloy and relatively small quantities of other vanadium alloys and vanadium metal.

Table 6.—Vanadium consumed in the United States in 1967, by uses

Use	Short tons p
Steel:	
High-speed	486
Hot-work and other tool	263
Stainless	45
Other alloy [1]	2,765
Carbon	814
Total steel	4,373
Gray and malleable castings	30
Nonferrous alloys [2]	565
Chemicals	127
Other [3]	75
Grand total	5,170

p Preliminary.
[1] Includes some vanadium used in high-speed or other tool steels not specified by reporting firms.
[2] Principally titanium-base alloys.
[3] Principally high-temperature alloys, welding rods, and cutting and wear-resistant materials.

relatively small quantity of vanadium contained in other feed materials. The quantity of oxide consumed in 1966 was abnormally high because government sales of pentoxide required domestic consumption or conversion within a limited time.

STOCKS

Producer's stocks of vanadium as fused oxide, precipitated oxide, metavanadate, metal, alloys, and chemicals, totaled 2,231 short tons of contained vanadium at yearend. This quantity is in addition to the consumers' inventory reported in table 5, and compares with 1,684 tons at the end of 1966 and a revised figure of 1,389 tons for the end of 1965. Included are some feed materials other than oxides and metavanadate. Vanadium contained in stocks of intermediates, sludges, and tailings held by oxide producers is not included in either of these figures. However, this appears to have been only a small quantity at the end of 1966 and 1967.

PRICES

Prices for technical-grade vanadium pentoxide dropped during the year. Metals Week quotations on merchant pentoxide for export were carried over from 1966 at \$1.60 to \$1.75 per pound of contained V_2O_5, and continued as such until May 1967. Then in a series of steps, prices dropped until by yearend they had reached \$1.05 to \$1.15, f.a.s. U.S. shipping port. Most domestic sales appear to have been made within a range of \$1.22 to \$1.30, f.o.b. mill, in the first part of the year, but it is probable that some domestic spot sales were made at higher prices in the first few months. Prices for domestic sales were down to \$1.05 to \$1.10 by yearend. Although pentoxide prices rose in 1966, the increase for domestic transactions was checked by Government sales. The AEC stocks were sold at prices averaging \$1.22, but ranging from \$1.17 to \$1.5275 per pound of contained V_2O_5, f.o.b. carrier's conveyance at storage location. Later in 1966 sales from national stockpile stocks were all made at a set price of \$1.22.

Contract prices for South African pentoxide to be delivered to the United Kingdom were cut 15 cents, to \$1.15, for the fourth quarter of 1967 and to \$1.05 for the first quarter of 1968. Japanese consumers of pentoxide were paying only \$1.10, delivered, by the end of September, and the price was reported to be down to \$1.05 in December.

The November 21, 1966 price of Carvan, \$2.38 per pound of contained vanadium, f.o.b. Marietta, Ohio, remained effective through 1967. However in mid-December an 8-cent increase was announced for shipments beginning January 2, 1968. Ferrovanadium prices, after increasing through 1965 and 1966, fell in 1967. For the first 4 months, Metals Weeks quoted merchant alloy containing 52 to 57 percent vanadium at \$3.50 to \$3.75 for export and \$3.35 to \$3.50 for domestic sales, per pound of contained vanadium. By yearend these quotations had both dropped to \$2.80 to \$2.90, f.o.b. shipping point, freight equalized to nearest main producer. This appeared to be a reasonable representation of the actual market at that time with most sales at the upper end of the range.

FOREIGN TRADE

The average declared value for exports of ore, concentrates, and technical-grade oxides, was \$1.44 per pound of contained vanadium pentoxide in 1967 and \$1.34 in 1966. The average declared value of ferrovanadium exported in 1967 was \$1.99 per pound of alloy, compared with \$2.29 in 1966. Quantities for both categories of exports were somewhat less in 1967 than in 1966.

Imports classified as ore and concentrates in 1967 contained 75 tons of vanadium pentoxide and came from the Netherlands and the Netherlands Antilles.

Tariff.—Presidential Proclamation 3822, signed December 16, 1967, authorized those tariff reductions that were promised by the Kennedy Round of negotiations earlier in the year. As a result, the following reductions in rates of duty, applicable

Table 7.—U.S. exports of vanadium, by countries

(Thousand pounds)

Destination	Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium (gross weight)		Vanadium ore, concentrates, pentoxide, vanadic acid, vanadium oxide, and vanadates (except chemically pure grade) (vanadium content)	
	1966	1967	1966	1967
Argentina	----------	----------	----------	3
Australia	----------	----------	36	64
Austria	----------	----------	329	361
Belgium-Luxembourg	----------	----------	111	----------
Brazil	22	6	----------	1
Canada	654	448	31	31
Chile	7	----------	10	----------
Colombia	----------	43	----------	----------
Czechoslovakia	----------	----------	164	75
Denmark	----------	----------	8	----------
France	----------	----------	70	296
Germany, West	33	----------	52	262
Italy	86	----------	----------	37
Japan	----------	----------	560	264
Mexico	95	141	13	4
Netherlands	27	20	174	----------
Spain	37	----------	----------	2
Sweden	----------	2	201	144
Taiwan	----------	----------	1	----------
United Kingdom	3	----------	8	31
Venezuela	----------	42	3	----------
Total:				
Quantity	964	702	1,771	1,575
Value (thousands)	$2,209	$1,398	$4,226	$4,043

Table 8.—U.S. imports of ferrovanadium, by countries

(Thousand pounds and thousand dollars)

Country	General imports				Imports for consumption			
	1966 [r]		1967		1966		1967	
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value
Belgium-Luxembourg	------	------	12	$24	------	------	------	------
Germany, West	16	$38	15	37	16	$38	15	$37
Total	16	38	27	61	16	38	15	37

[r] U.S.S.R. revised to none.

to most countries, became effective January 1, 1968, for the calendar year 1968. These will be further reduced in approximately equal annual steps until on January 1, 1972, they will roughly equal half the rates in effect in 1967.

TSUS Number	*Article*	*Percent ad valorem* 1967	1968
607.70	Ferrovanadium	12.5	11
632.58	Vanadium metal	10	9
632.68	Alloys of barium, boron calcium, strontium, thorium, or vanadium	15	13
417.42	Ammonium vanadate	32	28.5
420.34	Potassium vanadate	32	28.5
421.60	Sodium vanadate	32	28.5
422.58	Vanadium carbide	12.5	11
422.60	Vanadium pentoxide (anhydride)	32	28.5
422.62	Other vanadium compounds	32	28.5
423.94	Mixtures of two or more inorganic compounds, in chief value of vanadium	32	28.5
427.22	Vanadium salts of organic acids	32	28.5

Vanadium ore and concentrate continued to be free of duty.

WORLD REVIEW

In addition to the production reported in table 9, the U.S.S.R. produced vanadiferous slags from iron ores, and some other countries had relatively small unreported production from secondary sources or of a byproduct nature. Canada has recovered vanadium pentoxide from oil residues since 1965. Beginning somewhat earlier, Japan has been producing ammonium metavanadate and/or vanadium pentoxide from waste sulfuric acid resulting from the production of titanium dioxide. West Germany recovered a vanadium product from South-West African lead-vanadium concentrates (credited in table 9 to South-West Africa), and probably from other unreported byproduct or secondary sources as well. It is presumed that France still recovers vanadium pentoxide as a byproduct of bauxite processing, and possibly from other sources. Italy and Sweden may also have recovered vanadium from some of the above sources in the past 2 years or more.

Table 9.—World production of vanadium in ores and concentrates,[1] by countries

(Short tons)

Country	1963	1964	1965	1966	1967 p 2
Argentina	3	3	--------	--------	--------
Finland	771	1,084	r 1,063	r 1,069	1,292
Mexico	--------	--------	1	--------	--------
Norway e	755	740	750	730	740
South Africa, Republic of	1,392	1,282	1,519	1,711	e 2,100
South-West Africa (recoverable vanadium)	1,134	1,102	1,275	1,353	e 1,500
United States (recoverable vanadium)	3,862	4,362	5,226	5,166	4,963
Total 3	r 7,917	r 8,573	r 9,834	r 10,029	10,595

e Estimate. p Preliminary. r Revised.
1 Figures for Finland and Republic of South Africa are for vanadium in vanadium pentoxide product. The U.S.S.R. had vanadium production, but data are insufficient for estimation.
2 Compiled mostly from data available March 1968.
3 Total is of listed figures only; no undisclosed data included.

Australia.—A Western Australia Mines Department mapping party found titaniferous vanadium-iron deposits, outcropping over an 11- by 6½ mile area in the Jameson Range, 520 miles northeast of Kalgoorlie and some 900 miles inland from Perth. Based on cursory examination, the quantity of ore in the deposits was tentatively estimated to be 100 million tons. Vanadium analyses of seven random samples ranged from 0.82 to 2.42 percent.[2]

Canada.—Facilities to recover vanadium from the Athabaska tar sands may be installed within 2 to 4 years at Fort McMurray, Alberta, where recovery of oil from these sands was begun in 1967 by Great Canadian Oil Sands Ltd. It has been estimated that this source could supply 30 percent of annual U.S.-Canadian demand at current consumption rates.[3] The Montreal East refinery of Canadian Petrofina Ltd. continued to be Canada's only vanadium producer. At the beginning of 1967 it reportedly had the capacity to produce 1,000 pounds of vanadium pentoxide per day.

Finland.—Government-owned Otanmäki Oy, the only producer, increased production capacity of vanadium pentoxide approximately 20 percent in 1966–67, to 2,300 short tons. Production continued to come from underground mining of nearly vertical lenticular magnetite-ilmenite deposits associated with anorthosite and amphibolite, and a depth of 2,000 feet was reached. Vanadium values occurred with the magnetite rather than the ilmenite and varied directly with the magnetite content.

Norway.—After having been a producer and exporter of vanadiferous slag and vanadiferous pig iron for some years, the Bremanger Smelteverk division of Christiania Spigerverk changed to production of ferrovanadium for export in 1966. The source of the vanadium was the titaniferous magnetite ore of the Rødsand mine.

2 Mining Journal (London). V. 268, No. 6868, Apr. 7, 1967, p. 257.
3 Oil and Gas Journal. Athabaska Crude To Hit Pipeline Soon. V. 65, No. 41, Oct. 9, 1967, pp. 76–77.

South Africa, Republic of.—Transvaal Vanadium Co. (Pty) Ltd., a wholly owned subsidiary of Highveld Steel and Vanadium Corp. Ltd., continued to mine vanadium-bearing titaniferous magnetite by opencast methods from the Bushveld complex at the Kennedy's Vale mine in Steelpoort Valley. The plant near Witbank, 180 miles from the mine, chemically processed the screened ore to vanadium pentoxide for export to the United Kingdom, continental Europe, and Japan. The ore was of higher vanadium content than is normal for the complex. Transvaal Vanadium leased this Witbank property to the parent Highveld Steel and Vanadium Corp., Ltd. to be operated as Highveld's Vantra division. Expansion in 1967 brought a 300-ton increase in its annual capacity to produce pentoxide.

Construction of the integrated iron, steel, and vanadium works of Highveld Steel and Vanadium Corp. Ltd., started in August 1966 and proceeded on a schedule that will bring the entire plant into production in 1968. When capacity of the first stage of the project is reached, possibly by the end of 1970, 23 million pounds of vanadium pentoxide contained in slag and more than 400,000 tons of finished and semifinished steel will be produced per year at the plant, which is 7 miles west of Witbank and approximately 4 miles from the existing Vantra plant. Contracts have been made with a number of American and European firms for sale of all of the vanadiferous slag that will be produced through 1971. Mapochs mine at Roossenekal, roughly 50 miles from the steel-vanadium plant site, was expected to begin mining in the latter part of 1967, with the railway extension from Stoffberg scheduled for completion in March 1968. In April 1967, Newmont Mining Corp. acquired a 14.5-percent interest in Highveld Steel and Vanadium Corp. Ltd.

U.S.S.R.—Vanadiferous slag containing 14 to 15 percent vanadium pentoxide began to be exported to the United Kingdom and West Germany in 1966, and these shipments continued in 1967. The U.S.S.R. was reported to have been a supplier of vanadium to Czechoslovakia for some time. Plans called for doubling vanadium production from the large low-grade iron ore deposit in the Urals at Mount Kachkanar by 1970. The deposit was developed primarily for its vanadium content, mining of which commenced in 1963.

TECHNOLOGY

The Wilson Springs (Potash Sulfur Springs) vanadium deposits, an important new resource being mined in Arkansas approximately 6 miles southeast of Hot Springs and 6 miles west of the Magnet Cove intrusive locality, were described. The deposits, several in number, occur in the area of contact between a complex of alkalic igneous rocks and various Paleozoic sediments, including novaculite that was locally metamorphosed. Weathering averages 40 feet in depth over much of the igneous area. Vanadium content of the ore bodies is approximately 1 percent vanadium pentoxide (0.56 percent vanadium). The vanadium is seldom found as a discrete mineral, but occurs instead as a vicarious element in several of the rock-forming minerals and their alteration products. Columbium content of the ores being mined is usually under 0.10 percent columbium pentoxide. Titanium occurs chiefly as anatase but in insufficient quantity for recovery.[4]

Mining was in two open pits approximately half a mile apart and somewhat farther from the mill. Two 3½-cubic yard diesel shovels and nine 45-ton off-highway trucks were used. At the indicated rate of operation, ore reserves exceeded 10 years' supply, which is more than 6 million tons of ore. The mill has the capacity to treat 1,600 tons of ore per day, producing a modified vanadium oxide at the rate of 10 million pounds per year. Milling includes a sequence of crushing, rotary kiln drying, grinding, salt-roasting in a rotary kiln, water-leaching, and solvent-extracting. The product will be shipped to Marietta, Ohio, for use as feed material in the production of Carvan. Of a total capital expenditure of $14 million, $2 million was for control of air and water pollution.

Production of red cake, a form of vanadium oxide, from the processing of uranium-vanadium ores requires a concentration of 20 grams of vanadium pentoxide per liter of solution, while produc-

[4] Hollingsworth, J. S. Geology of the Wilson Springs Vanadium Deposits. Guide Book, Geological Society of America Field Conference, Little Rock, Ark., Nov. 13–19, 1967, pp. 22–28.

tion of ammonium metavanadate requires 100 grams per liter. Laboratory investigations of an autoclave process for extracting vanadium from ferrophosphorus produced alkaline leach solutions that contained only 7.3 grams of vanadium pentoxide per liter. By adding calcium chloride and adjusting the pH with caustic soda, dicalcium vanadate was precipitated. This was then dissolved with sulfuric acid or sodium bicarbonate solution to give liquors containing 25 to 125 grams of vanadium pentoxide per liter, from which red cake or ammonium metavanadate was obtained by conventional methods. Recoveries were excellent for each step.[5]

Ductile vanadium metal is a promising material for protecting the fuel elements of the breeder type of nuclear reactors. Ductility of the metal increases with its purity. In experiments conducted by the Bureau of Mines, 100-gram buttons of commercial-grade vanadium were melted in a 100-kw electron-beam furnace. Hydrogen content was reduced to 3 ppm or less, oxygen and carbon to less than 100 ppm each, and metallic impurities to 10 to 500 ppm each.[6] Laboratory-scale investigations of molten-salt electrorefining of vanadium in a helium atmosphere produced ductile 99.6-percent vanadium metal from a commercial 90-percent grade. Recovery of 87 percent was obtained with a $CaCl_2NaCl$-VCl_2 electrolyte, and 85 percent with KCl-LiCl-VCl_2.[7] With the latter electrolyte, extremely ductile vanadium of more than 99.9-percent purity was obtained from ductile scrap analyzing 99.4 percent vanadium.[8]

In man's ventures into the outer and submarine spaces, the strength and oxidation resistance of the metals that will be used are prime considerations. Bureau research with certain binary and ternary vanadium alloys of tungsten and chromium found them to have improved tensile strength and oxidation resistance as compared with unalloyed vanadium.[9]

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[5] Chindgren, C. J., L. C. Bauerle, and B. K. Shibler. Calcium Vanadate Precipitation and Processing. BuMines Rept. of Inv. 7058, 1967, 17 pp.

[6] Anable, W. E. Electron-Beam Purification of Vanadium. BuMines Rept. of Inv. 7014, 1967, 24 pp.

[7] Lei, K. P. V., F. R. Cattoir, and T. A. Sullivan. An Electrolytic Process for Producing Ductile Vanadium. BuMines Rept. of Inv. 6972, 1967, 22 pp.

[8] Lei, K. P. V., and T. A. Sullivan. Molten-Salt Electrorefining Vanadium Scrap. BuMines Rept. of Inv. 7036, 1967, 18 pp.

[9] Mathews, D. R., and H. G. Iverson. Properties of Vanadium-Base Tungsten and Chromium Alloys. BuMines Rept. of Inv. 6929, 1967, 22 pp.

Vermiculite

By Timothy C. May [1]

As a result of reduced construction activity the market for vermiculite fell in 1967. Crude vermiculite production in 1967 was 3 percent lower in volume but slightly higher in value than in 1966. The output of exfoliated vermiculite in 1967 was 7 percent lower than in 1966 and the total value was 5 percent less. The average value per ton of crude vermiculite increased 3 percent and that of exfoliated vermiculite almost 2 percent.

Table 1.—Vermiculite production statistics

	1963	1964	1965	1966	1967
United States:					
Production:					
Crude........thousand short tons..	226	226	249	262	225
Value........thousand dollars..	$3,572	$3,613	$4,460	$4,954	$4,974
Average value per ton..........	$15.81	$15.99	$17.91	$18.91	$19.51
Exfoliated.....thousand short tons..	172	177	177	193	180
Value........thousand dollars..	$13,877	$13,862	$13,424	$15,130	$14,378
Average value per ton..........	$80.68	$78.32	$75.84	$78.39	$79.88
World: Production crude thousand short tons..	329	343	380	382	368

DOMESTIC PRODUCTION

Crude Vermiculite.—Production declined 3 percent in 1967 to 255,000 tons. Five companies operating six mines produced the entire domestic output. Producers were W. R. Grace and Co., Zonolite Division, with mines in Lincoln County, Mont., and Laurens County, S.C.; Soloman's Mines Inc., Maricopa County, Ariz.; Patterson Vermiculite Co., Laurens County, S.C.; Perlite Producers, Inc., Llano County, Tex.; and D. L. Howe, Platte County, Wyo.

Exfoliated Vermiculite.—Production of exfoliated material declined 7 percent in quantity and 5 percent in value from the levels of 1966. Twenty-six companies operating 53 plants produced 180,000 tons of exfoliated material for domestic consumption. The major producing States and respective number of plants were as follows: California, 3; Texas, 4; Florida, 4; South Carolina, 3; and Illinois, 3. These States accounted for 40 percent of exfoliated vermiculite production.

CONSUMPTION AND USES

Producers of exfoliated vermiculite reported the following end use pattern for 1967; Aggregates (concrete, plaster, cement) 43 percent; insulation (loose fill, block, pipe covering, packing) 36 percent; agriculture (horticulture, soil conditioning, fertilizer carrier, litter) 17 percent; and miscellaneous 4 percent. The end use pattern changed only slightly from that of 1966.

[1] Commodity specialist, Division of Mineral Studies.

PRICES

The average value of crude vermiculite, screened and cleaned, at the mine, was $19.51 per short ton, compared with $18.91 in 1966. The average value of the exfoliated vermiculite f.o.b. producers plant was $79.88 per ton in 1967, compared with $78.39 in 1966. During the year, Metals Week quoted crude vermiculite from Montana and South Carolina at $18–$35 per ton f.o.b. mine; and material from the Republic of South Africa at $25.55–$40.15 per ton c.i.f. Atlantic ports.

FOREIGN TRADE

Imports of crude vermiculite from the Republic of South Africa in 1966 were 49 percent lower than in 1965. Crude vermiculite is imported duty free into the United States.

WORLD REVIEW

Canada.—Imported crude vermiculite from the United States and Transvaal, Republic of South Africa was exfoliated in Canada. Six companies produced exfoliated vermiculite at 11 locations in 1966: Calgary, Alberta; Vancouver, British Columbia, (two); Winnipeg and St. Boniface, Manitoba; St. Thomas, Stanleyville, and Toronto, Ontario; Lachine and Montreal, Quebec; and Regina, Saskatchewan.

In 1966, 314,916 cubic yards of exfoliated vermiculite valued at Can $2,594,819 was produced. Loose insulation consumed 72 percent, 6 percent less than 1965; plaster accounted for 14 percent; insulating concrete consumed 11 percent; 3 percent was used for minor purposes, including soil and fertilizer conditioners, underground pipe insulation and barbecue base. Exfoliated vermiculite sold at Can $0.25 to Can $0.30 per cubic foot, f.o.b. plant.[2]

South Africa, Republic of.—Crude vermiculite production in 1967 was 2 percent lower than in 1966. Local sales of vermiculite in 1967 amounted to 4,998 short tons, a decrease of 31 percent from 1965 sales. Total exports were 23 percent higher than in 1966. Vermiculite was produced by the Transvaal Ore Co. Ltd., at Phalaborwa.

[2] Wilson, H. S. Lightweight Aggregates 1966. Canada Dept. Mines and Tech. Surveys (Ottawa), June 1967, p. 4.

Table 2.—Free world production of vermiculite by countries [1]

(Short tons)

Country	1963	1964	1965	1966	1967 [p]
Argentina	3,064	4,071	1,857	[e r] 2,200	NA
Brazil	NA	NA	NA	441	240
India	746	473	807	551	409
Kenya	101	37	24	84	277
South Africa, Republic of	98,758	111,872	126,911	113,732	111,886
Tanzania	30	144	108	177	100
United Arab Republic	[2] 33	[2] 459	[2] 639	[3] 2,057	NA
United States (sold or used by producers)	226,278	226,299	249,352	262,321	255,000
Total [4]	329,010	343,355	379,698	[r] 381,563	367,912

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] Compiled mostly from data available June 1968.
[2] Includes mica.
[3] Includes asbestos.
[4] Total is of listed figures only; no undisclosed data included.

Table 3.—Republic of South Africa: Exports of crude vermiculite by countries

(Short tons)

Destination	1965	1966	1967
Australia	3,233	2,549	NA
Canada	2,866	2,565	NA
Denmark	1,328	----------	NA
France	10,138	8,523	NA
Germany, West	11,162	11,619	NA
Israel	829	----------	NA
Italy	12,715	14,123	NA
Japan	----------	2,955	NA
Netherlands	1,291	1,216	NA
Spain	2,770	2,460	NA
Sweden	785	965	NA
United Kingdom	37,535	27,277	NA
United States	16,692	8,432	NA
Other countries	4,667	3,207	NA
Total	106,011	r 85,891	105,346
Total value [1]	$1,912,130	r $1,576,986	$2,057,488
Average value	$18.04	r $18.36	$19.53

r Revised. NA Not available.
[1] Converted to U.S. currency at the rate of 1 rand equals US$1.3927 (1965), US$1.3913 (1966), and US$1.398 (1967).

Water

By J. Robert Wells [1]

The first Minerals Yearbook chapter devoted entirely to the subject of water appeared in 1954. That chapter discussed serious water shortages in some parts of the United States and directed attention to the urgency of expanding usable supplies by all possible means, especially by the promotion of processes and installations for the beneficiation of brackish and saline waters and by efforts to reverse the growing trend toward ruinous pollution. At that time the United States had about 160 million inhabitants and was using, from all sources of supply and for all purposes other than for the generation of hydroelectric power, a total of approximately 250,000 million gallons of water per day. Today the population of the United States has rolled past the 200 million mark, and the use of water per capita has gone up steadily in the interim. In 1967, as compared to 1954 figures, 25 percent more people were using 15 percent more water per individual, to push the total demand 44 percent higher. All-source withdrawals of water for all nonhydroelectric uses amounted to about 360,000 million gallons per day, and it is an understatement to say that the increases in both population and per-capita demand since 1954 have interacted to aggravate the Nation's water problems.

The extent to which the pollution predicament has remained unresolved was high-lighted recently in a speech by Senator Gaylord Nelson of Wisconsin with the pardonable hyperbole, "We Americans are standing ankle-deep in sewage, shooting rockets to the moon." President Johnson provided more food for sober thought with the starkly unexaggerated and unadorned statement, "It should be clear by now that we are in a race with disaster. Either the world's water needs will be met, or the inevitable result will be mass starvation in the world, mass epidemic in the world, mass poverty greater than anything you have ever seen before."

Legislation and Government Programs.—A plentiful and widely available provision of high-quality water is a resource of preeminent desirability, and efforts to secure and safeguard such a supply for all parts of the Nation are among the prime responsibilities of the Department of the Interior. Functions of the Department directly involved in water matters were administered in 1967 by the Office of the Assistant Secretary—Water and Power Development, and by the Office of the Assistant Secretary—Water Pollution Control. Performance of those functions was primarily allocated to the Office of Water Resource Research, the Federal Water Pollution Control Administration, the Office of Saline Water, the Bureau of Reclamation, and the Geological Survey's Water Resources Division. Other agencies of the Interior Department with less direct but still substantial involvement in water-related activities included the Bureau of Mines, the Fish and Wildlife Service, the Bureau of Outdoor Recreation, the National Park Service, the Bureau of Indian Affairs, and a number of regional power administration offices. The Department of Health, Education, and Welfare, the Department of Agriculture, and the Department of Commerce (Weather Bureau) were among additional Government agencies with duties significantly pertaining to the subject of water.

In accordance with the principles of the Federal Water Pollution Control Act and in compliance with provisions of the Water Quality Act of 1965, the various States submitted their respective compilations of proposed quality standards for intrastate and interstate waters. By mid-1967 all 50 States, the District of Colum-

[1] Commodity specialist, Division of Mineral Studies.

bia, Puerto Rico, and the Virgin Islands had presented their specifications for consideration, and by early 1968 the process of reviewing and evaluating the submitted version was well advanced.

The Federal Government organized and sponsored the International Water for Peace Conference held in Washington, D.C., May 23–31, 1967. As a sequel to U.S. participation in the Conference and to further the aims there expressed, President Johnson requested the establishment within the State Department of a permanent Water for Peace Office.

DOMESTIC SUPPLY

In any given area, and indeed in the Nation as a whole the annual supply of available water, except for relatively minor and still statistically unimportant amounts from desalinization processes, is directly dependent upon the provision of rain or snow that falls somewhere on land. Precipitation in 1967 in many parts of the contiguous United States substantially exceeded the amounts recorded in 1966, and some of the regional deficiencies of previous years, notably in the Northeast and East, were at least partly offset by frequent and heavy rainfall. In a number of months several States experienced more than double their normal precipitaion, and in 4 days of September a large part of southern Texas received from Hurricane Beulah a downpour equivalent to more than 400 percent of the usual total expectation for the whole month. A report was published in 1967 that provided a notable commentary on the general subject of water supply, domestic and worldwide.[2]

CONSUMPTION AND USES

Bureau of Mines publications in 1966 and 1967 included several reports on mineral-industry uses of water.[3]

PRICES

Quoted prices, influenced by factors as varied as weather and politics and by the quantity and quality of the water involved, as well as by the geographical setting, ranged from a few cents to $1 or more per 1,000 gallons. The U.S. average price per 1,000 gallons of water, pumped, treated, and delivered to the user's tap, was about $0.40, making water one of the cheapest of the bulk commodities at something less than $0.10 a ton.

In the majority of cities, bills for household water use included charges, sometimes separately specified, sometimes not, for sewer service. District of Columbia residents, for example, paid a minimum monthly charge of $13.77 for 3,600 cubic feet or less of metered water, of which $5.67 was for sewerage. The remainder, $8.10 for water only, was equivalent to about $0.30 per 1,000 gallons, provided the full 3,600 cubic feet was taken, or to a correspondingly higher unit rate if the actual consumption was less. Water beyond the first 3,600 cubic feet was billed at $0.15 per 100 cubic feet, equivalent to about $0.20 per 1,000 gallons, with an additional charge of 70 percent of that amount for sewer use.

Water for large-volume industrial uses was delivered to customers at prices varying generally from $0.01 to $0.15 per 1,000 gallons, while farmers commonly paid roughly half that amount, or from $1.50 to $15 per acre-foot (a unit equal to 325,900 gallons), for irrigation water.

Improved desalinization plants produced fresh water from salt-water feed at costs around $1 per 1,000 gallons, not greatly different from comparable figures in 1966, but conspicuously less than the $4 and $5 quoted before the inception in 1952 of the Office of Saline Water program.

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[2] Nace, Raymond L. Are We Running Out Of Water? U.S. Geol. Survey Circ. 536, 1967, 7 pp.

[3] Gilkey, Millard M., and Ronald B. Stotelmeyer. Water Requirements and Uses in Wyoming Mineral Industries. BuMines Inf. Circ. 8328, 1967, 92 pp.

Hale, William N. Water Requirements and Uses in Montana Mineral Industries. BuMines Inf. Circ. 8305, 1966, 103 pp.

Holmes, George H., Jr. Water Requirements and Uses in Nevada Mineral Industries. BuMines Inf. Circ. 8288, 1966, 66 pp.

WORLD REVIEW

The subject of water and its adequate supply continued in 1967 to be a matter of foremost concern throughout the world. According to information in current technical and industrial periodicals, at least 40 nations had major new water supply installations in the late planning stage, under construction, or recently put into service.

In addition to those depending upon fresh-water sources only, about 20 countries were either winning at least part of their potable water from the sea or had desalting plants in the processes of active study, firm planning, or actual construction. In a land where problems of water supply have been a subject of major interest for tens of centuries, the high-capacity flash distillation plant recently completed for the Southern Peru Copper Corporation went into fullscale operation extracting three-quarters of a million gallons of drinkable water per day from the salty Pacific. First of its size on the southern continent, this installation for supplying potable water for the sand-encircled port and smelter city of Ilo, Peru, is suggestive of future developments along South American's desert west coast, some parts of which have never known a single drop of rainfall in all recorded history.

Discussion, although not conclusive, continued in the matter of the proposed North American Water and Power Alliance (NAWAPA), under provisions of which as much as one-fifth of Canada's unused runoff water might be diverted from its present profitless escape into the Arctic Ocean and distributed to serve productive purposes in seven of her Provinces, 35 States of the United States, and three northern States in Mexico. At the other end of the earth, it is a simpler problem to obtain water for New Zealand's Scott Base in the Antarctic, home of 90 percent of the world's ice. There the supply is not pumped or drawn up in buckets, nor does it have to be impounded in a reservoir until used. Protruding portions of the adjacent landscape are simply sawed off and stored in piles near camp for melting as needed.[4]

Secretary of the Interior Stewart L. Udall was the presiding officer at the International Conference on Water for Peace held May 22–31, 1967 in Washington, D.C. Sessions of the conference, which attracted exhibits from 12 nations and 60 industrial organizations, were attended by approximately 4,500 delegates from about 75 participating countries.

TECHNOLOGY

Various branches of the U.S. Department of the Interior issued publications with significant relation to the technology of water. The Office of Water Resources Research published the annual Water Resources Research Catalogs, which list and discuss current water research projects; the Water Resource Thesaurus, for indexing and retrieving the literature of water resources research and development; and a Bibliography on Socio-Economic Aspects of Water Resources. The Office of Saline Water published the 1965 and 1966 Saline Water Conversion Reports, each consisting of three main sections—Research, Engineering and Development, Program Analysis and Coordination—and scheduled the comparable 1967 report for release early in 1968. The same Office also issued a series of Research and Development Progress Reports.

Over half of the U.S. patents closely related to water subjects issued in 1966 and 1967 dealt with apparatus and processes for the desalinization of seawater.

A treatise was published discussing the scientific, engineering, and economic aspects of a wide variety of salt-water conversion processes.[5] Desalting processes described in journal articles included those based on electrodialysis,[6] reverse osmosis,[7] and reverse osmosis assisted by sonic vibration.[8] The suitability and performance of

[4] South African Mining & Engineering Journal. Quarrying for Water. V. 77, No. 3849, Pt. 2, Nov. 11, 1966, p. 2663.

[5] Spiegler, K. S. (ed.). Principles of Desalination. Academic Press, Inc., New York, 1966, 566 pp.

[6] Friedlander, Henry Z., and Robert N. Rickles. Desalting by Electrodialysis. Chem. Eng., v. 73, No. 11, May 23, 1966, pp. 153–156.

[7] Chemical Engineering. Chementator: Polymers and Water Purification. V. 74, No. 12, June 5, 1967, pp. 63–64.

Sherwood, T. K., P. L. T. Brian, and R. E. Fisher. Desalination by Reverse Osmosis. Ind. & Eng. Chem. Fundamentals, v. 6, No. 1, February 1967, pp. 2–12.

[8] Harvey, Richard F. Sonic Vibration in Desalting the Sea. Chemistry, v. 40, No. 4, April 1967, pp. 28–29.

various possible materials for the fabrication of desalting plant evaporators, condensers, and heat exchangers was the subject of a number of published discussions.[9]

Unforeseeable difficulties that might arise in the desalinization process include the possible danger of dezincification of brass fittings in contact with water of high chloride-to-carbonate ratio and the risk of the detachment of old scale deposits and their migration to troublesome locations when established equilibria are disturbed by the passage through conduits long in service of water markedly different in character from that previously carried.

Research by the Bureau of Mines contributed significantly to distillation desalting technology with the development of a process for removing sulfate from the seawater feed ahead of the evaporator. Benefits include not only the possibility of recovering a number of byproducts in advantageous form, but also and most especially the achievement of notably superior efficiency through the virtual elimination of scale formation in all the crucially important heat transfer operations.

A drastic reduction of waterway pollution by green algae scum might result from the general application of a process in which an energetic reaeration step would be added to the customary activated-sludge treatment of city sewage. In experiments, this modification led to removal of almost all the contained phosphate, the substance chiefly to blame for the proliferation of the offending growth.[10] On Guernsey, one of the Channel Islands, operation was started of a new process for decomposing sewage solids by mixing the effluents with seawater that has been preelectrolyzed at low voltage to bring about the production of free chlorine and hypochlorites, both vigorous oxidizers.[11] Modern systems for the automatic and continuous monitoring of water supply quality were described in a journal article.[12] The Bureau of Mines presented the results of tests made to determine the effectiveness of coals and coal-derived materials as agents for eliminating certain undesirable organic substances from water treatment effluents,[13] and the Federal Water Pollution Control Administration prepared two bibliographies of primary importance in the field of water quality management.[14]

As the first of a planned series of papers based on its current research for advantageous methods of combating the harmful effects of acid- and iron-bearing mine water overflows, the Bureau of Mines published a report containing information and quantitative data assembled during the experimental treatment of such effluents either with coarse limestone or quicklime or with the two substances employed consecutively.[15] One of the authors of the Bureau report, E. A. Mihok, presented a related manuscript, "Limestone Neutralization of Mine Water," at the November 3, 1967, meeting of the Pittsburgh Section of the American Institute of Mining, Metallurgical and Petroleum Engineers (AIME). In addition to the quest for remedial measures, the aim of the Bureau's mine water program includes the development of preventive procedures such as minimizing discharges from active operations and sealing off workings that have been abandoned. West Virginia University, with a grant of $150,000 from the Northern West Virginia Coal Association, initiated research that will include a long-term of study of acid mine drainage in the Morgantown area and the construction there of a pilot plant for the experimental treatment of stream-polluting mine waters. Pennsylvania State University geologists, with the financial support of the Pennsylvania Coal Research Board, are seeking an explanation for the fact that from some strip coal mines the runoff water remains pure enough for domestic

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[9] Busche, Michael G. Water Desalination Poses Tough Materials Problems. Materials in Design Eng., v. 65, No. 2, February 1967, pp. 76–79.

Gordon, Hugh B. How Metals Resist Sea Water. Materials in Design Eng., v. 65, No. 5, May 1967, pp. 82–83.

[10] Engineering News-Record. More Air, More Sludge, Less Phosphates. V. 178, No. 7, Feb. 16, 1967, pp. 36, 41.

[11] Chemical Engineering. Electrolyzed Seawater Sterilizes Sewage Wastes. V. 73, No. 10, May 9, 1966, p. 98.

[12] Keyser, A. H. Water Quality Characteristics and Their Measurement. Instrumentation, v. 20, No. 1, first quarter 1967, pp. 6–11.

[13] Johnson, G. E., L. M. Kunda, A. J. Forney, and J. H. Field. The Use of Coal and Modified Coals as Absorbents for Removing Organic Contaminants From Waste Waters. BuMines Rept. of Inv. 6884, 1966, 56 pp.

[14] U.S. Department of the Interior, Federal Water Pollution Control Administration. Water Pollution Control, Waste Treatment and Water Treatment: Selected Biological References on Fresh and Marine Waters. 1966, 126 pp.

———. Selected List of Publications on Water and Water Pollution Control. June 1967, 7 pp.

[15] Deul, Maurice, and E. A. Mihok. Mine Water Research: Neutralization. BuMines Rept. of Inv. 6987, 1967, 24 pp.

consumption while from others it may be so laden with pollutants that it can so befoul clear mountain streams that they are useless to man and deadly to all forms of aquatic life. Demonstration of a significant correlation between the characteristics of the individual effluents and those of the corresponding ambient rock formations might justify predictions regarding the effects upon the environment to be expected from specific strip mining operations proposed for the future.

Among innumerable articles dealing with water topics that appeared in popular, industrial, and scientific periodicals, at least four were of major interest with regard to theoretical aspects of the fundamental chemical and physical nature of water.[16] The Library of Congress, through its National Referral Center for Science and Technology, issued a publication entitled, "A Dictionary of Information Resources in the United States: Water" which describes organization and institutions engaged in research or in the collection of data on water and water-related subjects. Additional information on both practical and theoretical water technology appeared in the Journal of the American Water Works Association; Water Resources Research (quarterly), American Geophysical Union; and Water Resources Bulletin (quarterly), American Water Resources Association.

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[16] Drost-Hansen, Walter. The Puzzle of Water. Internat. Sci. and Technol., No. 58, October -966, pp. 86–88, 90, 92, 94, 96.
Eyring, Henry, and Mu Shik Jhon. The Significant Structure Theory of Water. Chemistry, v. 39, No. 9, September 1966, pp. 7–13.
Smith, Cyril Stanley. Materials. Scientific American, v. 217, No. 3, September 1967, pp. 69–79.
Symons, M. C. R., M. J. Blandamer, and M. F. Fox. Is Water Kinky? New Scientist (London), v. 34, No. 544, May 11, 1967, pp. 345–346.

Zinc

By Harold J. Schroeder [1]

The domestic zinc industry operated at a substantially reduced level of activity with respect to mine production, smelter output, metal imports, and slab zinc consumption. Combined elements of metal supply approximately balanced demand although a buildup of stocks early in the year led to a 1-cent reduction in the price of zinc during May and June. Strikes at several smelters during the last half of the year contributed to a drawdown of stocks to near start-of-the-year levels.

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient zinc statistics

	1963	1964	1965	1966	1967
United States:					
Production:					
Domestic ores, recoverable content short tons	529,254	574,858	611,153	572,558	549,413
Value thousands	$122,533	$156,308	$178,284	$166,044	$151,562
Slab zinc:					
From domestic ores short tons	474,007	531,967	551,215	523,580	438,553
From foreign ores do	418,577	422,117	443,187	501,486	500,277
From scrap do	60,303	71,596	83,619	83,263	73,505
Total do	952,887	1,025,680	1,078,021	1,108,329	1,012,335
Secondary zinc [1] do	208,715	227,713	271,694	277,967	247,254
Exports of slab zinc do	33,853	26,515	5,939	1,406	16,809
Imports (general):					
Ores (zinc content) do	372,769	357,145	428,040	521,320	534,092
Slab zinc do	144,757	118,340	152,990	278,175	222,112
Stocks, December 31:					
At producer plants do	47,910	31,178	28,622	64,798	81,916
At consumer plants do	97,475	108,411	150,763	129,593	102,456
Consumption:					
Slab zinc do	1,105,113	1,207,268	1,354,092	1,410,197	1,236,808
All classes do	1,414,216	1,535,751	1,742,067	1,806,543	1,591,997
Price, Prime Western, East St. Louis cents per pound	12.01	13.57	14.50	14.50	13.85
World:					
Production:					
Mine short tons	4,035,975	4,432,615	4,750,780	4,960,118	5,175,463
Smelter do	3,844,313	4,126,982	4,354,306	4,563,224	4,233,331
Price: Prime Western, London cents per pound	9.60	14.74	14.12	12.75	12.37

[1] Excludes redistilled slab zinc.

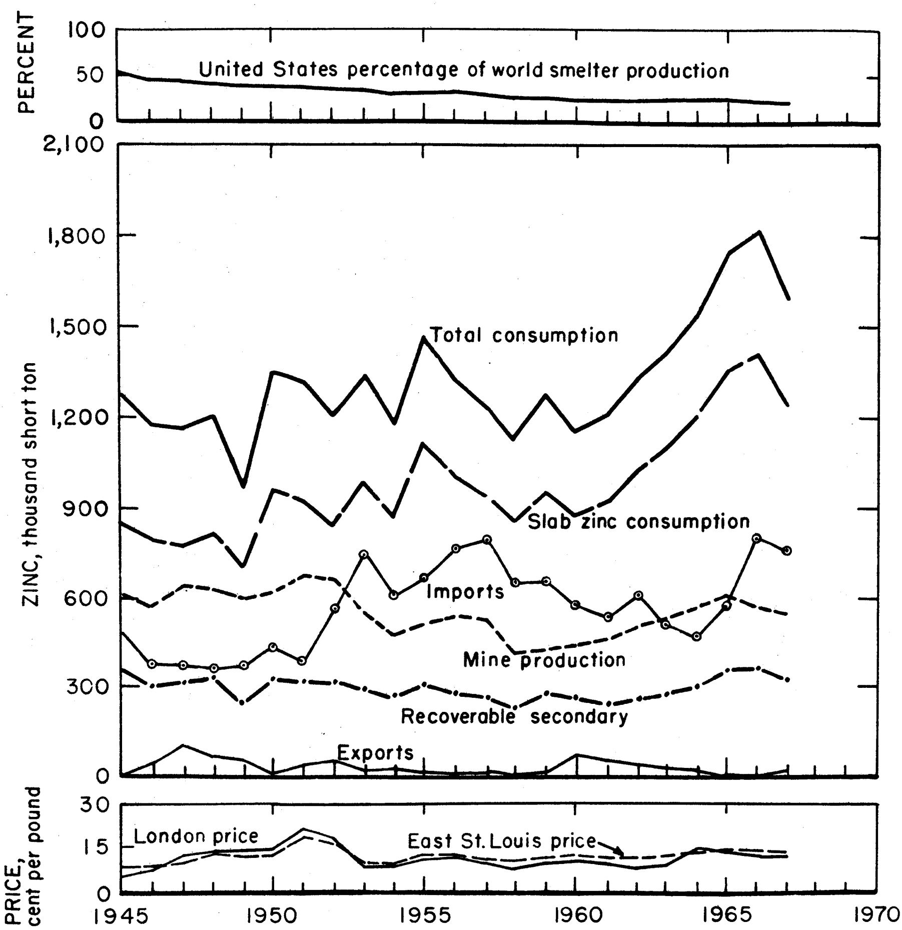

Figure 1.—Trends in the zinc industry in the United States.

Legislation and Government Programs.—The International Lead and Zinc Study Group met in Geneva during the second week in October and reviewed the current situation and short-term outlook of the world zinc industry. A study on consumption by the Special Working Group, published in 1966,[2] was reported to have received many favorable reviews.

The program to stabilize the mining of lead and zinc by small producers, which provided supplemental payments for eligible production when the market price is less than 14.5 cents per pound, remained in effect until January 1, 1970 (Public Law 89–238). Qualified producers became eligible for payments after the May price decline and payments of $95,317 for 8,850 tons of zinc were made. Zinc produced under the Act was approximately 1.6 percent of 1967 domestic mine production.

The General Services Administration (GSA) sold 24,760 tons of zinc to industry for domestic consumption by authority of Public Law 89–322 (November 1965) which released 200,000 tons of zinc from the national stockpile. Approximately

[2] International Lead and Zinc Study Group. Lead and Zinc, Factors Affecting Consumption. November 1966, 83 pp.

66,847 tons remained unsold at yearend. GSA also sold 2,166 tons of zinc for direct Government use by authority of Public Law 89–9 (April 1965) which released 50,000 tons from the national stockpile for that special use. Approximately 42,600 tons remained unsold at yearend.

There was 935,655 tons of zinc in the national (strategic) stockpile and 262,467 tons in the supplementary stockpile at the end of the year. Zinc stockpile objectives for both conventional and nuclear war, determined in 1963 and 1966, respectively, remained at zero.

DOMESTIC PRODUCTION

MINE PRODUCTION

Mines in the United States produced 549,400 tons of recoverable zinc, the second consecutive year of decreased output and the smallest quantity since 1963. States east of the Mississippi River produced 58 percent of the total output; Western States, 38 percent; and West Central States, 4 percent.

The sources of zinc production in 1967, classified according to types of ore, were as follows:[3] 53 percent from zinc ores; 33 percent from lead-zinc ores; 2 percent from lead ores; 6 percent from copper-lead, copper–zinc, and copper–lead–zinc ores; and 6 percent from all other classifications.

The 25 leading zinc-producing mines in the United States, listed in table 4, yielded 75 percent of the total domestic output. The four leading mines supplied 25 percent, and the first eight contributed 40 percent.

Tennessee maintained its rank as the leading producing State with output increasing 9 percent to 113,100 tons. Labor strikes at American Zinc Co. mines starting in October 1966 and at the New Market Zinc Co. mine starting in November 1966 curtailed output until settlement in February. The American Zinc Co. operated its Coy, Grasselli, Mascot No. 2, North Friends Station, and Young mines and continued development of the Immel mine. The New Jersey Zinc Co. operated its Jefferson City and Flat Gap mines and was developing a third mine scheduled for production in 1969. United States Steel Corp., Tennessee Coal & Iron Division, operated its Zinc Mine Works mine and mill during the year. The copper-zinc mines of Tennessee Copper Co. contributed a substantial quantity of zinc output to the State total.

New York output of recoverable zinc decreased 4 percent from the 1966 record quantity to 70,600 tons. St. Joseph Lead Co., the only zinc producer in the State, operated its Balmat and Edwards mines without interruption. Sinking of a new shaft at the Balmat continued with completion to the planned depth of 3,100 feet scheduled for 1970. The shaft will improve efficiency of operation and substantially increase the ore reserves available for mining.[4]

Idaho remained the leading mine producer in the Western States despite a 7-percent decrease to 56,500 tons. The Bunker Hill Co. reported recovering 13,737 tons of zinc in concentrate from milling 159,615 tons of ore from its Star Unit mines and 21,803 tons of zinc in concentrate from milling 366,025 tons of ore from its Bunker Hill mine.[5]

In Colorado, zinc production decreased 4 percent to the lowest quantity since 1963. Leading zinc producing mines were the Eagle of The New Jersey Zinc Co., the Idarado of Idarado Mining Co., the Emperius of Emperius Mining Co., the Sunnyside and Brennaman of Standard Metals Corp., and the Keystone mine operated by McFarland and Hullinger, which was closed indefinitely on September 2. The Idarado mine produced 438,000 tons of ore grading 4.32 percent zinc, 2.49 percent lead, 0.75 percent copper, and 2.33 ounces of silver per ton. Reserves decreased slightly to 4,018,000 tons at yearend.[6]

Pennsylvania output of zinc increased to 35,100 tons, the largest quantity since mining was resumed in 1958. The only operating mine was the Friedensville of The New Jersey Zinc Co.

In Utah, zinc production decreased 8 percent to 34,300 tons, with the reduction mostly due to labor strikes. The United

[3] Details of this breakdown are given in table 3 of the Lead chapter in this volume.
[4] St. Joseph Lead Co. Annual Report. 1967, p. 12.
[5] The Bunker Hill Co. Annual Report. 1967, p. 12.
[6] Newmont Mining Corp. Annual Report. 1967, p. 8.

States and Lark mine of United States Smelting, Refining and Mining Co. (USSR&M Co.) was the leading zinc producer. Other substantial producers were the United Park City mines of United Park City Mines Co., Mayflower mine of Hecla Mining Co., the Ophir mine of USSR&M Co., and the Burgin mine of Kennecott Copper Corp. At the Mayflower mine, 4,871 tons of zinc contained in concentrates was recovered from milling 127,000 tons of ore averaging 4.5 percent lead, 4 percent zinc, 0.9 percent copper, and 4.7 ounces of silver per ton.[7]

Zinc output in Wisconsin increased 17 percent to 29,000 tons, the highest production since 1927. The Eagle-Picher Co., the American Zinc Co., and Ivey Construction Co. operated mines and mills throughout the year. The New Jersey Zinc Co. began production in May at its new mine near Elmo and Mifflin Mining Co. began operating its Coker No. 1 mine late in October. The Eagle-Picher Industries closed its Kennedy mine in January.

Zinc production in New Jersey was from the Sterling Hill mine of The New Jersey Zinc Co. Ore from the mine was crushed and shipped without processing to a company-owned smelter in Palmerton, Pa.

In Washington, zinc mine output decreased to 21,500 tons, the lowest level since 1961. The Pend Oreille mine, Pend Oreille Mines and Metals Co., yielded 5,609 tons of zinc in concentrate and 1,835 tons of lead in concentrate from 293,000 tons of ore mined and milled. Output was curtailed because of a strike that began July 15.[8] American Zinc Co. brought its Calhoun property into initial production in October 1966 and operated at rated tonnage capacity in 1967, but initial ore grade was somewhat lower than expected. American Smelting and Refining Company suspended operations at its Van Stone mine on May 1.

Production in New Mexico decreased to 21,400 tons, the lowest output since 1963. The decrease was partly due to labor strikes but most importantly to the closing, in February, of the American Zinc Co. Kearney mine. Leading zinc producers were the Hanover and Linchburg mines of The New Jersey Zinc Co.; Oswaldo mine of Kennecott Copper Corp. leased to The New Jersey Zinc Co.; and the Princess mine of USSR&M Co.

Zinc output from Illinois advanced to 20,400 tons, the largest quantity since 1962. Production was from The Eagle-Picher Industries zinc mines in northern Illinois, and from increased byproduct zinc production associated with fluorspar mining in southern Illinois.

Virginia zinc mine production increased 7 percent to 18,800 tons, a reversal of the declining trend of the preceding 5 years. The New Jersey Zinc Co. operated the Austinville and Ivanhoe mines throughout the year.

Arizona mine output declined for the fifth year to 14,300 tons, the lowest level since 1939. The Iron King mine of Shattuck Denn Mining Corp. continued to be the largest zinc producer in the State. Closure of the Old Dick and Copper Queen mines of Cyprus Mines Corp. in January 1966 due to depletion of ore was a significant factor in the reduced State output.

In the Tri-State District of Oklahoma, Kansas, and Missouri, production was about 70 percent from the Oklahoma portion of the district with Kansas contributing most of the remainder.

Mine production of zinc from Missouri, mostly as a byproduct from lead mining in southeast and south central Missouri, increased to 7,400 tons, the largest output since 1953.

Kentucky produced 6,300 tons of zinc, a reduction of 4 percent from the record 1966 tonnage. Production was from the Hutson zinc mine of The Eagle-Picher Industries and as a byproduct from fluorspar mining operations.

In Montana, production was 3,300 tons, only about one-tenth of 1966 output. The reduction was mostly due to termination of mining at the Badger State mine in January. Remaining mine output ceased following closure of The Anaconda Company smelters by strike in July.

In Nevada, output was nearly cut in half to 3,000 tons, reflecting closures due to strikes. The leading producer was the Pan-American mine.

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[7] Hecla Mining Co. Annual Report. 1967, 23 pp.

[8] Pend Oreille Mines and Metals Co. Annual Report. 1967, p. 3.

DOMESTIC RESERVES

An investigation by the Bureau of Mines, completed in 1964,[9] estimated reserves of zinc to be 28.7 million tons and potential resources 62.1 million tons (see table 5). Ore reserves were defined as material that can be mined, processed, and marketed at a profit under the economic and technologic conditions prevailing at the time of inquiry. Potential (submarginal) resources were defined as material that may become a mineral (ore) reserve with improved economic conditions or by advancements in the technology of mining and metallurgy enabling more economical production methods.

SMELTER AND REFINERY PRODUCTION

The zinc smelting and refining industry operated 14 primary and eight secondary reduction plants producing slab zinc. Producers of slab zinc also made zinc compounds, alloys, zinc dust, and rolled zinc. Labor strikes closed the West Virginia plant of Matthiessen & Hegeler Zinc Co. from April 1 to August 8 and the zinc-producing facilities of The Anaconda Company from July 15 through the remainder of the year. A strike closed the Amarillo, Tex., plant September 30, but the facilities gradually returned to partial production although the strike was not settled at yearend.

According to company annual reports, the American Zinc Co. completed construction of new roaster, metal producing, and casting facilities at its Monsanto plant. The Bunker Hill Co. nearly completed construction to expand capacity by 20 percent or to 110,000 tons of slab zinc per year. St. Joseph Lead Co. curtailed output in the early part of the year but increased production in the latter part of the year as demand improved. The Anaconda Company in 1966 rehabilitated four units of the electrolytic zinc plant at Anaconda, inoperative since 1960, to process zinc concentrates on a combination purchase and toll agreement with Pine Point Mines, Northwest Territories, Canada. The New Jersey Zinc Co. constructed additional facilities at its Depue plant, resulting in a substantial increase in metal production capacity.

Slab Zinc.—Domestic smelter output of slab zinc declined from the record high quantity of 1966 and reversed the upward trend of the preceding 8 years. Included in the 1,012,300 tons of slab zinc output was molten zinc, used directly in alloying operations. Of the total, 938,800 tons was primary metal and 73,500 tons was redistilled secondary zinc. Primary output was 47 percent from domestic ores and 53 percent from foreign ores; 40 percent was electrolytic and 60 percent was distilled slab zinc. Of the 73,500 tons of redistilled secondary slab zinc, primary smelters produced 79 percent and the remainder was obtained from secondary smelters.

In 1967, Special High Grade was the principal grade produced, furnishing 43 percent of the total. Prime Western grade constituted 36 percent, and all other grades the remaining 21 percent.

Pennsylvania was the leading producing State, with Texas ranking second, Oklahoma third, and Illinois fourth. The slab zinc output of Pennsylvania, West Virginia, and Oklahoma was produced by the distillation process; the output of Montana and Idaho by the electrolytic process. Part of the Illinois and Texas slab output was distilled and part was electrolytic.

Primary Smelters and Electrolytic Plants.—Primary reduction plants processed roasted zinc ores and concentrates, zinc fume from Waelz kilns and slag-fuming plants, other primary zinc-bearing materials, and zinc-base scrap.

Capacity for slab zinc production at the primary zinc plants at yearend was reported to be 1,267,500 tons. Electrolytic plants reported 3,228 of their 3,928 electrolytic cells in use at yearend and an output of 373,965 tons (71 percent of the 525,000 tons of capacity). The horizontal-retort plants reported 28,448 of their 40,140 retorts in use during 1967. The remaining primary smelters were continuous-distilling vertical-retort plants. Combined horizontal- and vertical-retort production of 625,900 tons was 84 percent of the reported 1967 capacity of 742,500 tons.

Slag-Fuming Plants.—Many lead smelters recover a zinc-fume product from lead

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[9] Everett, F. D., and H. J. Bennett. Evaluation of Domestic Reserves and Potential Sources of Ores Containing Copper, Lead, Zinc, and Associated Metals. BuMines Inf. Circ. 8325, 1967, 78 pp.

blast-furnace slags containing about 7 to 13 percent zinc. Such slags were treated to extract zinc and remaining lead by the following companies in 1967:

Company	*Plant location*
American Smelting and Refining Company	Selby, Calif.
Do	El Paso, Tex.
The Anaconda Company	East Helena, Mont.
The Bunker Hill Co	Kellogg, Idaho
International Smelting & Refining Co	Tooele, Utah

These five plants treated 494,900 tons of hot and 34,900 tons of cold lead slag plus 4,400 tons of crude ore, all of which yielded 96,900 tons of oxide fume containing 62,200 tons of recoverable zinc. Corresponding figures for 1966 were 818,900 tons of feed materials, 133,600 tons of fume, and 87,100 tons of recoverable zinc.

Secondary Zinc Smelters.—Zinc-base scrap (principally skimmings and drosses, die-cast alloys, old zinc, engravers' plates, new clippings, and chemical residues) was smelted chiefly at secondary smelters, although about one-third was reduced at primary smelters and most sal ammoniac skimmings were processed at chemical plants.

Details of the zinc recovered in processing copper-base scrap are contained in the secondary copper and brass section of the Copper chapter of this volume.

BYPRODUCT SULFURIC ACID

Sulfur dioxide gases produced in roasting zinc sulfide concentrate at primary zinc plants were processed to yield 900,170 tons of sulfuric acid. At several plants, elemental sulfur was burned to produce additional quantities of acid.

ZINC DUST

Zinc dust data included in the tables are restricted to commercial grades that comply with close specifications as to percentage of unoxidized metal, evenness of grading, and fineness of particles; they do not include blue powder. Zinc content of the dust produced ranged from 95.00 to 99.60 percent, averaging 98.46 percent. Production of zinc dust was 50,300 tons, a 9-percent reduction from the 1966 record high and a reversal of the upward trend of the preceding 4 years.

CONSUMPTION AND USES

Consumption of slab zinc was 1.24 million tons, 12 percent below the 1966 record high and a reversal of the upward trend for the preceding 6 years. The reduced consumption was principally in the three largest industrial categories—zinc alloy, galvanizing, and brass—which consumed 535,100 tons, 458,600 tons, and 131,500 tons, respectively.

Of the 1.24 million tons of slab zinc used, 52 percent was Special High Grade, 29 percent Prime Western, and the remaining 19 percent all other grades. Galvanizing used mostly Prime Western grade while brass and bronze products consumed mostly the higher grades of zinc. Of the 535,100 tons of slab zinc used in zinc-base alloys, 99 percent was Special High Grade.

Rolling mills used 45,400 tons of slab zinc and remelted and rerolled 18,700 tons of metallic scrap produced in fabricating plants operated in connection with the rolling mills. In addition, a small quantity of purchased scrap (new clippings and old zinc) was melted and rolled. Small quantities of alloying metals were added for some uses. The rolled-zinc industry, however, classified these alloys as rolled zinc.

Net output of salable rolled zinc decreased 14 percent to 44,200 tons, approximately equal to 1965 production. Stocks of rolled zinc at the mills were 1,600 tons at yearend. Besides shipments of 20,000 tons of rolled zinc, the rolling mills consumed 42,700 tons of rolled zinc in manufacturing 25,300 tons of semifabricated and finished products.

Rolled zinc was produced in the form of sheet, strip, ribbon, plate, rod, and wire. Its major domestic use was for dry cell battery cases and similar cases for radio condensers and tube shields. Photoengraving plates, weather stripping, roof flashing, and household electric fuses were other uses.

CONSUMPTION OF SLAB ZINC BY GEOGRAPHIC AREAS

Ohio, Pennsylvania, Indiana, and Illinois accounted for 56 percent of the slab zinc used in galvanizing. The iron and steel industry used zinc to galvanize steel sheets, wire, tube, pipe, cable, chain, bolts, railway-signal equipment, building and pole-line hardware, and other items.

Connecticut again ranked first in consuming slab zinc in brass making, followed by Illinois and Michigan.

Michigan led in the consumption of slab zinc in making zinc-base alloys. Other large consuming States were Illinois, Ohio, New York, and Indiana.

ZINC PIGMENTS AND COMPOUNDS

Production.—Output of zinc pigments and compounds, excluding lithopone, was 296,600 tons, a 9-percent decrease from the high level of 1966 which had included record outputs of lead-free zinc oxide and zinc sulfate. Leaded zinc oxide production continued the downward trend of the past 20 years and was the lowest output since 1913.

Pigments and compounds were made from various zinc-bearing materials including ore, slab zinc, scrap, and residues. Plants producing zinc pigments and compounds numbered 15 for zinc oxide, nine for zinc sulfate, seven for zinc chloride, and one for lithopone.

Lead-free zinc oxide was made by several processes; 64 percent was made from ores and residues by the American process, 23 percent from metal by the French process, and 13 percent from scrap residues and secondary materials by other processes. Leaded zinc oxide was made from ores; zinc chloride was made from slab zinc and secondary zinc materials; and zinc sulfate was made from ores and secondary materials.

Leaded zinc oxide was produced in several grades, classified according to lead content. The more than 5 to 35 percent grade constituted 89 percent of the production. Relatively small quantities of the 5 percent or less, the more than 35 to 50 percent, and over 50 percent grades were produced.

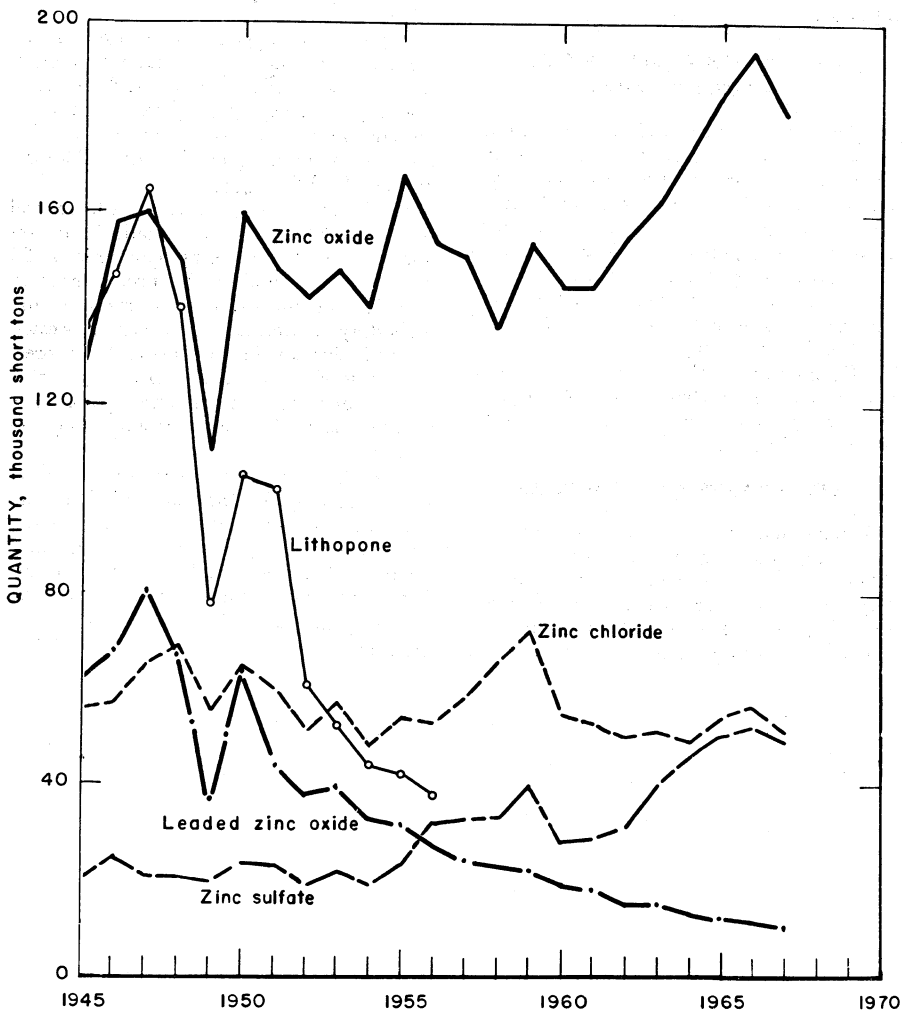

Figure 2.—Trends in shipments of zinc pigments.

Lithopone, a coprecipitate of zinc sulfide and barium sulfate, was produced but figures are withheld to avoid disclosing individual company confidential data.

Consumption and Uses.—Shipments of lead-free zinc oxide were 181,500 tons, 3 percent less than in 1966. The quantity received by the rubber industry accounted for 52 percent of the total shipped. The paint industry received 84 percent of the leaded zinc oxide shipped.

Lithopone was used principally in paint, varnish and lacquer, chemicals, paper, rubber, and floor coverings.

The principal uses of zinc chloride were for battery making, galvanizing, vulcanizing fiber, preserving wood, and refining oil, as well as for fungicides, solder, and tinning fluxes.

The chief uses of zinc sulfate were in rayon and agriculture. Other uses were in glue manufacture, flotation reagents, rubber, and medicine.

Prices.—Lead-free zinc oxide prices in carlots, freight allowed, in cents per pound were 15.25 cents for American process, 17.50 for French process, Green Seal, and 17.75 for French process, White Seal. Leaded zinc oxide of the 35 percent grade was quoted at 15.75 cents throughout the year but the 50 percent grade declined from 16.50 to 16.25 cents during June.

Zinc chloride (50° Baumé) was quoted in tankloads at 5.80 cents per pound and zinc sulfate (monohydrate, 36 percent) in carlots at 9.50 cents per pound throughout the year.

Foreign Trade.—Exports of zinc oxide decreased 5 percent but were the second largest quantity since 1952. Lithopone exports were about one-fourth the 1966 quantity and 21 percent below the average of the preceding 10 years.

Imports of zinc sulfate doubled, more than offsetting decreases in zinc oxide and zinc chloride, and resulted in a 2-percent increase in total imports of zinc pigments and compounds to the largest quantity since 1959. Zinc sulfate imports were supplied 75 percent from Mexico, 17 percent from Belgium-Luxembourg, and 7 percent from West Germany. Zinc oxide imports were supplied 59 percent from Mexico, 27 percent from Canada, and 11 percent from the Netherlands.

STOCKS

Producer Stocks.—Stocks of slab zinc at producer plants were 64,800 tons at the start of the year, increased rapidly to about 118,000 tons at the end of July, then declined to 81,900 tons by yearend.

Consumer Stocks.—Stocks of slab zinc at consumer plants, which were 129,600 tons at the beginning of the year, were drawn down to about 94,500 tons by the end of September, then moved upward to 102,500 tons by yearend.

PRICES

The quoted price of Prime Western grade zinc, East St. Louis market, was 14.5 cents per pound at the start of the year, had dual quotations of 13.50 and 13.75 cents from May 2 through June 19, and remained at 13.5 cents after June 19.

The London Metal Exchange price was the U.S. equivalent of 12.7 cents for January, trended downward to 12 cents for September, and showed relatively little change thereafter. A foreign producer price, quoted at the U.S. equivalent of 12.8 cents at the start of the year, was reduced to 12.3 cents in June and remained at that price the balance of the year.

During 1967, the quoted price for new clippings ranged from 6.75 to 7.50 cents per pound, averaging 7.02 cents. For old zinc, the quotation was 4.25 cents per pound throughout the year.

FOREIGN TRADE

Exports of slab zinc increased to 16,809 tons, a reversal of a declining trend for the preceding six years. The exports were 82 percent to India, a reflection of the sales from the Government stockpile in connection with contracts for the U.S. Agency for International Development (AID).

General imports were 222,112 tons for metal and 534,320 tons for ore. The metal imports were reduced from the preceding year but were the second largest since 1957 while the ore imports were the largest since 1943.

Imports of zinc fume, not shown in the tables, were reported by the Bureau of the Census to have been 18,566 tons containing 16,780 tons of dutiable zinc as general imports and 23,204 tons containing 21,435 tons as imports for consumption. Mexico was the source for all of the fume.

Tariff.—Duties on unmanufactured zinc and zinc containing materials remained unchanged and were as follows: Slab zinc, 0.7 cent per pound; zinc ores and concentrates and zinc fume, 0.67 cent per pound (on zinc content less certain allowable deductions for processing losses); zinc scrap, 0.75 cent per pound; and zinc dust, 0.7 cent per pound.

WORLD REVIEW

Argentina.—Cia. Minera Aguilar, S. A., a subsidiary of St. Joseph Lead Co., continued operation of a lead-zinc-silver mine in the Province of Jujuy in northern Argentina and through affiliated companies operated a zinc smelter and electrolytic zinc plant. All of the zinc produced was marketed in Argentina and Aguilar began a major expansion of facilities.[10]

Australia.—The Broken Hill district of New South Wales continued to be the leading Australian zinc-producing area. Mining companies operating and ranked in order of their output were: New Broken Hill Consolidated Ltd.; The Zinc Corp. Ltd.; North Broken Hill, Ltd.; and Broken Hill South Ltd. Combined output was approximately 2,819,000 tons of zinc-lead-silver ore, yielding 574,000 tons of zinc concentrate averaging 53.0 percent zinc.

Sulphide Corp. Pty., Ltd., operated its lead-zinc Imperial Smelting type furnace at Cockle Creek, New South Wales but output was restricted due to the reduced demand for zinc. Construction of facilities to refine 35,000 tons of zinc per year to higher grades was scheduled for completion in 1968. At Port Pirie, South Australia, The Broken Hill Associated Smelters Pty. Ltd., completed construction of a lead slag fuming plant and electrolytic zinc plant.[11]

Mount Isa Mines Ltd., during the fiscal year ended June 30, 1967, milled 1,060,000 tons of silver-lead-zinc ore and produced a record 37,350 tons of zinc in concentrates. Ore reserves were 36 million tons averaging 7.4 percent lead, 5.6 percent zinc, and 5.4 ounces of silver per ton. Construction continued on ore passes, a crushing system, and pump stations as part of a major expansion program largely completed the previous year.[12]

The Electrolytic Zinc Co. of Australasia Ltd., produced a record 161,185 tons of slab zinc at its Risdon, Tasmania, electrolytic plant during the fiscal year ending June 30, 1967. The company's mining-milling operations in the Read-Rosebery district milled 327,000 tons of ore yielding 122,100 tons of zinc, lead, and copper concentrates.[13]

Bolivia.—The Government of Bolivia and two U.S. firms, Philipp Brothers and United States Steel Corp., entered into an agreement in 1966 to operate the large lead-zinc-silver Matilde mine, inoperative since it was appropriated by the Government of Bolivia in 1952 from the Maurice Hochschild Co. The mine contains an estimated reserve of 3 million tons of ore averaging 18 percent zinc, 2 percent lead, and 1 ounce of silver per ton. Plans are to begin construction of a mill in late 1967 with an annual output of about 110,000 tons of zinc concentrate.

Canada.—Mine production increased 19 percent to a record 1,249,000 tons of zinc in concentrates, further establishing Canada's position as the world's largest producer of zinc. The increase was largely attributed to the first full year of operation of the Texas Gulf Sulphur Co. Timmins mine and greater output at the mines of Brunswick Mining and Smelting Corp. Slab zinc output also increased to a record 396,100 tons with the electrolytic zinc plants of Cominco, Ltd., Hudson Bay Mining and Smelting Co., and Canadian Electrolytic Zinc operating throughout the year. A new zinc reduction plant in New Brunswick began startup operations during the year.[14]

Cominco's zinc metal production was 202,015 tons, a 9-percent decrease from the record quantity attained in 1966. The combined zinc-lead production was derived approximately 30 percent from the company's Sullivan mine, 8 percent from other company mines, 59 percent from ores and concentrates purchased from Pine Point Mines, Ltd. (69 percent owned by Cominco), and 3 percent from other purchased ores and concentrates. Extraction of ore from company properties was 2,118,000 tons at the Sullivan mine, 256,000 tons from the Bluebell lead-zinc mine, and 1,854,000 tons from the Pine Point mines. Pine Point Mines, Ltd. continued development and construction of additional concentrating facilities to mine the adjacent Pyramid Mining Co., Ltd. property acquired in 1966.[15]

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10 St. Joseph Lead Co. Annual Report. 1967, pp. 14–16.
11 The Rio Tinto-Zinc Corp. Ltd. Annual Report. 1967, p. 33.
12 Mount Isa Mines, Ltd. Annual Report. 1967, 24 pp.
13 E Z Industries, Ltd. Annual Report. 1967, p. 4.
14 Fraser, D. B. Zinc. Canadian Min. J., February 1968, pp. 112–116.
15 Cominco, Ltd. Annual Report. 1967, 24 pp.

According to the annual report of Reeves MacDonald Mines Ltd., the company mined and milled 405,000 tons of ore at its Remac, British Columbia mine and produced concentrates containing 11,458 tons of zinc plus values in lead, silver, and cadmium. Development work during the year consisted of 9,749 feet of drifts, 5,349 feet of raises, and 14,201 feet of diamond and long hole drilling.

Hudson Bay Mining and Smelting Co., Ltd., operated its zinc-copper-lead mines along the Manitoba-Saskatchewan boundary. The mill treated 1,588,000 tons of ore—59.5 percent from the Flin Flon mine and the balance from the Chisel Lake, Stall Lake, and Schist Lake mines—which yielded 106,436 tons of 46.6 percent zinc concentrates plus copper and lead concentrates. Proven reserves at yearend totaled 16.9 million tons averaging 4.1 percent zinc. The electrolytic plant at Flin Flon treated 103,788 tons of zinc concentrate, 44,313 tons of zinc fume and stack dust from the copper smelter, and 19,962 tons of purchased materials to produce 72,061 tons of slab zinc.[16]

Willroy Mines Ltd., at its Manitouwadge, Ontario, operation milled 165,100 tons of ore from its operation and 503,500 tons of custom ore from Willecho Mines Ltd. The mill feed averaged 3.46 percent zinc, 0.60 percent copper, 0.17 percent lead, and 1.69 ounces of silver per ton. The ore from the Willroy mine averaged 3.33 percent zinc and yielded concentrates which contained 4,532 tons of zinc. Development included diamond drilling and drifting to explore a downward extension of the adjacent Big Nama Creek ore body. The ore reserves at yearend at the Willroy mine and the Nama Creek option were 1,334,000 tons, averaging 2.74 percent zinc, 1.10 percent copper, and 0.72 ounce of silver per ton.[17]

Noranda Mines Ltd., operated the Geco mine at Manitouwadge, Ontario, during 1967. Production was at the rate of almost 4,000 tons per day averaging 3.69 percent zinc, 2.02 percent copper, and 2.02 ounces of silver per ton. Exploration increased ore reserves to a yearend total of 26.7 million tons averaging 5.07 percent zinc, 2.1 percent copper, and 2.20 ounces of silver per ton.[18]

Texas Gulf Sulphur Co. in mid-February completed startup operations of the concentrator to treat ore from its Kidd Creek, Ontario, open pit zinc-copper-lead mine. The first nearly full year of operations resulted in output of 432,000 tons of 52 percent zinc concentrates.[19]

In Quebec, Quemont Mining Corp., Ltd., milled 444,000 tons of ore grading 2.30 percent zinc plus values in copper, silver, gold, and pyrite, yielding 14,438 tons of 52.8 percent zinc concentrate. Reserves at yearend were estimated at 1.1 million tons averaging 2.46 percent zinc.[20] According to its annual report for the year ending August 31, 1967, Cupra Mines Ltd. mined and milled 232,000 tons of ore yielding concentrates containing 4,670 tons of zinc plus values in copper, gold, and silver. The reserve at yearend was 601,000 tons averaging 3.73 percent zinc, 3.57 percent copper, and 1.26 ounces of silver per ton and an additional 200,000 tons of ore on the downward extension of the ore body. Solbec Copper Mines Ltd. was disrupted by a 6-month strike that curtailed mine production to 74,400 tons of copper-lead-zinc ore and milling to 3,400 tons. Ore reserves at yearend were 422,000 tons averaging 4.45 percent zinc.[21] The Sullico Mines Ltd. terminated operations in late 1966. From start of operations in 1949 until final closure, the mill treated 15.9 million tons of ore averaging 1.09 percent copper and 0.82 percent zinc.

Normetal Mining Corp., Ltd., mined and milled 348,000 tons of ore that yielded concentrates containing 41,398 tons of zinc. Reserves at yearend amounted to 1.6 million tons averaging 6.47 percent zinc and 2.11 percent copper and at present rates of extraction would be exhausted in 1972.[22]

In the Mattagami Lake district of Quebec, Mattagami Lake Mines Ltd., milled 1,414,000 tons of ore averaging 10 percent zinc and 0.6 percent copper to produce 248,352 tons of 51.7 percent zinc concentrate. Reserves at the end of the year were 18 million tons grading 10.4

16 Hudson Bay Mining and Smelting Co., Ltd. Annual Report. 1967, pp. 7–10.
17 Willroy Mines, Ltd. Annual Report. 1967, 16 pp.
18 Noranda Mines, Ltd. Annual Report. 1967, p. 18.
19 Texas Gulf Sulphur Co. Annual Report. 1967, 32 pp.
20 Quemont Mining Corp., Ltd. Annual Report. 1967, p. 4.
21 The Sullivan Mining Group. Annual Report. 1967, p. 39.
22 Noranda Mines, Ltd. Annual Report. 1967, p. 23.

percent zinc and 0.7 percent copper.[23] Orchan Mines Ltd. milled 375,000 tons of ore from its own mine and 329,000 tons of custom ore from the New Hosco mine. Ore reserves at yearend were 3.1 million tons containing 11 percent zinc and 1.2 percent copper. A substantial part of the concentrates from both mills were shipped to the zinc reduction plant of Canadian Electrolytic Zinc Ltd., at Valleyfield, Quebec, which produced a record 119,500 tons of slab zinc, 82 percent of rated capacity.[24]

In the Atlantic Provinces, Heath Steele Mines Ltd., mined zinc-lead-copper ore from its mine near Bathurst, New Brunswick and conducted a mine development program directed towards an output sufficient to operate the mill at full capacity. Brunswick Mining and Smelting Corp. Ltd. continued operation of its underground zinc-lead-copper Brunswick No. 12 mine and mill and completed the first full year of operation for the open pit copper-zinc No. 6 mine and concentrator. The combined output included 258,800 tons of zinc concentrates and 90,200 tons of zinc-lead concentrate. The associated smelting complex, incorporating a lead-zinc Imperial Smelting Furnace, experienced serious startup problems and will require extensive changes to attain the planned capacity. Ore reserves were increased during the year to approximately 80 million tons.[25]

In Newfoundland, Buchans Mining Co. Ltd. continued operation of their copper-lead-zinc mine and associated mill and produced 72,235 tons of zinc concentrates.

Congo (Kinshasa).—La Generale Congolaise des Minerais (GECOMIN) a Congolese Government company created January 1, assumed operation of the nationalized Union Miniere du Haut-Katanga's facilities. The Kipushi concentrator milled 1,140,000 tons of copper-zinc ore to produce 236,000 tons of 56.6 percent zinc concentrates. The company processed part of the zinc concentrates to produce 67,600 tons of electrolytic zinc and exported 85,100 tons of raw and roasted concentrates.

India.—Cominco-Binani Zinc Ltd., a joint venture of Metal Corporation of India, Ltd., and Cominco, Ltd. (Canada), completed construction of a 22,000-ton-per-year electrolytic zinc plant near Cochin in Kerala State. Initial production began in April and rated output is anticipated during the latter half of 1968.[26] The Government-owned Hindustan Zinc Ltd.'s Debari smelter in Rajasthan with a designed 18,000-ton annual output began operation in November.

Iran.—Bafq Mining Co., a Rio Tinto-Zinc Corp. Ltd. operating company, carried on development work at the Kuchke zinc-lead deposit. Reserves of 5 million tons of 16 percent combined lead and zinc were indicated and plans are for the new mine to produce on the order of 250 to 500 tons of ore per day.

Ireland.—Irish Base Metals Ltd., a subsidiary of Northgate Exploration Ltd., continued operation of its open pit lead-zinc-silver ore body and planned to supplement output with underground mining by 1970. Consolidated Mogul Mines conducted shaft sinking and other development at their Silvermines ore body for a 3,000-ton-per-day concentrating plant scheduled to begin production in 1968. Exploration for base metal deposits continued at an active pace at numerous locations in Ireland.

Japan.—Four Japanese lead and zinc producers—Mitsui Mining & Smelting Co. Ltd., Dowa Mining Co., Mitsubishi Metal Mining Co., and Nippon Mining Co.—have formed the Hachinohe Smelting Co. to build a new smelter with an approximate annual capacity of 30,000 tons of lead and 54,000 tons of zinc.[27] Total annual zinc smelting capacity is planned to increase from 555,000 tons in 1966 to 825,000 tons in 1970.

Mexico.—Asarco Mexicana, S. A. (49 percent owned by Asarco), operated a number of lead-zinc mines and a zinc smelter. Production included 62,535 tons of zinc metal and 50,410 tons of zinc in concentrates and fume sold. Mine, mill, and smelter expansion developments were in progress.[28]

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23 Mattagami Lakes Mines, Ltd. Annual Report. 1967, p. 6.

24 Noranda Mines, Ltd. Annual Report. 1967, p. 23.

25 Brunswick Mining and Smelting Corp., Ltd. Annual Report. 1967, 20 pp.

26 Cominco, Ltd. Annual Report. 1967, p. 23.

27 Engineering and Mining Journal. V. 167, No. 11, November 1966, p. 184.

28 American Smelting and Refining Co. Annual Report. 1967, pp. 10–11.

According to the annual report of Minera Frisco (Mexicanized company of San Francisco Mines of Mexico Ltd.) for the year ending June 30, 1967, a total of 930,000 tons of ore was milled from the company's San Francisco and Clarines mines and produced 98,300 tons of 57.1 percent zinc concentrate plus values in lead, copper, silver, and gold. Ore reserves at the end of the fiscal year were 5.8 million tons averaging 6.94 percent zinc, 4.63 percent lead, and 0.46 percent copper.

Compania Fresnillo, S. A. (49 percent owned by The Fresnillo Co.), operated lead-zinc-silver producing units at Fresnillo in Zacatecas, at Naica in Chihuahua, and at Zimapan in Hidalgo. In the year ending June 30, 1967, the company mined a total of 1,172,000 tons of ore and produced concentrates containing 39,353 tons of zinc as salable metal. Ore reserves at yearend totaled 4.6 million tons containing 4.6 percent zinc, 4.8 percent lead, and 4.93 ounces of silver per ton.[29]

Morocco.—The Boubeker and Touissit mines accounted for 90 percent of the zinc output. Under terms of a 5-year agreement concluded between the Governments of Morocco and Algeria, lead-zinc ore from the El Abed mine on the Algerian side of the border will be treated at the Boubeker mill.

Peru.—Cerro de Pasco Corp. produced a record 68,030 tons of slab zinc mostly from concentrates of its own mines. In addition, 93,606 tons of zinc in concentrates were produced for export. Drought conditions, which persisted during 1966 and reduced available power for zinc refining, ended early in 1967. Construction was nearly completed on a 50-ton-per-day pilot plant for recovery of metals contained in zinc leach residues.[30]

Cia. Minerales Santander, Inc., a St. Joseph Lead Co. subsidiary, produced a record quantity of zinc concentrate at their open pit lead-zinc-silver mine in the Peruvian Andes. Facilities for underground mining were in progress and scheduled for completion in 1968.[31] Other zinc producers included Cia. Minera Atacocha, S. A., Cia. des Mines de Huaron, Cia. Minera Milpo, S. A., Cia. Minera Raura, Northern Peru Mining Co., and Volcan Mines Co.

South-West Africa, Territory of.—Tsumeb Corp., Ltd., mined and milled, at the Tsumeb property, 728,000 tons of complex copper-lead-zinc sulfide and oxide ore averaging 2.95 percent zinc. Zinc contained in concentrates, sold and taken into account, was 4,600 tons compared with 10,400 tons in 1966.[32] Plans have been announced by the South African Iron & Steel Industrial Corp. Ltd. to expand production at the Berg Aukas mine and to construct an electrolytic zinc plant with an annual capacity of about 40,000 tons of zinc. Industrial Minerals Mining Corp. announced plans for a new zinc mine at Rosh Pina with scheduled production in late 1968.

Sweden.—According to the company's annual report, mines of the Boliden Mining Co., Ltd., yielded 104,500 tons of zinc concentrate containing 56,250 tons of zinc. A slag fuming plant treating lead and copper furnace slag recovered 32,600 tons of zinc fume, a record high quantity.

Thailand.—In late 1967 the Thai Government accepted bids for a concession to exploit zinc deposits at Mae Sod, Tak Province, estimated to contain 3.8 million tons of 35 percent zinc ore. The winning bidder will be required to provide an access road, power supply, and a 30-ton-per-day smelter. The concession was obtained by National Lead Co., but a final agreement had not been signed.

United Kingdom.—The Imperial Smelting Corp. Ltd., completed and began startup operations at Avonmouth on the world's largest zinc blast furnace. The older installation at Swansea, including a vacuum unit to produce the higher grades of zinc, operated throughout the year.[33]

Zambia.—The Zambia Broken Hill Development Co., Ltd., operated the Broken Hill mine and treated 200,000 tons of the ore in the heavy-medium plant which yielded 152,000 tons of sink product. The flotation plant treated 150,000 tons of the sink product plus 9,900 tons of mixed fines and silicate ore, yielding 51,961 tons of zinc concentrate averaging 54.1 percent

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29 The Fresnillo Co. Annual Report. 1967, pp. 8–9.
30 Cerro Corp. Annual Report. 1967, p. 4.
31 St. Joseph Lead Co. Annual Report. 1967, p. 16.
32 Newmont Mining Corp. Annual Report. 1967, p. 6.
33 The Rio Tinto-Zinc Corp. Ltd. Annual Report. 1967, p. 33.

zinc. The leach plant treated roasted zinc concentrate, flotation plant tailing, and zinc silicate ore, totaling 78,000 tons averaging 38.3 percent zinc. Leach solution was processed in the electrolytic plant to yield 24,350 tons of slab zinc. The Imperial-type vertical furnace treated 137,100 tons of sintered mill fines, slags, residues, and other material to produce 28,800 tons of slab zinc. The reserve of ore at yearend was 4.2 million tons grading 26.3 percent zinc and 12.3 percent lead.[34]

TECHNOLOGY

Results of several research investigations or studies were published by the Bureau of Mines [35] and the Geological Survey.[36]

A comprehensive coverage of zinc technology reported in the scientific and technical press was included in the 1,423 items contained in the monthly issues of the 1967 Zinc Abstracts, jointly published by the Zinc Development Association (London) and the American Zinc Institute.

The International Lead-Zinc Research Organization (ILZRO) sponsored numerous projects in 1967 to develop fundamental knowledge or particular applications of zinc or zinc-containing materials. Progress reports of these projects are released biannually by means of the ILZRO Research Digest, published in three parts: Part I describes die cast and wrought zinc projects; Part II, zinc for corrosion protection; and Part III, zinc chemistry.

A spring sampling geochemical technique to delineate anomalies associated with zinc deposits in southwest Wisconsin proved to be effective as an exploration tool. Validity of the method depends on existence of the proper relationships between the ore body and the hydrologic and topographic conditions. It is considered that these requisite conditions may also occur in many other zinc mining districts.[37]

An article described a zinc mill control system which continuously indicated and recorded the assays of feed, concentrates, and tailings. The system resulted in an improved quality of concentrate, reduction in reagent consumption, and was an important step in the direction of automation in zinc milling.[38]

Pressure hydrometallurgy techniques to replace roasting and leaching operations in production of electrolytic zinc received increased consideration by many operators. The method can be used for recovery of metals from complex bulk concentrates and would curtail air pollution associated with conventional roasting of concentrates.[39]

Continuous casting of zinc strip up to 38 inches wide and one-eighth to one-fourth inch thick has been used to produce feed stock for rolled zinc. A refractory nozzle is used to distribute the molten metal over water cooled rolls with care taken to prevent surface oxidation. The use of the process significantly reduces labor requirements.

An anodized finish is being acclaimed as an important new decorative and protective coating for zinc die castings. The coating is available in green, light gray, dark gray, and brown, and provides good corrosion, abrasion, and impact resistance.[40]

Vapor plating in vacuum chambers, used extensively for cadmium, is considered to have potential application for a wide range of zinc-coated products.[41]

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[34] The Zambia Broken Hill Development Co., Ltd. Annual Report. 1967, pp. 6–8.

[35] Koch, George S., Jr., and Richard F. Link. Geometry of Metal Distribution in Five Veins of the Fresnillo Mine, Zacatecas, Mexico. BuMines Rept. of Inv. 6919, 1967, 64 pp.

Knostman, Richard W. An Analysis of the Pacific Northwest Lead-Zinc Industry. BuMines Inf. Circ. 8327, 1967, 53 pp.

Ruppert, J. A., and P. M. Sullivan. Refining Iron-Contaminated Zinc by Filtration and Centrifugation. BuMines Rept. of Inv. 6889, 1967, 15 pp.

Spencer, Richard N., Seth C. Schaefer, and James E. Mauser. Electric Smelting of Complex Lead-Zinc Sinter. BuMines Rept. of Inv. 6999, August 1967, 28 pp.

[36] Heyl, A. V., and E. R. King. Aeromagnetic and Tectonic Analysis of the Upper Mississippi Valley Zinc-Lead District. U.S. Geol. Survey Bull. 1242–A, 1966 (1967), p. A1–A16.

Jones, W. R., R. M. Hernon, and S. L. Moore. General Geology of Santa Rita Quadrangle, Grant County, N. Mex. U.S. Geol. Survey Prof. Paper 555, 1967, 144 pp.

Prinz, W. C. Geology and Ore Deposits of the Philipsburg District, Granite County, Mont. U.S. Geol. Survey Bull. 1237, 1967, 66 pp.

[37] De Geoffroy, J., S. M. Wu, and R. W. Heins. Geochemical Coverage by Spring Sampling Method in the Southwest Wisconsin Zinc Area. Econ. Geol., v. 62, No. 5, August 1967, pp. 679–697.

[38] Fuller, M. L., P. E. McGarry, and J. R. Pellet. X-Ray Assaying and Reagent Control at Friedensville. Min. Cong. J., v. 53, No. 4, April 1967, pp. 108–112.

[39] Mackiw, V. N., T. W. Benz, and D. J. I. Evans. Recent Developments in Pressure Hydrometallurgy. Met. Rev., v. 11, No. 109, November 1966, pp. 143–158.

[40] Cook, Albert R. New Coatings for Zinc. Metal Prog., v. 91, No. 3, March 1967, pp. 111–126.

[41] Williams, B. J. Corrosion-Resistant Coatings by Physical Vapour Plating. Metal Finishing J., v. 13, No. 149, May 1967, pp. 173–177.

Table 2—Mine production of recoverable zinc in the United States, by States

(Short tons)

State	1963	1964	1965	1966	1967
Arizona	25,419	24,690	21,757	15,985	14,330
California	101	143	225	335	441
Colorado	48,109	53,682	53,870	54,822	52,442
Idaho	63,267	59,298	58,034	60,997	56,528
Illinois	20,337	13,800	18,314	15,192	20,416
Kansas	3,508	4,665	6,508	4,769	4,765
Kentucky	1,461	2,063	5,654	6,586	6,317
Missouri	321	1,501	4,312	3,968	7,430
Montana	32,941	29,059	33,786	29,120	3,341
Nevada	571	582	3,858	5,827	3,035
New Jersey	32,738	32,926	38,297	25,237	26,041
New Mexico	12,938	29,833	36,460	29,296	21,380
New York	53,495	60,754	69,880	73,454	70,555
North Carolina	13	--------	--------	--------	--------
Oklahoma	13,245	12,159	12,715	11,237	10,670
Oregon	3	W	W	--------	--------
Pennsylvania	27,389	30,754	27,635	28,080	35,067
Tennessee	95,847	115,943	122,387	103,117	113,065
Utah	36,179	31,428	27,747	37,323	34,251
Virginia	23,988	21,004	20,491	17,666	18,846
Washington	22,270	24,296	22,230	24,772	21,540
Wisconsin	15,114	26,278	26,993	24,775	28,953
Total	529,254	574,858	611,153	572,558	549,413

W Withheld to avoid disclosing individual company confidential data; excluded from total.

Table 3.—Mine production of recoverable zinc in the United States, by months

(Short tons)

Month	1966	1967	Month	1966	1967
January	49,132	43,173	August	49,771	48,821
February	48,764	43,501	September	45,490	43,283
March	53,943	50,817	October	44,066	43,779
April	50,014	49,528	November	43,940	41,814
May	51,650	50,493	December	42,006	41,537
June	47,928	47,967			
July	45,854	44,700	Total	572,558	549,413

Table 4.—Twenty-five leading zinc-producing mines in the United States in 1967 in order of output

Rank	Mine	State	County	Operator	Source of zinc
1	Balmat	New York	St. Lawrence	St. Joesph Lead Co	Lead-zinc ore.
2	Friedensville	Pennsylvania	Lehigh	The New Jersey Zinc Co	Zinc ore.
3	Sterling Hill	New Jersey	Sussex	do	Do.
4	Young	Tennessee	Jefferson	American Zinc Co	Do.
5	Eagle	Colorado	Eagle	The New Jersey Zinc Co	Zinc ore, copper ore.
6	Bunkerhill	Idaho	Shoshone	The Bunker Hill Co	Lead-zinc ore.
7	Zinc Mine Works	Tennessee	Jefferson	United States Steel Corp	Zinc ore.
8	Austinville and Ivanhoe	Virginia	Wythe	The New Jersey Zinc Co	Lead-zinc ore.
9	Star-Morning	Idaho	Shoshone	Hecla Mining Co	Do.
10	Edwards	New York	St. Lawrence	St. Joseph Lead Co	Zinc ore.
11	Idarado	Colorado	Ouray and San Miguel	Idarado Mining Co	Copper-lead-zinc ore.
12	New Market	Tennessee	Jefferson	New Market Zinc Co	Zinc ore.
13	Jefferson City	do	do	The New Jersey Zinc Co	Do.
14	Calhoun	Washington	Stevens	American Zinc Co	Do.
15	U.S. and Lark	Utah	Salt Lake	United States Smelting, Refining and Mining Co	Lead-zinc ore.
16	Flat Gap	Tennessee	Hancock	The New Jersey Zinc Co	Zinc ore.
17	Mascot No. 2	do	Knox	American Zinc Co	Do.
18	Shullsburg	Wisconsin	Lafayette	Eagle-Picher Industries, Inc	Do.
19	Iron King	Arizona	Yavapai	Shattuck Denn Mining Corp	Lead-zinc ore.
20	Copperhill	Tennessee	Polk	Tennessee Copper Co	Copper-zinc ore.
21	Deardorff Group	Illinois	Hardin and Pope	Ozark-Mahoning Mining Co	Fluorspar-lead-zinc ore.
22	Burgin	Utah	Utah	Kennecott Copper Corp	Lead-zinc ore.
23	Hanover	New Mexico	Grant	The New Jersey Zinc Co	Zinc ore.
24	Oswaldo	do	do	do	Do.
25	Page	Idaho	Shoshone	American Smelting and Refining Co	Lead-zinc ore.

Table 5.—Reserves and potential resources of zinc in the United States as of 1964, in terms of ore tonnage and contained zinc by ore classification

(Thousand short tons)

Classification	Reserves			Potential resources		
	Measured	Indicated	Inferred	Measured	Indicated	Inferred
Zinc and zinc-lead ores:						
Crude ore	64,650	197,690	282,800	7,000	86,370	2,490,000
Zinc content	3,050	8,170	10,020	170	3,120	56,190
Lead and lead-zinc ores:						
Crude ore	3,230	425,700	694,400	2,070	9,880	254,700
Zinc content	120	2,250	3,530	10	180	1,310
Zinc-copper, copper, copper-zinc, silver-lead, and lead-silver ores:						
Crude ore	3,102,080	1,821,650	4,643,620	238,200	1,142,420	12,342,100
Zinc content	400	1,090	90	20	260	830
Total:						
Crude ore [1]	3,170,000	2,445,000	5,620,000	247,300	1,239,000	15,100,000
Zinc content [1]	3,600	11,500	13,600	200	3,600	58,000

[1] Rounded totals.

Table 6.—Primary and redistilled secondary slab zinc produced in the United States

(Short tons)

	1963	1964	1965	1966	1967
Primary:					
From domestic ores	474,007	531,967	551,215	523,580	438,553
From foreign ores	418,577	422,117	443,187	501,486	500,277
Total	892,584	954,084	994,402	1,025,066	938,830
Redistilled secondary	60,303	71,596	83,619	83,263	73,505
Total (excludes zinc recovered by remelting)	952,887	1,025,680	1,078,021	1,108,329	1,012,335

Table 7.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by methods of reduction

(Short tons)

Method of reduction	1963	1964	1965	1966	1967
Electrolytic primary	358,093	389,383	408,128	433,576	371,267
Distilled	534,491	564,701	586,274	591,490	567,563
Redistilled secondary:					
At primary smelters	47,214	57,546	70,306	71,560	58,341
At secondary smelters	13,089	14,050	13,313	11,703	15,164
Total	952,887	1,025,680	1,078,021	1,108,329	1,012,335

Table 8.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by grades

(Short tons)

Grade	1963	1964	1965	1966	1967
Special High Grade	411,254	468,748	479,736	452,722	436,849
High Grade	104,301	112,056	112,451	139,814	92,956
Intermediate	18,372	19,050	17,985	23,555	26,522
Brass Special	98,190	81,034	86,695	103,184	91,079
Select	3,909	326	309	---	---
Prime Western	316,861	344,466	380,845	389,054	364,929
Total	952,887	1,025,680	1,078,021	1,108,329	1,012,335

Table 9.—Primary slab zinc produced in the United States, by States where smelted

(Short tons)

State	1963	1964	1965	1966	1967
Arkansas	11,143	----------	----------	----------	----------
Idaho	81,296	91,761	91,000	90,983	92,134
Illinois	108,971	114,866	114,131	96,809	115,659
Montana	118,090	125,334	143,927	174,821	111,834
Oklahoma	142,707	150,356	154,187	165,162	163,826
Pennsylvania and West Virginia	248,584	262,981	278,870	291,403	271,192
Texas	181,793	208,786	212,287	205,888	184,185
Total	892,584	954,084	994,402	1,025,066	938,830
Value (thousands)	$206,187	$260,274	$290,763	$301,164	$262,121

Table 10.—Primary slab zinc plants by group capacity in the United States in 1967

Type of plant	Plant location	Slab zinc capacity (short tons)
Electrolytic plants:		
American Smelting and Refining Company	Corpus Christi, Tex	525,000
American Zinc Co. of Illinois	Sauget, Ill	
The Anaconda Company	Anaconda, Mont	
Do	Great Falls, Mont	
The Bunker Hill Co	Kellogg, Idaho	
Horizontal-retort plants:		
American Smelting and Refining Company	Amarillo, Tex	742,500
American Zinc Co. of Illinois	Dumas, Tex	
Blackwell Zinc Co., Division of American Metal Climax, Inc	Blackwell, Okla	
Eagle-Picher Industries, Inc	Henryetta, Okla	
Matthiessen & Hegeler Zinc Co.[1]	LaSalle, Ill	
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. Joseph Lead Co	Josephtown, Pa	

[1] Plant closed July 1, 1961.

Table 11.—Secondary slab zinc plants by group capacity in the United States in 1967

Company	Plant location	Slab zinc capacity (short tons)
American Smelting and Refining Company	Sand Springs, Okla	55,900
Do	Trenton, N.J	
American Zinc Co. of Illinois	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 Steel Corp	Martins Ferry, Ohio	

Table 12.—Stocks and consumption of new and old zinc scrap in the United States 1967

(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	178	945	1,038	---	1,038	85
Old zinc	377	4,031	---	3,929	3,929	479
Engravers' plates	357	3,376	---	3,083	3,083	650
Skimmings and ashes	11,709	60,915	62,434	---	62,434	10,190
Sal skimmings	256	608	481	---	481	383
Die-cast skimmings	830	5,978	4,526	---	4,526	2,282
Galvanizers' dross	9,179	66,198	62,272	---	62,272	13,105
Diecastings	4,832	40,808	---	41,837	41,837	3,803
Rod and die scrap	557	1,215	---	1,575	1,575	197
Flue dust	683	5,213	4,254	---	4,254	1,642
Chemical residues	1,236	12,836	11,009	---	11,009	3,063
Total	30,194	202,123	146,014	50,424	196,438	35,879
Chemical plants, foundries and other manufacturers:						
New clippings	---	4	4	---	4	---
Old zinc	9	---	---	7	7	2
Engravers' plates	---	---	---	---	---	---
Skimmings and ashes	3,228	11,563	11,005	---	11,005	3,786
Sal skimmings	5,363	8,269	8,532	---	8,532	5,100
Die-cast skimmings	---	---	---	---	---	---
Galvanizers' dross	---	---	---	---	---	---
Diecastings	19	341	---	335	335	25
Rod and die scrap	60	91	---	131	131	20
Flue dust	540	3,567	3,713	---	3,713	394
Chemical residues	2,060	22,820	23,703	---	23,703	1,177
Total	11,279	46,655	46,957	473	47,430	10,504
All classes of consumers:						
New clippings	178	949	1,042	---	1,042	85
Old zinc	386	4,031	---	3,936	3,936	481
Engravers' plates	357	3,376	---	3,083	3,083	650
Skimmings and ashes	14,937	72,478	73,439	---	73,439	13,976
Sal skimmings	5,619	8,877	9,013	---	9,013	5,483
Die-cast skimmings	830	5,978	4,526	---	4,526	2,282
Galvanizers' dross	9,179	66,198	62,272	---	62,272	13,105
Diecastings	4,851	41,149	---	42,172	42,172	3,828
Rod and die scrap	617	1,306	---	1,706	1,706	217
Flue dust	1,223	8,780	7,967	---	7,967	2,036
Chemical residues	3,296	35,656	34,712	---	34,712	4,240
Total	41,473	248,778	192,971	50,897	243,868	46,383

[1] Figures partly revised.

Table 13.—Production of zinc products from zinc-base scrap in the United States

(Short tons)

Product	1963	1964	1965	1966	1967
Redistilled slab zinc	60,303	71,596	83,619	83,263	73,505
Zinc dust	23,749	29,742	33,512	34,326	32,801
Remelt spelter	3,740	3,646	5,324	6,970	4,831
Remelt die-cast slab	10,168	8,934	14,760	13,003	14,520
Zinc-die and diecasting alloys	5,894	5,116	5,463	4,333	3,882
Galvanizing stocks	611	1,684	1,450	1,585	1,690
Rolled zinc	4	---	---	---	---
Secondary zinc in chemical products	35,210	36,130	47,997	39,834	38,289

Table 14.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1966	1967	Form of recovery	1966	1967
New scrap:			As metal:		
Zinc-base	139,151	129,774	By distillation:		
Copper-base	131,476	106,637	Slab zinc [1]	82,244	72,595
Aluminum-base	3,000	2,895	Zinc dust	33,811	32,309
Magnesium-base	299	234	By remelting	8,317	6,366
Total	273,926	239,540	Total	124,372	111,270
Old scrap:			In zinc-base alloys	16,231	17,273
Zinc-base	45,990	40,862	In brass and bronze	172,098	146,441
Copper-base	36,139	36,142	In aluminum-base alloys	7,147	6,145
Aluminum-base	4,000	3,165	In magnesium-base alloys	529	431
Magnesium-base	156	140	In chemical products:		
Total	86,285	80,309	Zinc oxide (lead-free)	16,500	17,255
			Zinc sulfate	10,136	9,536
Grand total	360,211	319,849	Zinc chloride	12,896	11,236
			Miscellaneous	302	262
			Total	235,839	208,579
			Grand total	360,211	319,849

[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		Year	Short tons	Value	
		Total	Average per pound			Total	Average per pound
1963	40,362	$12,592,944	$0.156	1966	55,485	$20,418,480	$0.184
1964	45,979	15,724,818	.171	1967	50,273	18,098,280	.180
1965	51,958	19,328,376	.186				

Table 16.—Consumption of zinc in the United States

(Short tons)

	1963	1964	1965	1966	1967
Slab zinc	1,105,113	1,207,268	1,354,092	1,410,197	1,236,808
Ores (recoverable zinc content)	[1]104,705	[1]105,948	[1]122,892	[1]126,696	[1]114,301
Secondary (recoverable zinc content) [2]	204,398	222,535	265,083	269,650	240,888
Total	1,414,216	1,535,751	1,742,067	1,806,543	1,591,997

[1] Includes ore used directly in galvanizing.
[2] Excludes redistilled slab and remelt zinc.

Table 17.—Slab zinc consumption in the United States, by industry use

(Short tons)

Industry and product	1963	1964	1965	1966	1967
Galvanizing:					
Sheet and strip	238,919	257,328	270,826	264,312	236,135
Wire and wire rope	39,466	42,793	43,884	39,114	36,745
Tubes and pipe	56,563	62,166	63,224	68,848	61,792
Fittings (for tube and pipe)	7,787	8,802	8,641	10,150	11,768
Tanks and containers	NA	NA	NA	4,285	4,137
Structural shapes	NA	NA	NA	17,838	18,779
Fasteners	NA	NA	NA	4,340	4,234
Pole-line hardware	NA	NA	NA	11,400	9,985
Fencing, wire cloth, and netting	NA	NA	NA	15,821	16,544
Job galvanizing	39,223	44,354	51,011	NA	NA
Other and unspecified uses	38,329	40,893	44,835	59,859	58,486
Total	420,287	456,336	482,421	495,967	458,605
Brass products:					
Sheet, strip, and plate	61,462	64,701	58,864	97,095	67,237
Rod and wire	43,517	47,246	45,510	60,079	40,759
Tube	10,786	10,402	10,030	12,148	8,884
Castings and billets	3,969	3,258	3,050	3,378	2,295
Copper-base ingots	7,784	8,565	7,402	9,352	8,121
Other copper-base products	719	923	1,992	3,500	4,241
Total	128,237	135,095	126,848	185,552	131,537
Zinc-base alloy:					
Die casting alloy	462,543	517,354	629,809	596,371	525,960
Dies and rod alloy	720	604	535	495	420
Slush and sand casting alloy	5,356	6,624	7,626	9,170	8,738
Total	468,619	524,582	637,970	606,036	535,118
Rolled zinc	42,166	44,181	45,882	52,612	45,443
Zinc oxide	16,037	19,991	25,781	28,438	29,774
Other uses:					
Wet batteries	1,216	1,168	1,188	1,529	1,284
Desilverizing lead	2,095	2,393	2,444	2,776	1,394
Light-metal alloys	5,660	4,769	8,124	10,239	8,805
Other [1]	20,796	18,753	23,434	27,048	24,848
Total	29,767	27,083	35,190	41,592	36,331
Grand total	1,105,113	1,207,268	1,354,092	1,410,197	1,236,808

NA Not available.
[1] Includes zinc used in making zinc dust, bronze powder, alloys, chemicals, castings, and miscellaneous uses not elsewhere mentioned.

Table 18.—Slab zinc consumption in the United States in 1967, by grades and industry use

(Short tons)

Industry	Special High Grade	High Grade	Intermediate	Brass Special	Prime [1] Western	Remelt	Total
Galvanizing	24,636	25,337	1,421	102,482	301,700	3,029	458,605
Brass and bronze	38,263	58,838	210	5,741	26,879	1,606	131,537
Zinc-base alloys	531,365	1,169	53	93	1,470	968	535,118
Rolled zinc	20,528	11,556	6,061	7,290	8	------	45,443
Zinc oxide	9,369	914	-----	---------	19,491	-----	29,774
Other	19,334	3,391	303	8,138	5,114	51	36,331
Total	643,495	101,205	8,048	123,744	354,662	5,654	1,236,808

[1] Includes select grade.

Table 19.—Rolled zinc produced and quantity available for consumption in the United States

	1966			1967		
	Short tons	Value		Short tons	Value	
		Total	Average per pound		Total	Average per pound
Production: [1]						
Photoengraving plate	12,378	$7,277,518	$0.294	12,002	$9,003,750	$0.375
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	34,670	15,581,246	.225	29,028	13,224,651	.228
Rod and wire	W	W	W	W	W	W
Total rolled zinc	51,424	25,773,635	.251	44,240	24,652,763	.279
Imports	1,708	670,000	.196	648	276,000	.213
Exports	4,921	3,198,000	.325	3,565	2,709,000	.380
Available for consumption	48,222	----------	------	41,034	----------	------
Value of slab zinc (all grades)	------	----------	.147	------	----------	.140
Value added by rolling	------	----------	.104	------	----------	.139

W Withheld to avoid disclosing individual company confidential data.
[1] Figures represent net production. In addition, 21,061 tons in 1966 and 18,672 tons in 1967 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 1967, by industries and States

(Short tons)

State	Galvanizers	Brass mills [1]	Die casters [2]	Other [3]	Total
Alabama	34,299	W		W	35,999
Arizona	W			W	W
Arkansas				W	W
California	32,542	2,320	9,898	1,575	46,335
Colorado	W	W	W	W	4,043
Connecticut	3,199	35,686	W	W	41,717
Delaware	W	W	W	W	1,307
Florida	3,066		W		W
Georgia	W		W		W
Hawaii	W				W
Idaho			W	W	W
Illinois	42,221	25,482	77,300	W	167,633
Indiana	65,063	W	44,492	W	141,876
Iowa	833			W	W
Kansas		W	W	W	W
Kentucky	W	W		W	15,726
Louisiana	1,197			W	W
Maine	W				W
Maryland	W	W		W	29,292
Massachusetts	2,820	W		W	8,136
Michigan	4,958	15,192	132,485	W	154,945
Minnesota	2,873	W			W
Mississippi	W				W
Missouri	7,692	W	5,915	W	15,060
Nebraska	W	W		W	1,933
New Hampshire		W			W
New Jersey	3,217	6,003	W	1,857	W
New Mexico				W	W
New York	14,356	W	64,815	W	93,598
North Carolina	W		W	W	1,258
Ohio	89,235	W	77,718	1,425	W
Oklahoma	4,108		W	W	9,009
Oregon	602	W	W	W	831
Pennsylvania	60,365	7,525	24,032	W	133,641
Rhode Island	W	W		W	752
Tennessee	784		W	W	2,529
Texas	15,098	W	W	W	48,794
Utah	W	W			652
Virginia	224	37	W	W	1,909
Washington	998			W	2,083
West Virginia	11,791	W		W	13,038
Wisconsin	1,483	W	8,405	W	14,787
Undistributed	52,552	37,686	89,090	106,640	244,271
Total [4]	455,576	129,931	534,150	111,497	1,231,154

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	1966				1967			
	Production (short tons)	Shipments			Production (short tons)	Shipments		
		Short tons	Value [2]			Short tons	Value [2]	
			Total	Average per ton			Total	Average per ton
Zinc oxide [3]	202,806	193,665	$52,230,204	$270	187,208	181,486	$50,299,922	$277
Leaded zinc oxide [3]	10,662	11,557	3,038,171	263	9,699	10,306	2,596,913	252
Zinc chloride, 50° B [4]	58,436	56,461	W	W	50,853	51,229	W	W
Zinc sulfate	53,328	51,698	7,936,753	154	48,847	48,800	8,436,628	173

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	1966					1967				
	Zinc in pigments and compounds produced from—				Total zinc in pigments and compounds	Zinc in pigments and compounds produced from—				Total zinc in pigments and compounds
	Ore		Slab zinc	Secondary material		Ore		Slab zinc	Secondary material	
	Domestic	Foreign				Domestic	Foreign			
Zinc oxide	76,851	28,140	28,438	28,546	161,975	65,719	29,057	29,774	25,131	149,681
Leaded zinc oxide	4,269	2,294	------	------	6,563	3,235	2,922	------	------	6,157
Total	81,120	30,434	28,438	28,546	168,538	68,954	31,979	29,774	25,131	155,838
Zinc chloride [2]	------	------	W	W	14,141	------	------	W	W	12,080
Zinc sulfate	W	W	------	9,725	17,911	3,430	4,076	------	W	16,015

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	1963	1964	1965	1966	1967
Zinc oxide:					
Rubber	82,776	93,568	103,057	104,866	94,388
Paints	34,382	31,176	30,249	27,100	24,547
Ceramics	9,381	9,447	10,009	12,147	9,850
Chemicals	NA	NA	11,365	13,678	17,509
Agriculture	NA	NA	977	1,559	5,048
Photocopying	NA	NA	W	11,405	14,039
Coated fabrics and textiles	W	W	W	W	W
Floor covering	W	438	363	W	W
Other	35,732	39,674	30,550	22,910	16,105
Total	162,271	174,303	186,570	193,665	181,486
Leaded zinc oxide:					
Paints	14,899	13,124	10,951	r 10,462	8,644
Rubber; Other and unspecified	574	489	899	r 1,095	1,662
Total	15,473	13,613	11,850	r 11,557	10,306

r Revised.
W Withheld to avoid disclosing individual company confidential data, included with "Other."
NA Not available.

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
1963	W	W	10,785	9,407	29,326	23,674	40,111	33,081
1964	18,066	16,103	11,248	9,807	17,292	11,231	46,606	37,141
1965	21,204	18,886	14,331	12,449	15,009	10,637	50,544	41,972
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

W Withheld to avoid disclosing individual company confidential data, included with "other."

Table 25.—U.S. exports of zinc pigment

Kind	1966 Short tons	1966 Value (thousands)	1967 Short tons	1967 Value (thousands)
Zinc oxide	3,633	$1,089	3,440	$1,064
Lithopone	3,017	644	735	267
Total	6,650	1,733	4,175	1,331

Table 26.—U.S. imports for consumption of zinc pigments and compounds

Kind	1966 Short tons	1966 Value (thousands)	1967 Short tons	1967 Value (thousands)
Zinc oxide	14,492	$2,787	13,767	$2,567
Zinc sulfide	363	119	431	143
Lithopone	182	33	116	22
Zinc chloride	1,594	266	1,167	197
Zinc sulfate	1,616	177	3,291	351
Zinc cyanide	100	73	46	35
Zinc compounds, n.s.p.f	302	178	170	89
Total	18,649	3,633	18,988	3,404

Table 27.—Stocks of zinc at zinc-reduction plants in the United States, Dec. 31

(Short tons)

	1963	1964	1965	1966	1967
At primary reduction plants	46,374	30,680	27,635	63,626	81,307
At secondary distilling plants	1,536	498	987	1,172	609
Total	47,910	31,178	28,622	64,798	81,916

Table 28.—Consumer stocks of slab zinc at plants, Dec. 31, by industries

(Short tons)

Date	Galvanizers	Brass mills [1]	Zinc die-casters [2]	Zinc rolling mills	Oxide plants	Other	Total [3]
Dec. 31, 1966	r 71,229	r 15,646	r 35,920	3,371	463	r 2,964	r 129,593
Dec. 31, 1967	56,617	14,287	24,770	2,578	675	3,529	102,456

r Revised.
1 Includes brass mills, brass ingot makers, and foundries.
2 Includes producers of zinc-base alloy for diecastings, stamping dies, and rods.
3 Stocks on Dec. 31, 1966, and Dec. 31, 1967, include 261 and 270 tons, respectively, of remelt spelter.

Table 29.—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	1966			1967		
	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] [3]		East St. Louis	London [2] [3]
January	$92.00	14.50	13.73	$92.00	14.50	12.68
February	92.00	14.50	13.60	92.00	14.50	12.80
March	92.00	14.50	13.64	92.00	14.50	12.67
April	92.00	14.50	12.64	92.00	14.50	12.34
May	92.00	14.50	12.25	88.40	13.65	12.48
June	92.00	14.50	12.32	86.00	13.57	12.44
July	92.00	14.50	12.00	84.00	13.50	12.03
August	92.00	14.50	12.02	84.00	13.50	12.09
September	92.00	14.50	12.27	84.00	13.50	11.91
October	92.00	14.50	12.52	84.00	13.50	11.88
November	92.00	14.50	13.07	84.00	13.50	12.40
December	92.00	14.50	12.95	84.00	13.50	12.06
Average for year	92.00	14.50	12.75	87.20	13.85	12.37

[1] Joplin: Metal Statistics, 1967. East St. Louis: Metal Statistics, 1967. London: Metals Week.
[2] Conversion of English quotations into U.S. money based on average rates of exchange recorded by Federal Reserve Board.
[3] Average of daily mean of bid and asked quotations at morning session of London Metal Exchange.

Table 30.—Average price received by producers of zinc, by grades

(Cents per pound)

Grade	1963	1964	1965	1966	1967
Special High Grade	11.66	14.17	15.05	14.93	14.06
High Grade	11.61	13.64	14.55	14.63	14.12
Intermediate	11.79	14.03	14.70	14.85	13.99
Brass Special	11.80	13.90	14.62	15.02	13.94
Select	11.29	13.55	14.88	--------	--------
Prime Western	11.35	12.97	14.16	14.36	13.81
All grades	11.55	13.64	14.62	14.69	13.96
Prime Western; spot quotation at St. Louis [1]	12.01	13.57	14.50	14.50	13.85

[1] Metal Statistics, 1968.

Table 31.—U.S. exports of slab and sheet zinc, by countries

(Short tons)

Destination	Slabs, pigs, and blocks			Sheets, plates, strips, or other forms, n.e.c.		
	1965	1966	1967	1965	1966	1967
Argentina	(1)	-------	(1)	18	29	42
Australia	-----	-------	-------	74	42	24
Belgium-Luxembourg	-----	-------	-------	12	-------	11
Brazil	789	61	188	42	44	7
Canada	211	191	1,198	2,144	2,059	1,934
Chile	172	69	142	60	102	59
Colombia	23	21	93	33	49	34
Denmark	-----	-------	(1)	74	48	34
Germany, West	2	1	451	1,572	773	18
India	1,822	4	13,724	10	3	-------
Italy	-----	1	-------	38	33	7
Korea, South	1,858	-------	-------	-------	1	3
Mexico	1	29	6	19	18	32
Netherlands	-----	-------	-------	59	48	18
New Zealand	-----	-------	-------	77	23	48
Philippines	225	-------	350	33	30	12
South Africa, Republic of	62	-------	-------	114	149	113
Spain	49	47	25	47	21	18
Sweden	-----	-------	-------	29	22	26
Switzerland	-----	-------	-------	5	20	27
Turkey	350	-------	357	(1)	2	-------
United Kingdom	1	2	-------	168	148	149
Venezuela	100	512	148	92	332	188
Viet-Nam, South	-----	46	67	-------	664	481
Other	274	422	60	400	261	280
Total	5,939	1,406	16,809	5,120	4,921	3,565

[1] Less than ½ unit.

Table 32.—U.S. exports of zinc by classes

Year	Slabs, pigs, or blocks		Sheets, plates, strips, or other forms, n.e.s.		Zinc scrap and dross (zinc content)		Semifabricated forms, n.e.s.	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1965	5,939	$1,765	5,120	$3,051	5,617	$1,153	2,764	$1,931
1966	1,406	749	4,921	3,198	4,469	702	r 3,034	r 1,894
1967	16,809	4,287	3,565	2,709	1,665	530	2,161	1,177

r Revised.

Table 33.—U.S. imports of zinc, by countries

(Short tons)

Country	1965	1966	1967
Ores (zinc content):			
Algeria	4,408	164	9,264
Australia	2,667	4,334	4,836
Bolivia	4,093	5,788	9,576
Canada	201,353	272,950	289,387
Germany, West	1,341	9,685	6,248
Guatemala	4	318	-------
Honduras	6,786	10,776	9,727
Mexico	117,354	114,677	119,135
Morocco	5,037	7,407	6,516
Netherlands	-------	3,198	-------
Peru	73,721	78,254	69,357
Philippines	9	25	-------
South Africa, Republic of	11,267	12,565	8,419
Yugoslavia	-------	769	-------
Other	-------	410	1,627
Total	428,040	521,320	534,092

Country	1965	1966	1967
Blocks, pigs, or slabs:			
Australia	1,120	27,007	7,187
Belgium-Luxembourg	8,889	27,469	16,100
Canada	88,554	116,778	80,487
Congo (Kinshasa)	12,614	12,814	2,921
Germany, West	230	6,062	939
Japan	12,995	19,805	41,621
Mexico	12,787	22,702	18,673
Norway	-------	4,032	3,753
Peru	10,323	30,805	33,568
Poland	-------	5,421	9,870
Spain	1,768	926	2,094
United Kingdom	-------	258	1,145
Yugoslavia	887	551	474
Other	2,823	3,545	3,280
Total	152,990	278,175	222,112

Table 34.—U.S. imports for consumption of zinc, by classes

Year	Ore (zinc content)		Blocks, pigs, and slabs		Sheets, plates, strips, and other forms	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1965	402,936	$53,829	153,957	$42,605	1,381	$453
1966	396,375	51,696	280,307	75,624	1,708	670
1967	431,319	58,075	222,002	57,531	648	276

Year	Old and worn out		Dross and skimmings		Zinc dust		Total value [1]
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	
1965	1,576	$337	3,125	$667	244	$57	$97,948
1966	2,032	402	4,531	893	1,286	398	129,683
1967	1,465	240	2,498	433	3,771	1,211	117,766

[1] In addition, manufactures of zinc were imported as follows, 1965, $481,431; 1966, $545,003; 1967, $318,287.

Table 35.—U.S. imports for consumption of zinc, by countries

(Short tons)

Country	1965	1966	1967	Country	1965	1966	1967
Ores (zinc content):				Blocks, pigs, or slabs:			
Algeria	1,655	164	9,264	Australia	1,766	27,007	7,187
Australia	3,307	-------	3,334	Belgium-Luxembourg	9,101	27,469	15,989
Bolivia	2,932	321	137	Canada	88,585	116,758	80,482
Canada	202,004	233,093	274,854	Congo (Kinshasa)	12,614	12,814	2,921
Germany, West	1,341	5,945	24	Germany, West	248	6,063	939
Guatemala	4	318	-------	Japan	11,092	21,712	41,621
Honduras	8,246	677	1,612	Mexico	12,787	22,773	18,673
Mexico	104,939	87,112	83,653	Peru	10,356	30,854	33,568
Peru	60,619	52,718	45,274	Poland	-------	5,421	9,870
Philippines	25	-------	55	Spain	3,230	1,050	2,094
South Africa, Republic of	11,425	12,440	9,584	United Kingdom	336	258	1,145
Other	6,439	3,587	3,528	Yugoslavia	887	551	474
				Other	2,955	7,577	7,039
Total	402,936	396,375	431,319	Total	153,957	280,307	222,002

Table 36.—World mine production of zinc (content of ore) recoverable where indicated, by countries [1] [2] [3]

(Short tons)

Country [2]	1963	1964	1965	1966	1967 p
North America:					
Canada	497,180	729,939	r 910,928	r 1,046,963	1,248,977
Guatemala [4]	1,289	----------	938	r 549	272
Honduras	r [5] 8,230	9,445	12,265	13,661	14,383
Mexico	r 264,354	r 259,708	r 247,883	r 241,604	317,854
United States [4]	529,254	574,858	611,153	572,558	549,413
South America:					
Argentina	31,677	25,257	32,715	r 29,270	30,038
Bolivia	r 4,662	r 10,523	r 14,999	r 17,646	18,468
Brazil	----------	----------	r 5,750	NA	NA
Chile	557	1,108	r 1,524	2,301	1,238
Colombia e	100	110	r 53	r 330	610
Ecuador	395	r 420	260	149	177
Peru [4]	214,836	260,873	280,533	284,196	350,450
Europe:					
Austria [4]	7,816	8,004	7,609	8,568	8,952
Bulgaria	63,831	70,775	73,036	e r 90,000	e 90,000
Finland	73,142	69,436	76,070	59,938	e 62,500
France	20,060	18,564	23,040	r 25,677	e 28,000
Germany:					
East e	r 11,000	r 11,000	r 11,000	r 13,000	13,000
West	119,213	122,699	120,284	117,462	116,803
Greece [6]	r 13,730	r 11,410	r 11,660	r 8,600	11,500
Hungary	2,900	3,100	3,600	e 3,600	NA
Ireland	----------	----------	1,584	r 27,300	26,900
Italy	r 118,291	122,720	127,438	r 128,277	136,397
Norway	14,383	13,771	r 14,261	r 14,673	e 13,400
Poland	r 162,100	r 166,100	r 167,700	r 165,700	216,200
Portugal	r 188	1,049	r 3,254	r 2,585	NA
Spain	101,118	97,509	r 43,283	60,659	65,154
Sweden	93,682	85,070	r 87,000	r 94,000	NA
U.S.S.R. e [4]	r 440,000	r 470,000	r 520,000	r 550,000	590,000
Yugoslavia	97,317	101,193	101,213	96,121	e 95,000
Africa:					
Algeria	r 40,000	38,932	42,334	e r 13,000	e 13,000
Congo (Brazzaville)	786	5,578	e 7,600	e 7,600	NA
Congo (Kinshasa)	114,139	116,338	131,345	126,600	88,469
Morocco	36,418	46,678	56,458	r 59,218	50,178
South-West Africa, [4] Territory of	36,715	r 35,311	r 32,936	r 31,132	e 26,000
Tunisia	4,809	3,681	5,222	6,387	4,577
Zambia	42,100	r 52,000	r 52,200	70,100	NA
Asia:					
Burma	8,865	8,438	8,579	e r 7,000	e 5,100
China, mainland e	110,000	110,000	110,000	110,000	100,000
India	6,460	6,520	5,861	5,386	5,809
Iran [7]	e 11,000	e r 17,000	e r 17,000	e r 19,000	NA
Japan	218,209	238,602	243,633	r 279,577	289,038
Korea:					
North e	110,000	110,000	115,000	115,000	125,000
South	1,245	2,800	7,844	12,889	15,117
Philippines	4,291	2,355	2,270	1,817	1,706
Thailand	r 942	1,520	r 2,326	e r 2,600	----------
Turkey	5,044	6,268	r 8,000	r 3,770	NA
Oceania: Australia	393,647	385,953	r 391,139	r 413,655	445,783
Total [8]	r 4,035,975	r 4,432,615	r 4,750,780	r 4,960,118	5,175,463

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

[1] Data derived in part from the International Lead and Zinc Study Group Monthly Bulletin, Yearbook of the American Bureau of Metal Statistics, the United Nations Statistical Yearbook, the Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London), and Metal Statistics (Metallgesellschaft) Germany.

[2] Czechoslovakia produces concentrate for export, and North Viet-Nam and Rumania also produce zinc, but data are not available.

[3] Compiled mostly from data available June 1968.

[4] Recoverable.

[5] United States imports.

[6] Estimated content of zinc concentrate only.

[7] Year ended March 20 of year following that stated.

[8] Totals are of listed figures only, no undisclosed data included.

Table 37.—World smelter production of zinc, by countries [1] [2] [3]

(Short tons)

Country [2]	1963	1964	1965	1966	1967 p
North America:					
Canada	284,021	337,728	r 358,498	382,612	396,134
Mexico [4]	62,557	65,506	69,158	78,909	NA
United States	892,584	954,084	994,402	1,025,066	938,830
South America:					
Argentina	r 21,700	r 24,500	r 26,000	24,563	e 25,000
Brazil	-------	-------	e 85	NA	NA
Peru	61,231	68,016	68,829	69,033	69,443
Europe:					
Austria	13,074	14,215	14,455	15,654	15,605
Belgium [5]	227,437	245,308	r 264,300	r 277,500	250,586
Bulgaria	61,800	64,657	72,492	e 66,000	e 72,000
France (including dust)	186,392	209,706	211,683	r 216,043	203,600
Germany:					
East e	11,000	11,000	11,000	r 13,000	12,500
West	115,969	117,988	118,724	135,558	113,155
Hungary	1,700	1,500	1,700	e 1,600	NA
Italy	81,091	80,483	89,175	85,130	98,134
Netherlands	39,421	41,559	44,997	45,588	39,357
Norway	r 50,707	53,304	57,955	r 56,350	60,324
Poland	r 199,700	r 206,000	r 209,900	r 213,000	NA
Spain	71,353	71,023	r 58,991	61,280	76,791
U.S.S.R. e	r 510,000	r 545,000	r 590,000	r 625,000	660,000
United Kingdom	110,911	122,396	117,742	111,715	115,000
Yugoslavia	46,539	49,066	50,778	56,316	58,630
Africa:					
Congo (Kinshasa)	58,118	61,237	62,853	r 67,800	67,783
Zambia	54,510	51,491	52,289	r 46,600	49,035
Asia:					
China, mainland (refined) e	100,000	100,000	100,000	100,000	90,000
India	-------	-------	-------	-------	e 5,000
Japan	311,148	348,420	405,433	r 489,598	505,906
Korea:					
North e	70,000	75,000	80,000	80,000	90,000
South	-------	-------	-------	1,570	2,709
Oceania: Australia	201,350	207,795	222,867	217,739	217,809
Total [6]	r 3,844,313	r 4,126,982	r 4,354,306	r 4,563,224	4,233,331

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

1 Data derived in part from the International Lead and Zinc Study Group Monthly Bulletin, Yearbook of the American Bureau of Metal Statistics, the United Nations Monthly Bulletin and Statistical Yearbook, Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London), and Metal Statistics (Metallgesellschaft) Germany.

2 North Viet-Nam and Rumania also produce zinc, but production data are not available.

3 Compiled mostly from data available June 1968.

4 In addition, other zinc-bearing materials were as follows: 1963, 3,400; 1964, 3,839; 1965, 7,241; 1966, 10,729; and 1967, NA.

5 Includes production from reclaimed scrap.

6 Totals are of listed figures only, no undisclosed data included.

Zirconium and Hafnium

By Robert F. Griffith [1]

Zircon production in the United States in 1967 increased about 4 percent over that of 1966.

Consumption for the past 3 years was about equal at 130,000 to 135,000 tons per year. The 30-percent decrease in consumption by foundries in 1967 was compensated by increased usage in ceramics and the production of metal and alloys. A sharp increase in orders for commercial nuclear power reactors was largely responsible for the increased zirconium and hafnium sponge production of 42 and 75 percent, respectively. Net imports of zircon remained at about 57,000 tons with Australia continuing to supply over 97 percent.

Legislation and Government Programs.—There is no objective for the two types of zirconium mineral concentrate in the national stockpile. Stocks of the 16,514 tons of Brazilian baddeleyite, containing 11,162 tons of zirconium dioxide, and 1,721 tons of low-grade material, containing 398 tons of zirconium dioxide, are for sale by the General Services Administration. The Atomic Energy Commission had a yearend inventory of 1,500 tons of zirconium sponge and 37.5 tons of hafnium crystal bar.

Table 1.—Salient zirconium and hafnium statistics in the United States

(Short tons)

	1966	1967
Zircon:		
Production	W	W
Imports	57,976	59,303
Exports	2,311	2,729
Consumption [1]	[1] 34,000	[e] 134,000
Stocks, yearend, dealers and consumers [1]	38,000	48,000
Zirconium oxide:		
Production [2]	4,000	8,625
Producers' stocks, yearend [3]	1,169	1,132

[e] Estimate. W Withheld to avoid disclosing individual company confidential data.
[1] Excludes foundries.
[2] Excludes that used in metal manufacture.
[3] Excludes that used in metal manufacture and the equivalent zirconia content of refractories.

DOMESTIC PRODUCTION

Zircon was recovered as a byproduct of processing titanium mineral bearing sands at two dredging operations and a mill operated by E. I. du Pont de Nemours & Co., Inc. on the Trail Ridge deposit in Florida; a dredging operation and mill at Folkston, Ga., operated by Humphreys Mining Co. for Du Pont; and from tailings at the old Skinner mine, near Jacksonville, Fla., which were reworked, principally for the recovery of monazite-xenotime by Carpco Research and Engineering, Inc., for National Lead Co.

Domestic reserves of zircon are large but can not be exploited for the zircon alone. The probable increase in the production of titanium minerals from sand deposits will increase the capability to expand zircon production enough to satisfy foreseeable demand.

Production of milled zircon by five companies remained near the 1966 level of 35,000 tons. Zirconium oxide production for other than metal manufactured totaled to about 8,600 tons. Production of refractories containing an average of about 57 percent zirconia decreased 22 percent to 25,000 tons.

Zirconium sponge production increased 42 percent over that of 1966, in response to increase demand for the metals used in reactor tubing. Plant expansions that are in progress will increase U.S. sponge capacity to an estimated 3.2 million

[1] Commodity specialist, Division of Mineral Studies.

pounds by yearend 1968. Changes in ownership of the two domestic producers of zirconium and hafnium sponge were made in 1967. The Wah Chang Corp. facility at Albany, Ore., was acquired by Teledyne, Inc., of Los Angeles, Calif. On May 16, Amax Specialty Metals, Inc., of Akron, N. Y., a wholly owned subsidiary of American Metal Climax, Inc., became sole owner of the sponge plant at Parkersburg, W. Va., and the mill at Akron, N. Y., by purchasing the 50-percent interest held by Carborundum Metals Company.

Ingot production increased 27 percent to 1,270 tons; powder, 110 percent to 128 tons; crystal bar and miscellaneous milled and fabricated products, exclusive of tubing, 47 percent to 663 tons. Scrap recovery decreased 40 percent, to 289 tons. However, ferro and other alloys, exclusive of the zircalloys, rebounded from a 54-percent drop in 1966, to 3,759 tons, more than double the 1966 production.

Reflecting the increase in zirconium sponge production, output of hafnium oxide increased 38 percent and sponge, 75 percent.

In late 1966, Westinghouse Electric Corp. announced plans to build a zirconium ingot melting facility and a mill at Blairsville, 40 miles east of Pittsburgh to produce zirconium alloy tubing for nuclear power reactors. The plants were scheduled for production in late 1967 and early 1968.

Construction was started on a manufacturing plant for zirconium alloy tubing at Kennewick, Wash., by Sandvik Specialty Metals Corp., owned jointly by United Nuclear Corp. and Sandvikens Jernverk, of Sweden. Startup is scheduled for mid–1968.

Plans for the merger of Harbison-Walker Refractories with Dresser Industries, Inc., were announced.

Producers of zircon products in 1967 were as follows:

Company:	*Location*	*Product*
Carpco Research & Engineering Inc.[1]	Jacksonville, Fla	Zircon.
Continental Mineral Processing Co	Sharonville, Ohio	Zircon milled.
Corhart Refractories Co	Buckhannon, W.Va	Zircon and zirconia refractories.
Do	Corning, N.Y	Do.
Do	Louisville, Ky	Do.
E. I. du Pont de Nemours & Co., Inc	Trail Ridge, Fla	Zircon.
A. P. Green Refractories Co., Remmey Division.	Philadelphia, Pa	Zircon and zirconia refractories.
Harbison-Carborundum Corp	Falconer, N.Y	Do.
Harbison-Walker Refractories Co	Mount Union, Pa	Do.
Howmet Corp., Minerals Division	Camden, N.J	Zircon milled.
Humphrey Mining Co	Folkson, Ga	Zircon.
M&T Chemicals, Inc	Andrews, S.C	Zircon milled.
National Lead Co., Titanium Alloy Manufacturing Division (TAM).	Niagara Falls, N.Y	Do.
Shieldalloy Corp	Newfield, N.J	Do.
The Chas. Taylor Sons Co	Cincinnati, Ohio	Zircon and zirconia refractories
Do	South Shore, Ky	Do.
Walsh Refractories Corp	St. Louis, Mo	Do.

[1] From tailings.

Producers of zirconium products in 1967 were as follows:

Company:	Location	Product
Alcan	Riverside, Calif	Mill and other fabricated products.
Amax Specialty Metals, Inc	Akron, N.Y	Alloys, ingots, tubing.
Do	Parkersburg, W.Va.	Mill and other fabricated products, sponge.
Custom Tube Division, Clark & Wheeler, Inc.	Paramont, Calif	Mill and other fabricated products.
Foote Mineral Co	Exton, Pa	Alloy powder.
Harvey Aluminum, Inc	Torrence, Calif	Ingots, tubing.
Jessop Steel Co	Washington, Pa	Mill and other fabricated products.
Latrobe Steel Co	Latrobe, Pa	Do.
M&T Chemicals Inc	Rahway, N.J	Chloride, oxide.
Metal Hydrides, Inc	Beverly, Mass	Alloy powder, carbonitride and hydride.
National Lead Co., Titanium Alloy Manufacturing Division (TAM).	Niagara Falls, N.Y.	Alloys, carbonitride and hydride, chloride, compounds, oxide.
Norton Co	Huntsville, Ala	Oxide.
Nuclear Materials & Equipment Corp.	Apollo, Pa	Alloy powder.
Ohio Ferro-Alloy Corp	Canton, Ohio	Alloys.
Oregon Metallurgical Corp., (OREMET).	Albany, Oreg	Ingots, mill and other fabricated products.
Reactive Metals, Inc	Niles, Ohio	Mill and other fabricated products, tubing.
Rem, Inc	Albany, Oreg	Mill and other fabricated products.
Shieldalloy Corp	Newfield, N.J	Alloys.
Tizon Chemical Corp	Flemington, N.J	Compounds, oxide.
Transelco, Inc	Penn Yan, N.Y	Alloys, compounds.
Union Carbide Corp	Alloy, W.Va	Alloys.
Do	Niagara Falls, N.Y.	Do.
Vanadium Corporation of America	Cambridge, Ohio	Do.
Ventron Corp	Beverly, Mass	Do.
Wah Chang Albany Corp	Albany, Oreg	Alloys, ingots, mill and other fabricated products, sponge.
Wolverine Tube Division, Calumet & Hecla Inc.	Allan Park, Mich	Tubing.
Zircon Corporation of America	Solon, Ohio	Oxide.

Producers of hafnium products in 1967 were as follows:

Company:	Location	Product
Amax Specialty Metals, Inc	Akron, N.Y	Oxide, sponge and/or products.
Do	Parkersburg, W.Va.	Do.
Climax Molybdenum Co. of Michigan.	Coldwater, Mich	Do.
NUMEC	Apollo, Pa	Do.
Reactive Metals, Inc	Niles, Ohio	Do.
Wah Chang Albany Corp	Albany, Oreg	Do.

CONSUMPTION AND USES

Zircon consumption in the United States in 1967 was estimated at 134,000 tons, up slightly from 1966. Consumption in foundry sand facings, and blasting grain fell from 60 percent in 1966 to 45 percent, but this decline was more than offset by increased usage in ceramics and metal and alloys.

Information supplied by the principal dealers and consumers indicated that refractories consumed 21 percent of zircon; porcelains, enamels, glazes, pottery, and other ceramic applications, 19 percent; metal and alloys, 12 percent; and chemicals and others, 3 percent.

In foundry applications, the greater

density of zircon and its higher price result in a mold or core cost several times that of silica sand. Nevertheless, because it gives a better finish, reduces surface inclusions, metal penetration, and scabs, and lowers cleaning costs zircon is competitive, and foundry use continued as its largest market. The drop in zircon consumption by foundries in 1967 was believed to have resulted from the substantially increased use of washed and graded chromite sands, which occurred during the year. Although chromite sand has disadvantages its cost is lower and it will continue to be used where specifications are less exacting.

Most zirconium bearing refractories produced, consisted of bricks and shapes made predominantly from zircon and zirconia. Expressed as the equivalent of 9-inch bricks, shipments in 1966 increased 63 percent over those of 1965, to 1.96 million bricks valued at $5.97 million, about a 20-percent decrease in unit price. Preliminary data for 1967 indicated that shipments decreased 27 percent compared with 1966, to 1.44 million bricks valued at $5.4 million.[2]

Consumption of zircon for ceramics increased from an estimated 12 percent of total zircon consumption in 1966 to about 19 percent in 1967. Zirconium compounds are desirable as opacifiers in ceramic enamels and glazes because of their high reflectivity of light and thermal stability.

Diversified uses of zirconium oxide, in addition to those in refractories and ceramics, include heat exchangers, high-temperature bearings, fuel cells, and missile nose cones. Air under pressure of 2,000 pounds per square inch is ducted over and through hexagonal blocks of zirconium oxide heated to 4,200° F in a wind tunnel. The heat is transferred to the air, causing it to expand and blast through the tunnel at more than 5,000 miles per hour.[3]

Similar hexagonal blocks are also used in heat exchangers handling high-temperature fluids. Both the races and balls of an antifriction bearing that withstood 1,500°F in U.S. Air Force tests were made of zirconia.[4] A zirconium oxide solid-electrolyte fuel cell was used to regulate the flow of air and fuel in a furnace control system.[5]

Zirconium metal and alloy consumption kept pace with the expansion of its major market, the nuclear industry. Since early 1966, U.S. utility companies have ordered nuclear power reactors with a combined capacity of over 40,000 megawatts. Each megawatt requires from 100 to 175 pounds of zirconium. Zirconium alloy tubing, because it is extremely resistant to corrosion and readily allows the passage of thermal neutrons without capturing or absorbing them, is the choice material for the fuel-rod cladding that contains enriched uranium. About 500,000 feet of tubing having an average weight of about 0.1 pound per foot was used in each new reactor. Zirconium was also used for reactor structural purposes. The boiling water type reactor uses an estimated 40 percent of total zirconium requirement for structural members and the pressurized water type about 10 percent. Thus, on the order of 30 to 45 tons of zirconium was required for each new nuclear power reactor of the capacity ordered in 1967. A continuing market exists because one-fourth to one-third of the zirconium tubing must be replaced each year, and there is no scrap salvage from the used tubes.

The Navy Nuclear Program is also a major consumer of zirconium and hafnium for use in its various nuclear powered vessels.

Reactor-grade, high-ductile zirconium is used as finely shredded foil in camera flash bulbs. An estimated 60 tons was consumed for this increasingly important application because zirconium provides a brighter, higher-peak flash than competitive materials. About 3 percent of the zirconium consumed was used as a material of construction in petrochemical plants and in urea, sulfuric acid, and hydrochloric acid processing plants since its excellent anticorrosion properties justified the higher cost compared with competitive materials.

A promising use of zirconium alloys is in the production of huge electromagnets with inner coils made from zirconium-copper, a material with high conductivity and mechanical strength. Zirconium-columbium superconducting solenoid lenses are used in cryogenic equipment in an electron microscope system. A new English-devel-

[2] U.S. Department of Commerce, Bureau of the Census. Refractories. Current Ind. Repts., Summary for 1966, Ser. M32C(66)-5, May 24, 1967.
[3] Ceramic Age. Zirconium Oxide Heat Exchanges. V. 83, No. 6, June 1967, p. 45.
[4] Iron Age. Ball Bearing Survives 1,500° F. V. 199, No. 3, Jan. 19, 1967, p. 25.
[5] Chemical & Engineering News. V. 45, No. 22, May 22, 1967. p. 53.

oped titanium alloy for jet aircraft contains zirconium and tin. Columbium-base alloys with zirconium have resistance to molten metals and were developed for use at elevated temperatures and for superconducting applications, such as in superconducting magnets. Another columbium-base alloy with 10 percent hafnium, 10 percent tungsten, and 0.10 percent yttrium is dispersion-hardened by the creation of hafnium carbides and has excellent strength and formability and superior weld ductility.

A new alloy, 80 percent hafnium and 20 percent tantalum, is used as cladding to protect refractory alloys against oxidation up to 2,200° C, and may be suitable for rocket nozzles, thrust inserts, turbine-engine components, and space-vehicle leading edges.

A refractory zirconia cloth, its thermal and chemical stability enhanced by yttria, is stable up to 1,600° C in oxidizing, reducing, inert gas, and vacuum atmospheres, and may have use in ablative plastics, filter media, and high-temperature insulation. Long-lived cutting tools based on tantalum nitride with 40 percent zirconium diboride are used for machining refractory materials.

Among the zirconium compounds, the hydroxide was used as a constituent of ceramic colors and stains; the ammonium carbonate solution in water-repellent formulations for textiles, leather, paper, and in latex paints; the acetate for water repellants and for leather re-tan; and the oxychloride as a fixative agent for starch finishes on cotton textiles.

The principal use for hafnium is in control rods for naval reactors, where, in contrast to zirconium, the element acts as a barrier to, and captures, thermal neutrons. The next important use was as a strengthening agent in refractory alloys of columbium, tantalum, molybdenum, and tungsten. A hafnium-tantalum alloy was used in rocket nozzle liner applications because of its excellent oxidation resistance.

STOCKS

At yearend, dealers and millers held 14,800 tons of crude and milled zircon, an increase of 2,100 tons over 1966 figure. Similar stocks held by the principal consumers, excluding foundries, increased 7,700 tons in 1967, to 33,200 tons. Stocks of zirconium oxide dropped 3 percent as reported by all producers and consumers, to 2,200 tons. Yearend stocks of metal and alloys included: 212 tons of sponge, 144 tons of ingot, 562 tons of scrap, 12 tons of powder, and 1,938 tons of alloys including ferrozirconium. Yearend stocks of zirconium-bearing refractories remained at about 9,000 tons. Yearend stocks of hafnium materials included: 155 tons of oxide, 32 tons of sponge, and 4 tons of crystal bar.

PRICES

The prices of zircon and its products remained relatively stable throughout the year. Zircon prices are closely allied to those for its coproduct, rutile, particularly in Australia. It is conceivable that a drop in the price of rutile would cause a corresponding increase in zircon prices in order to maintain profitable operations. The price and availability of hafnium are also controlled by the market for reactor-grade zirconium. Current practice is to apportion about half of the extraction and separation costs to each product.

Zircon and its products and compounds during 1967 were quoted as follows:

	Price
Zircon:	
Domestic, containing 66 percent ZrO_2, f.o.b. Starke, Fla., per short ton [1]	$47.25
Source not indicated, containing 66 percent ZrO_2, Camden, N.J., bulk, per short ton [1]	59.50
Imported, sand, containing 65 percent ZrO_2, c.i.f. Atlantic ports, in bags, per long ton [1]	61.00
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]	
Chemically pure white ground, barrels or bags, works per pound	1.50
Milled, bags, 5-ton lots, from works, per pound	0.645
Zirconium hydride:[2] Electronic grade, powder, drums, from works, per pound	14.50 to 16.00
Zirconium:	
Reactor-grade sponge, per pound [3]	5.00 to 7.00
Reactor-grade ingot and alloy ingot, per pound [3]	6.00 to 8.00
(Commercial grades about $1 per pound less)	
Strip, hot and cold rolled, per pound, average [3]	14.00
Plate, per pound, average [3]	10.00
Bars and rod, forged or hot rolled, per pound, average	12.00
Powder, commercial, per pound [4]	10.00
Zirconium compounds (f.o.b. warehouse Jersey City, N.J.), single-drum prices:[3]	
Basic sulfate, per pound of contained ZrO_2	0.91
Carbonate, per pound of contained ZrO_2	0.945
Hydroxide, per pound of contained ZrO_2	1.00
Oxide, per pound as is	0.95
Acetate, per pound as is	0.367
K_2ZrF6, per pound as is	0.565
Hafnium:[3]	
Sponge, per pound	75.00
Bar and plate, rolled, per pound	130.00

[1] Metals Week. V. 38, Nos. 1–52, January-December 1967.
[2] Oil, Paint and Drug Reporter. V. 192, No. 26, Dec. 25, 1966.
[3] Quoted by a leading producer.
[4] American Metal Market. V. 75, No. 1, January 1968.

FOREIGN TRADE

Materials classed as zirconium ore and concentrate weighing 2,729 tons and valued at $359,774, were exported to 16 countries, of which the major recipients were Canada with almost 2,000 tons, Colombia, Chile, Argentina, and Mexico. Although the average declared value was $132 per short ton, the values ranged from $84 (Canada) to $460, indicating that some of the material was processed beyond the milled stage. Unwrought zirconium and zirconium alloys plus waste and scrap, weighing 78,906 pounds and valued at $582,741, and wrought zirconium and alloys, weighing 558,706 pounds, and valued at $6,325,851, were shipped to 17 countries. The United Kingdom, Canada, and West Germany, in that order, received about 85 percent. Shipments of unwrought material to the United Kingdom dropped from 124,840 pounds in 1966 to 10,719 pounds in 1967. However, shipment of zircalloy tubes for nuclear power reactors increased from 130,339 pounds in 1966 to 260,567 pounds.

The unit value of zircon imports, over 97 percent from Australia, increased from $28.50 per short ton in 1966, to $32. Imports of zirconium oxide dropped to 170,210 pounds valued at $113,416, from 500,870 pounds valued at $160,544 in 1966. No shipments were recorded from Canada, a major supplier in 1966. Other zirconium compounds weighing 1,388,000 pounds and valued at $207,900 were received from five countries. The United Kingdom, with 25 percent of the weight and 42 percent of the value, and Japan, with 67 percent of the weight and 42 percent of the value, were the major suppliers.

Table 2.—U.S. imports for consumption of zircon, by countries

(Short tons)

Country	1965	1966	1967
Argentina	------	225	--------
Australia	57,744	56,231	57,908
Canada [1]	1,027	1,236	1,111
Ethiopia	------	110	--------
Malaysia	------	11	56
Norway	------	140	--------
Syrian Arab Republic	------	--------	228
United Arab Republic	------	23	--------
United Kingdom	102	--------	--------
Total:			
Quantity	58,873	57,976	59,303
Value (thousands)	$1,690	$1,652	$1,891

[1] Believed to be country of shipment rather than country of origin.

Imports of unwrought zirconium, waste and scrap, weighed 162,837 pounds and were valued at $487,649. About 111,600 pounds with an average value of $4 per pound came from France. The rest, from the United Kingdom, Canada, and West Germany, was valued at less than $1 per pound and was apparently scrap. Unwrought alloys from France and West Germany weighed 408 pounds and were valued at $3,313. Wrought zirconium, principally from Sweden, weighed 6,079 pounds, and was valued at $137,880. Ferrozirconium, principally from France, Japan, and Australia with minor quantity from the United Kingdom, weighed 1,451,614 pounds and was valued at $259,872. Unwrought hafnium, probably sponge or ingot, weighing 52 pounds and valued at $5,232, was received from West Germany.

WORLD REVIEW

World production of zircon by the non-Communist countries was estimated at 330,000 tons in 1965, of which Australia supplied 77 percent. World resources, current and potential production, reserves, marketing, and uses of zircon were discussed.[6] The United States consumes about 40 percent of the zircon produced in the free world.

[6] Ward, J. Prospects for Australian Zircon. Australian Mineral Industry, pt. 1, Quarterly Review, v. 19, No. 1, September 1966, pp. 13–21.

Table 3.—Free world production of zirconium concentrates: by countries [1]

(Short tons)

Country	1963	1964	1965	1966	1967 p
Australia	207,011	206,173	r 253,978	r 273,458	327,420
Brazil	392	569	543	r 546	NA
Ceylon	---------	---------	NA	167	NA
Korea, South	---------	-------	---------	90	6
Malagasy Republic	428	564	710	r 777	NA
Malaysia (zircon exports)	289	162	629	r 866	NA
Nigeria	886	171	---------	NA	NA
Senegal	3,383	611	---------	---------	NA
South Africa, Republic of	2,648	---------	---------	---------	---------
United Arab Republic	44	45	---------	r 429	NA
United States	W	W	W	W	W
Total [2]	215,081	208,295	255,860	276,333	327,426

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

[1] Compiled mostly from data available April 1968.

[2] Total is of listed figures only; no undisclosed data included.

Australia.—Zircon was produced as a coproduct of rutile from the East Coast field in New South Wales and Queensland by nine companies. The ratio of zircon to rutile ranges from 4:3 to 4:5. The combined productive capacity of these companies, including present expansion plans, is 325,000 short tons of zircon per year.

The West Coast field in southwestern Australia supplies zircon as a byproduct of ilmenite. Productive capacity of two companies recovering zircon is estimated at 40,000 tons per year.

Brazil.—A Government-owned company started a pilot plant unit at its plant in Sao Paulo for the production of zirconium and uranium from "Caldasito," a mixture of baddeleyite and zircon mined in the region of Poços de Caldas in Minas Gerais.

Canada.—Eldorado Mining & Refining, Ltd. began construction of a plant at Point Hope, Ontario, to produce 300 tons of reactor-grade zirconium alloy ingot per year. Production, scheduled for late 1968, will be by a new process developed with the financial aid of the Canadian Government's program for Advancement of Industrial Technology, which bypasses the sponge step and produces the desired alloy directly from a zirconium halide, in the reduction furnace.[7]

Germany, West.—Plans were announced by Wah Chang Corp. to construct a zirconium plant in West Germany with unnamed European partners. Startup is scheduled for late 1968.[8]

India.—Kilogram quantities of nuclear-grade zirconium oxide were produced at a pilot plant at Trombay and a larger plant was planned.[9] The Government banned the export of zircon sand under schedule 1 of the export control order.[10]

South Africa, Republic of.—Large deposits of heavy minerals, including an estimated 2.2 million tons of zircon, occur as beach deposits in the Bothaville District of the Orange Free State and in the Wolmaransstad, Delmas, and Carolina Districts of the Transvaal.[11]

TECHNOLOGY

The world's supply of zircon now comes principally from beach-sand deposits where zircon is recovered as a coproduct with rutile and other heavy minerals. As the richer deposits become exhausted, it will be necessary to rely on those of lower grade that contain 1 percent, or less, of total heavy minerals. A high-capacity, low-cost, lightweight, primary wet-gravity, cone-type separator was developed to treat economically marginal deposits of low-grade sand.[12]

The fastest growing use of zircon is in the production of hafnium-free zirconium metal and alloys used in nuclear power reactors. Because a small percent of nitrogen or other impurity adversely affects the mechanical properties of the metal, the "Zircaloys" were developed in the mid-fifties to eliminate unfavorable influences. Zircaloy–2, the first developed, contained 1.5 percent tin and minor quantities of iron, chromium, and nickel. In the later developed zircaloy–4, more iron was substituted for nickel. Studies to better understand the properties of these alloys and to improve their usefulness may lead to the development of new alloys.[13]

[7] Chemical Engineering. V. 74, No. 10, May 8, 1967, p. 84.

[8] Metals Bulletin (London). No. 5180, Mar. 10, 1967, p. 26.

[9] Department of Atomic Energy, Government of India. Annual Report, 1965–66. 1966, 60 pp.

[10] Metal Bulletin (London). No. 5170, Feb. 3, 1967, p. 27.

[11] Republic of South Africa Department of Mines. Quarterly Information Circular, Minerals, October–December 1966.

[12] Carpenter, J. Hall. The Reichert Cone Separator. Canada Min. and Met. J., v. 59, No. 656, December 1966, pp. 1413–1417.

[13] Agua, E. N., and C. M. Owens. The Microstructural Characterization of Cold-Rolled Zircaloy–4 Sheet. Trans. AIME, v. 239, 1967, pp. 155–161.

Babyak, W. J. Hydride Habit in Zirconium and in Unstressed and Stressed Zircaloy–4. Trans. AIME, v. 239, 1967, pp. 252–257.

Bertle, C. G. Diffusion of Zirconium in Zirconium Hydride. J. Am. Ceram. Soc., v. 50, No. 3, Mar. 21, 1967, pp. 166–167.

Davis, R. J. Oxide Growth and Capacitance on Preirradiated Zircaloy–2 and Zirconium. J. Electrochem. Soc., v. 114, No. 2, February 1967, pp. 124–127.

Marshall, R. P. Adsorption of Gaseous Hydrogen by Zircaloy–2. J. Less-Common Metals (Netherlands), v. 13, No. 1, July 1967, pp. 45–52.

Rosler, Ulrich. Zirconium and Its Alloys. Siemens Review, v. 33, No. 3, March 1966, pp. 211–216.

Slattery, G. F. The Terminal Solubility of Hydrogen in Zirconium Alloys Between 30 and 400° C. J. Inst. Metals (London), v. 95, P. 2, February 1967, pp. 43–47.

Steward, K. P., and B. A. Cheadle. The Effects of Preferred Orientation on the Mechanical Properties and Deformation Behavior of Zircaloy–2 Fuel Sheathing. Trans. AIME, v. 239, 1967, pp. 504–513.

Commercial grade zirconium sponge is produced by reducing zirconium tetrachloride with magnesium metal. In producing reactor grade (low-hafnium) sponge, commercial grade tetrachloride is treated by solvent extraction to separate the hafnium from zirconium, and the resulting zirconium oxide is chlorinated before final reduction to the metal. A new method using calcium reduction of zirconium fluoride was under development by Eldorado Mining and Refining at Port Hope, Ontario, Canada to directly produce specific alloys for use in nuclear power applications.[14]

The recognized contribution of automotive exhaust gases to air pollution has revived interest in electric-powered automobiles. Fuel cells, which convert chemical energy to electrical energy, are being considered as one possible power source. A solid electrolyte, high-temperature fuel cell using zirconia as the principal constituent of the electrolyte was developed.[15]

Because zircon refractories are resistant to abrasion and molten metals and have low thermal expansion, the refractory industry, exclusive of foundry sand use, accounts for about 20 percent of domestic zircon consumption. An isostatic pressing technique was developed for producing a high density, heat-resistant zircon refractory, weighing 265 pounds per cubic foot.[16]

A revised book describing the newer analytical procedures for zirconium, hafnium, and their alloys was published. It contains general sampling methods, safety measures, information on reagents, and analytical techniques employing absorptiometry, volumetry, polarography, flame photometry, atomic-adsorption spectrophotometry, and spectrography.[17]

Hafnium oxide is produced in conjunction with the production of reactor grade zirconium. The ratio of recovery is about 1 pound of hafnium oxide per 50 pounds of zirconium oxide. It is relatively expensive to make reactor grade hafnium metal used primarily for use in control rods for naval reactors. Crude hafnium tetrachloride must be purified to remove all traces of oxygen before reduction with magnesium. The resultant hafnium sponge is further purified by the iodide bar process to increase ductility.[18] A family of hafnium-base products, rare-earth pyrohafnates, was developed for use as control rods for commercial reactors. Reportedly, these materials are fully competitive with other control rod materials, such as silver-indium-cadmium alloys, that are used in the civilian nuclear market.[19]

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14 Metals Week. A New Way To Produce Zirconium. V. 35, No. 15, Apr. 10, 1967, p. 10.

15 Bray, Donald T., Lee D. La Grange, Ulrich Merten, and Charles D. Park (assigned to General Dynamics Corporation). Fuel Cell Having Zirconia-Containing Electrolyte and Ceramic Electrodes. U. S. Pat. 3,300,344, Jan. 24, 1967.

16 Blast Furnace and Steel Plant. V. 55, No. 1, January 1967, p. 83.

17 Elwell, W. T., and D. F. Dodd. Analysis of the New Metals Titanium, Zirconium, Hafnium, Niobium, Tantalum, Tungsten, and their Alloys. Pergamon Press, New York, 1966, 275 pp.

18 Nielsen, Ralph H. Hafnium and Hafnium Compounds. Encyclopedia of Chemical Technology. John Wiley & Sons, Inc., New York, v. 10, 1966, pp. 754–768.

19 American Metal Climax, Inc. AMAX News Release. Dec. 11, 1967.

Minor Metals

By Staff, Division of Mineral Studies

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ARSENIC [1]

Domestic Production.—Arsenic is produced in the United States solely as a byproduct of base-metal ores, primarily copper ore, and only at the Tacoma, Wash., plant of American Smelting and Refining Company. Production figures cannot be published. Production in 1967 was, however, severely curtailed by the strike at copper facilities beginning on July 15 and continuing through the end of the year.

Consumption and Uses.—Apparent consumption of arsenic, essentially all as white arsenic (As_2O_3), increased approximately 23 percent in comparison with that of the previous year as imports rose to over 54,100 pounds. Calcium and lead arsenate chemicals were the major end products with minor amounts of arsenic used in sodium arsenate, arsenic acid, and several other chemical compounds. Some of these products, especially herbicides, were in short supply in 1967 because demand for military and agriculture use increased beyond industry expectation.

Arsenic is primarily used for the toxic effect on plants and insects, and to a minor degree in alloying of metal such as lead to increase fluidity in shot casting. Small quantities of sodium arsenite are used as an algaecide in farm ponds, to kill off potato foliage before harvest, and a significant tonnage is used as a wood preservative. Arsenic acid is commonly used in Oklahoma and Texas as a cotton desiccant to remove leaves prior to mechanized harvest. Mono- and di-sodium methyl arsenates are used to control Johnson grass in cotton cultivation, particularly in the southeastern cotton growing area. Many rodenticides contain arsenic toxicants, and arsenic acid is used for parasitic control in chicken feed. Federal recommendations for use of calcium arsenate are now limited chiefly to the control of bollworm and cotton leafworm, and of lead arsenate to fruit insects and caterpillars. Substantial amounts of granular paris green, prepared from arsenic trioxide and acetate of copper, are used as a mosquito larvicide.

Table 1.—Consumption of arsenic wood preservatives in the United States

(Short tons)

Year	Consumption of Wood preservatives: Wolman salts (25 percent sodium arsenate)	Consumption of Wood preservatives: Other
1964	1,970	1,646
1965	1,864	2,283
1966	2,330	2,256

Source: Forest Service, U.S. Department of Agriculture.

[1] Prepared by Donald E. Moulds.

While synthetic compounds have curtailed or supplanted use of arsenic in many pesticide control applications, the widening use of pesticides, especially in developing countries, indicated a continued trend in consumption of arsenic.

Stocks.—Domestic producer stocks of white arsenic declined substantially as shipments exceeded production due to the strike. Heavy demand likewise indicated a drawdown of commercial stocks at manufacturing plants.

Prices.—The price of refined white arsenic, 99.5 percent, at New York docks, in barrels, small lots, increased on February 1 to 6 to 6½ cents per pound from the 5.35 cents-per-pound price effective April 1, 1966. This is the fifth consecutive increase at New York since 1962. Refined white arsenic in bulk carload lots at Laredo, Tex., continued at $87 per ton throughout the year and crude white arsenic remained at $69 per ton at Laredo, Tex., and Tacoma, Wash.

Arsenic metal was quoted in London at £445 per ton throughout the year although the pound devaluation reduced the U.S. equivalent price to 47.7 cents per pound in October 1967 from the prior 55.6 cents per pound.

The price of lead arsenate in 50-pound bags increased from 29 cents per pound to 30 cents, and sodium arsenate, 60 percent arsenic pentoxide, in ton lots, increased from 26 cents per pound to 29 cents during the year.

Foreign Trade.—No exports of arsenic metal or white arsenic were reported and data on exports of arsenical compounds were not available but constitute a significant quantity in the form of herbicides and other pesticides.

Imports of arsenic metal, sulfide, and white arsenic increased radically in 1967 in comparison with that of previous years. Import of arsenical compounds, however, declined. Total declared value of imports was approximately $2.89 million in 1967. Sweden continued to be the major supplier of metal contributing all except 573 pounds of the total metal imports. Mexico was the leading supplier of white arsenic with 42 percent of the total followed by Sweden, 23 percent; France, 21 percent; U.S.S.R., 6 percent; Belgium-Luxembourg, 4 percent; Republic of South Africa, 4 percent; and small amounts from the United Kingdom, Canada, and Peru. Belgium-Luxembourg supplied all of the sulfide material, and Canada, the United Kingdom, Belgium-Luxembourg, and West Germany supplied various arsenic compounds. The sheepdip originated in Australia.

Table 2.—U.S. imports for consumption of white arsenic (As_2O_3 content), by countries

Country	1965		1966		1967	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Belgium-Luxembourg	------	-------	(1)	(1)	1,107	$160
Canada	------	-------	--------	-------	90	11
France	3,447	$238	4,315	$331	5,557	466
Mexico	10,288	889	11,828	945	11,453	1,017
Peru	------	-------	--------	-------	18	1
South Africa, Republic of	------	-------	6	(1)	968	82
Sweden	1,691	136	2,526	201	6,245	616
U.S.S.R.	99	8	--------	-------	1,626	149
United Kingdom	------	-------	--------	-------	11	1
Total	15,525	1,271	18,675	1,477	27,075	2,503

[1] Less than ½ unit.

Table 3.—U.S. imports for consumption of arsenicals, by classes

(Thousand pounds)

Class	1965	1966	1967
White arsenic (As_2O_3 content)	31,050	37,350	54,149
Metallic arsenic	361	362	590
Sulfide	92	60	578
Sheepdip	20	----------	10
Calcium arsenate	--------	200	----------
Sodium arsenate	309	364	253

World Review.—Sweden is one of the major source countries with production from the Boliden mine of Boliden Mining Co. Ltd. having a reported production of 570,000 metric tons of arsenic since 1926. This mine was permanently shut down in late 1967 upon exhaustion of the ore deposit. Future arsenic production in Sweden will depend on output from other copper mines developed by the Boliden Company. A stockpile of arsenic materials previously accumulated at the Boliden plant was also reported to have been exhausted in 1966.

Producers in the European area were reported to be committed in early March for the 1967 production at about ½ cent-per-pound premium above prior contracts and spot-lots were very limited in the United Kingdom, France, and West Germany.

Production statistics for major producing areas are not currently available. The increasing foreign production of base-metal ores containing arsenic was reported to have been offset by lower arsenic yields and difficulties in initiating new production. The estimated output for 1967, excluding the United States, therefore appears to be in the general area of the 54,000 tons of white arsenic produced in 1965–66.

Table 4.—Production of white arsenic, in selected countries [1] [2]

(Short tons)

Country	1963	1964	1965	1966
Brazil	323	207	282	r 349
Canada	94	162	202	r 351
France	11,668	12,563	[3] 11,436	e 11,200
Germany, West [3]	62	42	78	416
Japan	904	550	528	603
Mexico [4]	14,666	16,380	15,188	r 15,152
Peru	683	685	550	r 402
Portugal	622	410	[5] 440	e 330
Rhodesia, Southern	605	206	e 70	NA
South-West Africa	--------	----------	----------	44
Spain	161	158	131	123
Sweden	16,369	19,809	18,188	r 16,204
U.S.S.R.e	7,200	7,200	7,500	r 7,600
Total [6]	r 53,357	r 58,372	r 54,593	r 52,774

e Estimate. r Revised. NA Not available.

[1] Arsenic may be produced in Argentina, Austria, Belgium, China (mainland), Czechoslovakia, East Germany, Finland, Hungary, United Kingdom, and Yugoslavia, but there is too little information to estimate production. U.S. figure withheld to avoid disclosing individual company confidential data.

[2] Compiled mostly from data available April 1968.

[3] Exports.

[4] Including black arsenic.

[5] Estimated equivalent recoverable arsenic trioxide content of concentrates produced.

[6] Total of listed figures only; no undisclosed figures are included.

CESIUM AND RUBIDIUM [2]

Domestic Production.—Two firms processed imported pollucite into cesium primary products in 1967 compared with four in 1966.

Cesium compounds were produced during both years by American Potash & Chemical Corp., Trona, Calif., and Penn

[2] Prepared by Donald E. Eilertsen.

Rare Metals Division of Kawecki Chemical Co., Revere, Pa., the latter firm also produced cesium metal. Dow Chemical Co., Midland, Mich., and Rocky Mountain Research, Inc., Denver, Colo., produced cesium primary products in 1966, but not in 1967. Shipments of cesium primary products (equivalent cesium) from all sources were somewhat smaller in 1967 than those in 1966; however, shipments in both years were near the annual average for 1961–65.

Penn Rare Metals was the only producer of rubidium primary products in 1966 and 1967. Shipments of rubidium primary products (equivalent rubidium) by this firm and by two former producers, American Potash & Chemical Corp., Trona, Calif., and MSA Research Corp., Callery, Pa., were much larger in 1967 than those in 1966, which were slightly larger than the annual average for 1961–65.

Consumption and Uses.—Pollucite consumption was small in 1967 compared with record usage in 1966. Rubidium raw material consumption was slightly larger in 1967 than in 1966. Statistical data on the consumption of cesium and rubidium primary products were not available.

No new large uses for cesium or rubidium were reported.

The National Aeronautics and Space Administration continued to use small quantities of cesium in research and development of advanced energy conversion or space propulsion systems. A milestone in the development of propulsion systems for long range space missions was achieved in 1966 when a cesium ion electric engine completed 341 days of continuous operation in a space simulation chamber.[3]

Various forms of cesium had applications such as in photomultiplier tubes, infrared lamps, scintillation, counters, and spectrophotometers. Rubidium and its compounds can be used as alternatives for cesium and its compounds for some uses.

Table 5.—Prices of cesium and rubidium and some of their salts

Item	1 to 277 grams (per gram)	1 to 9 pounds (per pound)	10 to 99 pounds (per pound)	100 to 999 pounds (per pound)	1,000 pounds and more (per pound)
Cesium, 99.5 percent	$1.40–$3.60	$250–$275	$200–$225	$150–$175	$100
Cesium, 99.9 percent	1.80– 4.00	300– 325	250– 275	190– 220	125
Cesium salts, technical grade:					
Carbonate and chloride	.21– .27	32	30	----------	----
Fluoride	.26– .32	40	38	----------	-----
Hydroxide	.30– .36	45	43	----------	-----
Rubidium, 99.5 percent	1.40– 3.60	275– 300	200– 250	150– 175	100
Rubidium, 99.8 percent	1.80– 4.00	325– 375	250– 315	190– 220	125
Rubidium salts, technical grade:					
Carbonate	.27– .31	41	39	----------	-----
Chloride	.33– .40	47	45	----------	-----
Fluoride	.48– .53	60	58	----------	-----
Hydroxide	.56– .62	67	65	----------	-----

Source: Penn Rare Metals Division, Kawecki Chemical Co.

Foreign Trade.—Data on the exports of cesium and rubidium metals and their compounds and on imports of cesium metal and rubidium compounds were not separately classified. Imports for consumption of cesium chloride were 22 pounds, valued at $557, from the United Kingdom; and 725 pounds, valued at $31,246, from West Germany. Imports of other cesium compounds totaling 1,680 pounds, valued at $51,866, were all from West Germany. Imports of rubidium totaling 327 pounds, valued at $3,769, were from Canada.

Technology.—The National Aeronautics and Space Administration continued its long range program involving the use of cesium in advanced energy conversion or space propulsion systems. Although these have an important potential for the future, they involve a very small present consumption.

In the field of energy conversion, studies comparing cesium and potassium as work-

[3] American Metal Market. Cesium Ion Engine Runs 341 Days. V. 73, No. 233, Dec. 5, 1966, p. 20.

ing fluids in boiling metal turbogenerator (Rankine Cycle) space powerplants have been completed by the Oak Ridge National Laboratory. Reports defining the conditions under which either metal exhibits superiority over the other are in draft form.

Several contractors, including the General Atomic Division of General Dynamics and the General Electric Company, have been determining the compatibility of refractory metal alloys, brazing alloys, and refractory oxides with cesium vapor. Impurity effects are of some importance.

A flight test of a cesium ion engine was scheduled for inclusion in the Applications Technology Satellite-D launch in July 1968.[4]

Bureau of Mines metallurgists reported that good results were obtained in extraction of cesium from pollucite ore by volatilization. Charges of 1 part of pollucite, 2 parts of limestone, and 0.23 part calcium chloride roasted in a tube furnace for periods of 2 hours yielded the following recoveries of cesium in chloride sublimate products: 89.1 percent when using 1100° C and vaccum; 92.9 percent when using 1250° C with an air sweep; and 95.2 percent when using 1250° C without an air sweep.[5] The Bureau also developed a rapid and accurate flame photometric method for measuring the cesium and rubidium content of ores and related extractive metallurgical products. The method is accurate within 2.5 percent of the amount of cesium and rubidium present and especially accurate in the range from 1 to 25 percent.[6]

GALLIUM[7]

Domestic Production.—Gallium metal was produced by the Aluminum Company of America at their Bauxite, Ark., plant and by The Eagle-Picher Co. at their Quapaw, Okla., plant. Gallium chloride and gallium oxide were also produced by The Eagle-Picher Co. The gallium production was derived as a byproduct from processing bauxite and zinc ore.

Consumption and Uses.—The largest use of gallium is in semiconductors, principally in the form of the arsenide or phosphide and to a lesser extent for doping germanium semiconductors. Minor uses of gallium were for high-temperature thermometers, sealant for glass joints, constituent of solders and other alloys, and various experimental applications.

Prices.—Market prices, per gram, of various-grade gallium from bauxite sources were the same as in 1966 and are as follows:

	Percent of purity		
	99.99	*99.999*	*99.9999*
Up to 999 grams	$1.40	$1.50	$1.70
1,000 to 4,999 grams	1.20	1.30	1.50
5,000 to 24,999 grams	1.10	1.15	1.35
Over 25,000 grams	.95	1.00	1.20

Foreign Trade.—General imports of gallium (unwrought, waste, and scrap) were reported to be 2,925 pounds comprised of 1,501 pounds from Japan, 859 pounds from Switzerland, 545 pounds from West Germany, and 20 pounds from other countries. The reported average value was about 7 cents per gram which was very low compared with domestic quotations for gallium metal and makes it unlikely that most of the imports were in the form of refined metal.

Technology.—The Bureau of Mines published a research report on recovering gallium and germanium from fly ash and flue dusts generated during the industrial burning of coal. Use of selective volatilization, leaching, and precipitation on a laboratory scale demonstrated the technical feasibility of extracting the two metals. However, the economics of producing and marketing either of the two metals by that process does not appear likely in the foreseeable future.[8]

[4] Maltz, Joseph. Written Communication. National Aeronautics and Space Administration, Materials Engineering Branch, Washington, D.C. Apr. 5, 1968.
[5] Nichols, I. L., and K. C. Dean. Volatilization of Cesium Chloride from Pollucite Ore. BuMines Rept. of Inv. 6780, 1966, 8 pp.
[6] Farley, Kenneth R., and H. E. Peterson, Determination of Cesium and Rubidium by Flame Photometry. BuMines Rept. of Inv. 6820, 1966, 19 pp.
[7] Prepared by H. J. Schroeder.
[8] Waters, R. F. and H. Kenworthy. Extraction of Germanium and Gallium from Coal Fly Ash and Phosphorous Furnace Flue Dust. BuMines Rept. of Inv. 6940, 1967, 33 pp.

GERMANIUM[9]

Domestic Production.—The primary germanium output was essentially all derived from smelter residues generated in the retorting and refining of zinc concentrates from germanium-bearing zinc-lead ores of the Kansas-Oklahoma area, and from fluorspar-zinc-lead ores of the Kentucky-Illinois area. American Zinc Company operated a germanium refinery at Fairmont, Ill., and the Eagle-Picher Industries, Inc. operated at a refinery at Miami, Okla. The American Zinc Company plant was in the process of closure at the end of 1967 and germanium residues and recycling of manufacturing scrap will be directed to refining facilities operated by other companies.

Kawecki Chemical Company, Revere Pa., and Sylvania Electric Products Inc., Towanda, Pa., operate refineries mainly for reprocessing domestic scrap supplemented by imports of germanium dioxide and scrap.

Statistical data are not available on domestic production of dioxide or metal. Requirements, however, indicate that production in 1967 was comparatively stable with some 30,000 pounds of new germanium required to supplement the 60,000 pounds of refined metal reclaimed from recycled scrap.

Consumption and Uses.—Essentially all of the germanium is used in manufacturing semiconductor devices for electronic applications. The electronic industry, with a significantly expanding sales record during the past several years, appeared to have had a decline in sales of semiconductor diodes and transistors in 1967. Sales of semiconductor diodes continued to exceed 1 billion units of which germanium accounted for about 43 percent in comparison with 51 percent in 1966. Transistor sales declined more severely with the total below 800 million units. Germanium devices accounted for 36 percent of the sales in comparison with 43 percent in 1966. Germanium was reported to have maintained its desirable position in semiconductors requiring maximum reliability and switching speed.

The competitive price stability achieved in 1967, and continued research in processing and infrared applications along with ample supply indicate that germanium may have reached a low in consumption and renewed growth potential.

Stocks.—Data on stocks of germanium in the form of primary dioxide and metal, and as scrap for reprocessing, are not available. Stocks of all of these materials, situated at both domestic and foreign producers and consumers, were considered more than ample throughout the year.

Prices.—The downward trend in germanium metal and dioxide prices, initiated in 1965, ended in September 1966 when the price for purified ingot was reduced to $175.25 per kilogram (2.2 pounds) in 10-kilogram lots. This quoted price continued throughout 1967. The price of electronic-grade germanium dioxide also continued at $88.40 per kilogram throughout the year. The decline in price from $252 per kilogram, early in 1965, to the current $175.25 per kilogram is indicative of the competition between germanium and silicon for the semiconductor market and, also, the availability of supply of this byproduct material.

Foreign Trade.—Imports of germanium during 1966 and 1967 were compiled and published in a basket category by the Bureau of the Census and include metal, dioxide, and manufacturing scrap. The total for 1966 was 3,026 pounds valued at $151,600, an average of $50.09 per pound. During 1967, total imports amounted to 3,381 pounds valued at $266,600, an average of $78.85 per pound and indicates a significantly larger amount of metal. The gross weight of imports by countries was as follows: United Kingdom, 124 pounds; Netherlands, 201 pounds; Belgium-Luxembourg, 607 pounds; West Germany, 1,056 pounds; Switzerland, 513 pounds; and Italy, 880 pounds.

World Review.—The major foreign producers of germanium are Republic of the Congo (Kinshasa), Territory of South-West Africa, Japan, Italy, the United Kingdom, and Yugoslavia. Germanium is also recovered from imported ores in the world's largest germanium refinery, Socíeté Génerale Métallurgique de Hoboken, Belgium, and at refineries located in West Germany. Germanium recovery was also initiated in 1967 at a 900-pound annual rate from flue dusts at the Bor copper smelter in Yugoslavia, and increased production by extraction of germanium directly from the copper concentrates was planned.

[9] Prepared by Donald E. Moulds.

INDIUM[10]

Domestic Production.—The American Smelting and Refining Company produced indium metal and chloride at its Perth Amboy, N.J., plant and indium metal at its Denver, Colo., plant. The Anaconda Company produced 61,000 troy ounces of indium at its Great Falls, Mont., plant compared with 177,000 troy ounces in 1966. Source material for indium production was certain smelter flue dusts and residues in which the trace quantities of indium occurring in zinc minerals were concentrated.

Uses.—Indium was used in electronic devices in a variety of ways, such as a component of solder for connecting leadwires to germanium transistors, and as a property-modifying component of the intermetallic germanium semiconductor. The compounds of indium arsenide, indium antimonide, and indium phosphide were also used in semiconductor applications.

A significant use of indium was in sleeve-type bearings to promote resistance to corrosion and wear. Indium was also used in solders, glass-sealing alloys, and dental alloys.

Prices.—The market quotations for indium were $2.75 per troy ounce for 30 to 90 troy ounces for stick shapes; in ingot shapes prices were $2.30 per troy ounce for 100-ounce lots and $2 per troy ounce for lots above 10,000 ounces.

Foreign Trade.—Imports for consumption of indium (unwrought, waste, and scrap) totaled 289,764 troy ounces valued at $493,084. Canada supplied 275,371 ounces ($448,995), Peru supplied 13,187 ounces ($41,076), Japan supplied 997 ounces ($2,451), and the Netherlands supplied 209 ounces ($562).

RADIUM[11]

Domestic Production. — No primary radium was produced domestically but Radium Chemical Co., New York, distributed radium salts for the Belgian company Union Minière du Haut-Katanga, which was still recovering radium from Congolese ores. Other domestic concerns handling radium materials were Canadian Radium & Uranium Division, Canrad Precision Industries, Inc., New York; and United States Radium Corp., Morristown, N.J. These companies handled radioisotopes also, and radium was a relatively small part of their business.

Uses.—The principal use for radium was in therapeutic treatment of cancer because of the penetrative power of its gamma radiation. Radium purchased by doctors or hospitals may be returned to the laboratories for conversion or to be changed from one type of container to another. Radium for these uses was also available on a lease or rental basis. The use of radium in luminous paints for instrument and clock dials and in static eliminators has been largely supplanted by cheaper and less hazardous radioisotopes. One large producer of luminous paints estimated that radium was used in less than 10 percent of their production. Increasing use was made of tritium (hydrogen-3) and krypton-85, which make brighter luminous compounds than radium and have little or no penetrating gamma radiation. Radium-beryllium neutron sources ranging from 300 to 600 millicuries were also being replaced by sources having no gamma-radiation component, such as plutonium-beryllium. Likewise, polonium-210, a pure alpha emitter was supplanting radium in static eliminators. The principal radioactive substitutes for radium in medical treatment included cobalt-60, cesium-137, iridium-192, and gold-198.

Although AEC has no direct control over the use of radium, most States, under radiological health programs, have comprehensive programs concerning radium sources; only nine States have no regulations or inspections. Tighter internal controls were initiated by shipping agencies and railroads because of the loss during shipment of several radium-bearing capsules, one a radium-beryllium neutron source used in oil-well logging and the other in a medical applicator. For many years, the Armed Forces used radium bearing luminous compounds in watch dials, compass faces, aircraft instrument panels, and gunsights. Efforts have been made to dispose of some of these surplus materials and suggestions have been made on

[10] Prepared by H. J. Schroeder.
[11] Prepared by Charles T. Baroch.

methods to be used.[12] It was reported that the U.S. Army planned to destroy 70,000 old compasses in which dangerous radon gas had accumulated.

RHENIUM[13]

Domestic production of rhenium metal decreased substantially in 1967 as a result of the prolonged copper strike and there was a substantial drawdown of stocks to meet demand. Consumption, primarily in high-temperature, high-strength refractory metal alloys, also decreased.

Table 6.—Rhenium metal statistics

(Pounds of contained rhenium)

	1963	1964	1965	1966	1967
Consumption [e]	500	1,500	1,010	1,040	850
Imports	20	212	469	84	96
Stocks (December 31)[e]	280	560	620	600	40

[e] Estimate.

Domestic Production.—Production of rhenium, a byproduct of porphyry copper ores, fell approximately 27 percent, largely as a result of the copper strike which closed the principal recovery plant for the last 5½ months of the year. Chase Brass & Copper Co., Inc., Solon, Ohio (a subsidiary of Kennecott Copper Corp.), remained the only domestic producer of rhenium metal powder during the year. As in 1966, rhenium salts were recovered for Chase by Shattuck Chemical Co., Denver, Colo., and until closed by the copper strike, by Kennecott at its new molybdenite roasting facility near Garfield, Utah, which began operation in mid-1966. This plant will have an annual capacity of about 3,500 pounds of rhenium contained in ammonium perrhenate salts.

Early in 1966 Chase Brass & Copper Co., Inc., purchased Cleveland Tungsten, Inc., Solon, Ohio, a subsidiary of Molybdenum Corporation of America (Molycorp), and in September of that year Chase moved its Rhenium Division from Waterbury, Conn., to Solon where it was consolidated with Cleveland Tungsten into Cleveland Refractory Metals, a new division of Chase.

The only significant sources of rhenium continued to be the porphyry copper deposits of the United States, Chile, Congo (Kinshasa), and the U.S.S.R. Rhenium metal was recovered at plants in the United States, the Soviet Union, West Germany, United Kingdom, and Belgium.

Consumption and Uses. — Approximately 850 pounds of rhenium metal powder was consumed, primarily in high-temperature, high-strength tungsten-rhenium (W-Re), tungsten-rhenium-molybdenum (W-Re-Mo), and molybdenum-rhenium (Mo-Re) alloys during the year, about 19 percent less than 1966 consumption. Tungsten-rhenium alloys were used as high-temperature structural materials in fast nuclear reactors and in aerospace applications. As has been the case since 1964, approximately 85 to 90 percent of the rhenium metal consumed during 1967 continued to be used in refractory metal alloys in research projects. Other applications continued to be in electrical contacts, flash bulb filaments, catalysts, and coatings.

[12] Halperin, Jerome A., and John M. Heslep. Radium in Military Surplus Commodities. Public Health Reports, v. 81, No. 12, December 1966, pp. 1057–1063.

[13] Prepared by Richard F. Stevens, Jr.

Prices.—Cleveland Refractory Metals quoted the following prices for rhenium materials, minimum order $50:

	Per pound
Ammonium perrhenate (NH_4ReO_4), up to 5 pounds	$425
Ammonium perrhenate, over 5 pounds	$400
Potassium perrhenate ($KReO_4$), up to 5 pounds	$395
Potassium perrhenate, over 5 pounds	$370
Rhenium metal, grade I, up to 1 pound	$650
Rhenium metal, grade I, 20 or more pounds	$580
Rhenium sintered bar (melting stock), up to 1 pound	$800
Rhenium sintered bar (melting stock), 5 or more pounds	$750
Rhenium rod stock, 0.2 inche in diameter	$900
Rhenium rod stock, 0.025 inch in diameter	$1,260
Rhenium strip, 0.6 inch thick	$815
Rhenium strip, 0.001 inch thick	$1,580

During 1967, rhenium metal powder could reportedly be obtained for about $500 per pound when credit for returned rhenium alloy scrap was included in the price. This scrap material was recycled to recover the rhenium content using a special process in which high-purity rhenium metal was produced from a mixed starting material of crude rhenium salts and rhenium scrap.

Foreign Trade.—During 1967, imports of high-purity rhenium metal powder totaled 96 pounds valued at $42,512. Imported rhenium metal powder continued to be sold at approximately $20 per pound less than comparable domestic rhenium, despite the duty (10.5 percent ad valorem) paid.

In accordance with the Kennedy Round Tariff Negotiations which were completed during the year, the duties on unwrought and wrought rhenium were to be reduced in stages by 50 percent over the 5-year period, 1968–72. In the first stage, effective January 1, 1968, the duty on unwrought rhenium was to be reduced from 10.5 percent to 9 percent and that for wrought rhenium from 18 percent to 16 percent.

Table 7.—U.S. imports of rhenium metal, by countries

(Pounds of contained rhenium)

Country	1963	1964	1965	1966	1967
France	----	-------	5	--------	23
Germany, West	20	208	460	84	72
United Kingdom	----	4	4	--------	1
Total	20	212	469	84	96

WORLD REVIEW

France.—The U.S. rhenium imports from France are believed to represent material marketed by the Belgium firm Sté. Générale des Minérals for Société Générale Métallurgique de Hoboken, Hoboken, Belgium, a company associated with Fansteel Metallurgical Corp., which recovers the rhenium from porphyry copper concentrates from the Congo (Kinshasa).

Germany, West.—Rhenium metal powder was recovered and marketed in West Germany by Herman Stark, Goslar, from porphyry copper concentrate imported from Chile. Stark's annual estimated production of rhenium metal is believed to be about 500 pounds.

Yugoslavia.—Exploration of the abandoned Mackatica molybdenum mine near Surulica indicated the presence of significant quantities of rhenium. It has been estimated that there are approximately 40 tons of rhenium content present in the mine and probably considerably more in the unexplored deposits in the surrounding area of some 60 square miles. Tests indicated that the molybdenum ore from this mine has an average rhenium content of 150 grams (0.33 pound) per ton of ore.

Technology.—The rhenium recovery circuit at the new molybdic oxide plant of Kennecott Copper Corp. outside Salt Lake City, Utah, was described by H.R. Spedden and J.D. Prater in a talk, "Ken-

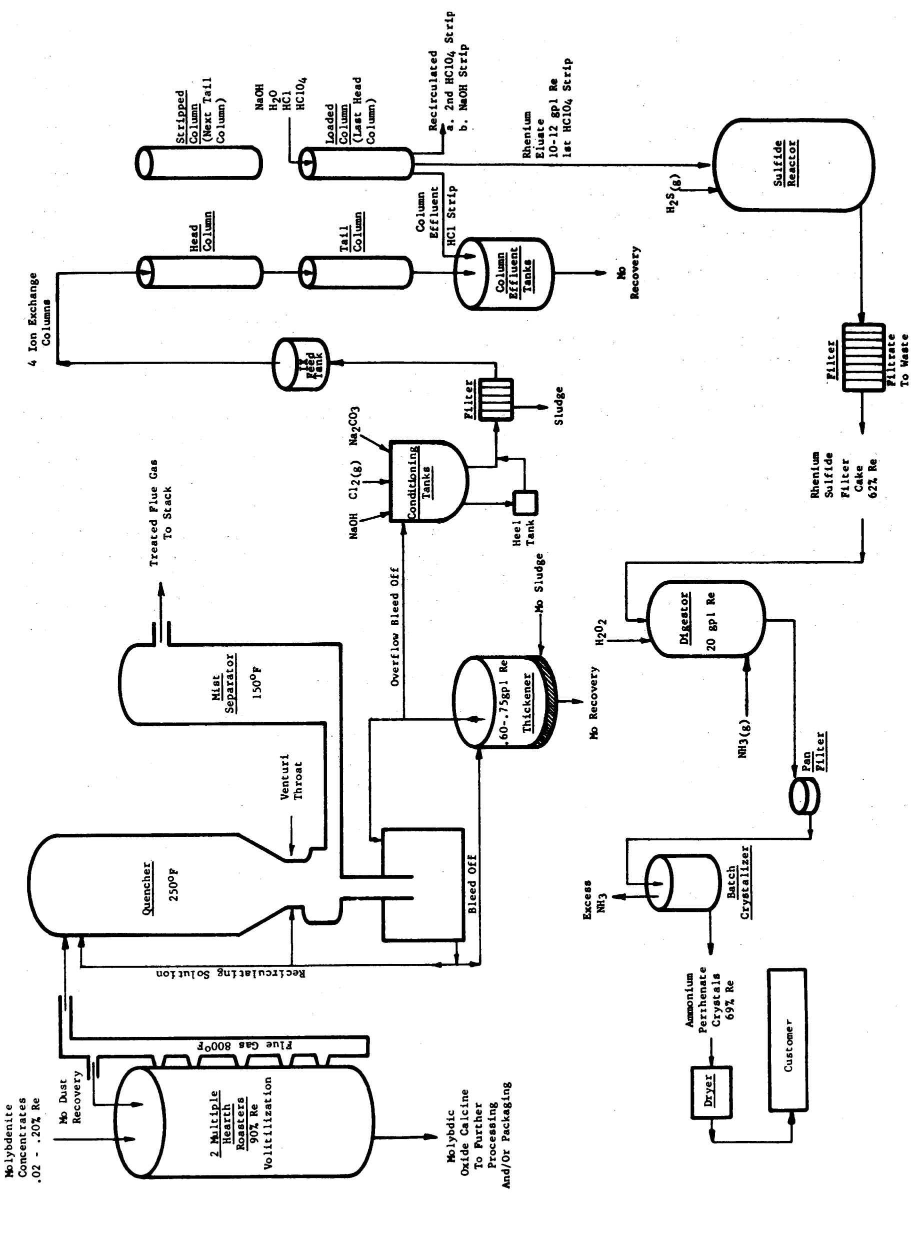

Figure 1.—Rhenium recovery flowsheet at Kennecott Copper Corporation, molybdic oxide plant. (Courtesy Kennecott Copper Corp.)

necott Copper Corporations' Molybdenite Roasting Plant," at the Rocky Mountain Minerals Conference in Denver in September 1966. A detailed flow sheet of this operation is shown in figure 1.

The significant advantages offered by alloying tungsten and tungsten-base alloys with rhenium were found to be the lowering of the ductile-brittle transformation temperature and the imparting of sufficient ductility to allow the resulting alloys to be formed at or near room temperature while still retaining exceptional high-temperature, high-strength properties. A method of preparing ultrafine, extremely homogeneous, and finely mixed tungsten-rhenium powders continued to be developed by Bureau of Mines scientists which allowed closely controllable compositions by the hydrogen coreduction of the freeze-dried ammonium compounds obtained from an aqueous solution.

Technetium (Tc), a radioisotope found in the waste fission products of nuclear reactors, is a sister element to rhenium and has similar properties. Because of its similarity and potentially more abundant supply technetium continued to be evaluated as a replacement for rhenium in tungsten-base alloys. In addition, studies of technetium as a catalyst to replace rhenium are being conducted at Brigham Young University, Provo, Utah.

SCANDIUM [14]

Domestic Production.—Scandium was recovered in small quantities from thortveitite and euxenite imported from Norway and from sludges recovered in uranium and tungsten processing. The principal producers, refiners, or dealers in scandium were as follows: Alfa Inorganics, Inc., Beverly, Mass.; Atomergic Chemetals Co., Division of Gallard-Schlesigner Chemical Manufacturing Corp., Carle Place, N.Y.; King Products, Inc., Arlington, N.J.; Research Chemicals, Division of Nuclear Corporation of America, Phoenix, Ariz.; Semi-Alloys, Inc., Mount Vernon, N.Y.; and Semi-Elements, Inc., Saxonburg, Pa.

Most uranium ores contain traces of scandium and when such ores are treated by processes using solvent extraction, part of the scandium accumulates in the organic solvent along with some other elements. The organic solvent must be purified periodically, and the resulting sludge, mostly iron, contains up to 0.10 percent scandium.

Consumption and Uses.—Demand in 1967 for scandium appeared to be little changed over what it has been for several years. Scandium metal and compounds continued to be used primarily in experimental work on a laboratory scale. Consumption was measured in grams, but several producers offered some compounds in pound lots. The only commercial use reported was for the radioisotope scandium-46, used in small quantities for logging oil wells; it was produced at the Oak Ridge National Laboratory of the Atomic Energy Commission.

Most demand was from university and other research groups, some of which were engaged in Government research of a classified nature. Most research interest appeared to be centered on the use of scandium in alloys and of scandium oxide for heat- and corrosion-resistant coatings. Small quantities of high-purity scandium sheet were reportedly used in nuclear research. In other suggested uses scandium oxide and carbide were tested as special refractories and ceramic shapes and as high-termperature semiconductors.

Prices.—Prices of scandium and its compounds covered a wide range, as usual, and were very little different from those of 1966 but were appreciably less than those in 1965. Price variations depended on purity and quantity, mainly, but also because few standard use specifications had been developed and most orders were filled on a custom basis.

Scandium oxide of 99.9-percent purity was quoted at $2.80 to $5.00 per gram in 25-gram to 1-pound lots. The most common scandium salts—chloride, nitrate, sulfate, oxalate, and acetate—were priced per gram from $5.00 to $6.50 for hydrous forms and from $6.50 to $7.50 as anhydrous salts, with somewhat higher prices for quantities less than 100 grams. Less common scandium compounds such as the selenide or telluride were quoted at prices up to $50 per gram.

Scandium metal in ingot form was listed on one price sheet at $32 per gram in 10-

[14] Prepared by Charles T. Baroch.

gram lots, Scandium foil, which seems to be increasing in demand, was available at prices varying from about $23 per gram for a thickness of 60 mils (thousandths of an inch) to about $75 per gram for thin foil of 5 to 10 mils thick.

The radionuclide scandium-46, as the chloride in a solution of hydrocloric acid and with a specific activity of 10 curies per gram, was offered at $20 per millicurie and 10 millicuries for $35.

Technology. — Nuclear Science Abstracts[15] for 1967 indexed 280 abstracts concerning scandium, 132 of which were on scandium isotopes, 49 were on the determination of scandium, 24 were on separation and purification of scandium principally by ion exchange and solvent extraction, 24 were on scandium oxide and other compounds, 18 were on alloys, and the balance were principally concerned with physical characteristics of scandium, its alloys, and compounds.

SELENIUM[16]

Although strikes in the nonferrous industry drastically reduced domestic production of selenium during the second half of 1967, a record first half maintained the year's total at 96 percent of the 1966 level.

The Government inventory of selenium was increased by the addition of 22,037 pounds to the Commodity Credit Corporation stockpile inventory. Also, 48,963 pounds is on order, and will be added to the 22,037 pounds before March 1968. This total of 71,000 pounds was obtained by barter from Canada and Japan. With the exception of these additions, the inventory remained unchanged during 1967, with 97,100 pounds of selenium in the national stockpile and 306,602 pounds in the supplemental stockpile.

Domestic Production.—In the United States, six plants produced selenium. Five of the six were located at the following major electrolytic refineries: American Metal Climax, Inc., Carteret, N. J.; American Smelting and Refining Co., Baltimore, Md.; International Smelting and Refining Co., Perth Amboy, N. J.; Kennecott Copper Corp., Garfield, Utah; and Kennecott Refining Corp., Anne Arundel County, Md. The sixth producer, the Kawecki Chemical Co., Boyerstown, Pa., is primarily a producer and fabricator of rare metals and rare metal alloys or compounds for electronic equipment.

Table 8.—Salient selenium statistics

(Thousand pounds of contained selenium)

	1963	1964	1965	1966	1967
United States:					
Production	928	929	540	620	598
Shipments to consumers	679	646	824	845	659
Imports for consumption	339	293	251	286	301
Stocks, Dec. 31, producers	1,022	1,305	1,021	797	736
Price per pound, commercial grade	$4.50–$5.75	$4.50–$6.00	$4.50–$6.00	$4.50–$6.00	$4.50–$6.00
World: Production	2,016	2,160	1,799	2,000	2,069

Consumption and Uses.—About half of the selenium consumed in 1967 went into electrical or electronic equipment. Pigments and glass consumed approximately one-fourth of the total. The remainder was used in xerography, as a catalyst in organic reactions, and as a reagent in electroplating. Consumption declined more than 15 percent in 1967.

Stocks.—The sharp 1966 decline in producers' stocks was extended by a further slight reduction during 1967. However, producers' stocks at the end of the year were substantially greater than their annual shipments to consumers.

Prices.—Selenium prices remained steady at $4.50 per pound, for commercial

[15] U.S. Atomic Energy Commission. Nuclear Science Abstracts. V. 21, Nos. 1–24, 1967, 4,880 pp.

[16] Prepared by J. A. Rowland.

grade, and $6.00 per pound, for the high-purity grade.

Foreign Trade.—Seventy-seven percent of the selenium imported during 1967 was from Canada; 20 percent was shipped from the United Kingdom; Japan and West Germany supplied the remaining 3 percent.

World Review.—A 30-percent increase in Canadian production of selenium offset losses in United States and Swedish production, and raised 1967 world production to the highest level since that of 1964. An increase in Canada's production of refined copper accounted for some of the increase in selenium but, evidently, substantial stocks of selenium-bearing copper slimes were also available.

Table 9.—World production of selenium by countries [1]

(Pounds)

Country	1963	1964	1965	1966	1967 p
Australia e	3,500	3,500	5,250	4,400	NA
Belgium-Luxembourg (exports)	54,013	87,082	r 93,035	r 91,271	r 90,400
Canada	468,772	465,746	512,077	r 575,412	752,221
Finland	15,417	14,500	12,577	11,973	e 13,900
Japan	313,494	325,926	348,038	r 421,190	422,172
Mexico	r 6,336	r 6,980	r 18,137	r 3,772	NA
Peru	r 19,791	16,797	18,964	13,131	NA
Sweden	156,500	180,800	r 176,400	e r 181,000	e 170,000
United States	928,000	929,000	540,000	620,000	598,000
Yugoslavia	4,120	8,439	17,441	r 20,558	e 22,000
Zambia [2]	45,962	r 121,699	r 57,574	e 58,000	NA
Total [3]	r 2,015,905	r 2,160,469	r 1,799,493	r 2,000,707	2,068,693

e Estimate. p Preliminary. r Revised. NA Not available.
1 Compiled mostly from data available May 1968.
2 Contained in copper refinery slimes exported for treatment.
3 Total is of listed figures only; no undisclosed data included.

Technology.—A 1967 Bureau of Mines publication deals comprehensively with contemporary technology of selenium.[17] Over 1 thousand technical articles published on selenium in 1967 were abstracted for publication by the Selenium-Tellurium Development Association, Inc. The Association also sponsored a 2-day international symposium on the Physics of Selenium and Tellurium. Major topics for discussion were: band structure, crystal growth and characterization, optical properties, and electrical properties.

The toxic characteristics of selenium received considerable attention during the year. Cigarette paper was found to contain 10 parts per million of selenium and the selenium content of other types of paper ranged from 1.2 to 6.5 parts per million. There was also considerable debate over the possibility that selenium could cause lung cancer.

Selenium was one of the three components in two new ferromagnetic spinels developed during the year. Further developments could create a substantial demand for the metal. Continuing research in animal nutrition added to the evidence that selenium may be an important trace feed additive.

TELLURIUM [18]

Domestic production of tellurium was reduced more than 30 percent by strikes that closed a large proportion of the copper refiners during much of the second half of 1967. Imports, however, were increased to 5 times the 1966 level.

Domestic Production.—Commercial tellurium is a byproduct of electrolytic refining of copper and lead.

The following companies reported production during 1967: American Metal Climax, Inc., Carteret, N.J.; American Smelting and Refining Company, Baltimore, Md.; International Smelting & Refining Co., Perth Amboy, N.J.; Kawecki Chemical Co., Boyertown, Pa.; Penn Rare Metals, Inc., New York, N.Y.; Phelps

17 Lansche, Arnold M. Selenium and Tellurium, A Materials Survey. BuMines Inf. Circ. 8340, 1967, 56 pp.
18 Prepared by J. A. Rowland.

Table 10.—Salient tellurium statistics

(Thousand pounds of contained tellurium)

	1963	1964	1965	1966	1967
United States:					
Production, primary and secondary	201	145	195	199	135
Shipments to consumers	134	122	146	215	172
Stocks, Dec. 31, producers	141	162	212	195	186
Imports	2	6	18	18	91
Price per pound, commercial grade	$6	$6	$6	$6	$6
World: Production	320	281	321	334	247

Dodge Refining Corp., New York, N.Y.; and United States Smelting, Refining and Mining Co., East Chicago, Ind.

Consumption and Uses.—Seventy-five percent of the tellurium consumed in 1967 was about equally distributed to ceramics, chemical compounds, and alloys. A considerable part of the remaining 25 percent was used in thermoelectric devices and small quantities were used in rubber and explosives.

Stocks.—Despite the sharp decline in domestic production, producers' stocks of tellurium dropped less than 5 percent. Thus, with the substantial decline in shipments, producers' stocks at the close of 1967 were slightly larger than their annual shipments.

Prices.—Tellurium prices remained at $6.00 per pound for commercial grade in 100-pounds lots.

Foreign Trade.—An increase of 73,000 pounds in tellurium imports more than compensated for the 64,000-pound decline in domestic production during 1967. Three countries supplied these imports: 44,978 pounds were imported from Canada, 23,000 were imported from Japan, and 22,400 pounds were imported from Peru.

World Review.—Moderate increases in Canadian and Japanese production of tellurium amounted to about one-fourth of the 1967 drop in U.S. production. Thus, despite a probable significant increase in Peruvian production, a decline of more than 10 percent should be anticipated in free world production during 1967.

Technology.—A 1967 Bureau of Mines publication reviews the technology and production of tellurium.[19]

On October 12 and 13, an International Symposium on the Physics of Selenium and Tellurium was sponsored by the Selenium-Tellurium Development Association, Inc. The purpose of the symposium was to improve the understanding of basic properties of tellurium and, thus, promote wider use of the metal in electronic and optical devices. Proceedings of the Symposium are to be published, late in 1968, by Pergamon Press Limited.

[19] Work cited in footnote 17.

Table 11.—Free world production of tellurium by countries [1]

(Pounds)

Country	1963	1964	1965	1966	1967 p
Australia [2]	e 2,000	3,500	---------	---------	NA
Canada	76,842	77,782	69,794	r 72,239	82,098
Japan	13,256	7,573	r 20,324	22,701	29,760
Peru	26,634	r 46,758	r 36,046	39,654	NA
United States	201,000	145,000	195,000	199,000	135,000
Total [3]	319,732	280,613	321,164	333,594	246,858

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Compiled mostly from data available May 1968.
[2] Recovered in copper refinery by Electrolytic Refining and Smelting Co. of Australia Pty. Ltd.
[3] Total is of listed figures only; no undisclosed data included.

Tellurium was one of the three components in two new ferromagnetic spinels developed by Semi-Elements, Inc. during 1967. Further development of either spinel could create additional demand for tellurium. A steady demand for considerable quantities of tellurium could result from general acceptance of a new lithium-tellurium battery developed by Argonne National Laboratories.

THALLIUM[20]

Domestic Production.—American Smelting and Refining Company, at its Denver, Colo. plant, was the only domestic producer of thallium and thallium sulfate. Production was from certain base-metal smelter flue dusts, residues, or other smelter products into which part of the trace quantities of thallum contained in the ores were concentrated.

Uses.—The ruling by the U.S. Department of Agriculture, under authority of the Federal Insecticide, Fungicide, and Pesticide Act, to prohibit the private use of thallium products in control of insect and rodent pests, effective August 1, 1965, has sharply curtailed the use of thallium for that purpose. Use of thallium for electronics, components of solder, fusible alloys, and other minor applications has apparently increased substantially, largely offsetting the losses for pesticides.

Price.—The quoted price of thallium metal remained $7.50 per pound.

Foreign Trade.—Imports for consumption of thallium (unwrought, waste, and scrap) totaled 117 pounds with 100 pounds obtained from West Germany, 16 pounds from Canada, and 1 pound from the United Kingdom.

[20] Prepared by H. J. Schroeder.

Minor Nonmetals

By Staff, Division of Mineral Studies

Contents

GREENSAND [1]

Domestic production of greensand (glauconite) increased 5 percent in quantity and decreased 1 percent in value compared with that of 1966. The average annual production for 1963–67 was 3,298 short tons valued at $193,576. The material was marketed for use as a soil conditioner and a water softener.

Since only two firms, Kaylorite Corp. of Maryland and Iversand of New Jersey, produced greensand in 1967, statistics on production and sales for the year are withheld to avoid disclosing individual company confidential data.

IODINE [2]

Production of naturally occurring iodine in the United States decreased in 1967, because late in 1966 one of the country's two producing facilities, the operation near Seal Beach, Calif., was closed down. Michigan, the only producing State, ıeached a new high with an output slightly above that of 1966. Imports of iodine decreased substantially during 1967 owning to the reduction in deliveries under the barter program.

Legislation and Government Programs.—The Government strategic stockpile contained 2,955,693 pounds of iodine, the supplemental stockpile 4,149,923 pounds, and the Commodity Credit Corporation stockpile 251,928 pounds for a total of 7,357,544 pounds at the end of 1967. The stockpile objectives for iodine is 8 million pounds.

Under the barter program authorized by the Agricultural Trade Development and Assistance Act of 1954, as amended, (Public Law 480, 83d Congress) and the Commodity Credit Corporation Act, as amended, approximately 252,000 pounds of iodine was delivered to the Government stockpile in 1967.

Domestic Production.—Crude iodine production in the United States was 16 percent lower in volume and 13 lower in value than in 1966. The entire 1967 output was recovered from natural brines at Midland, Mich., by the Dow Chemical Co., and production from this source was slightly higher than in 1966. Operations of The Dow Chemical Co., near Seal Beach, Calif., were phased out in September 1966.

Consumption and Uses.—The consumption of crude iodine declined 5 percent compared with 1966 consumption. However. a large increase in the consumption of crude iodine for sanitizers, disinfectants, and intermediates resulted in a 44-percent increase in the consumption of iodine organic compounds compared with 1966 levels. Much of the iodine and its compounds was consumed in medicines and antiseptics and agriculture. New applications for iodine included use as a stabil-

[1] Prepared by Richard W. Lewis.
[2] Prepared by Timothy C. May.

izer and as a catalyst in chemical processes. Iodine is also becoming useful as a lubricant and cutting-oil additive for difficult to lubricate and hard to machine space-age materials.

Table 1.—Crude iodine consumed in the United States

Products	1966			1967		
	Number of plants	Crude iodine consumed: Thousand pounds	Crude iodine consumed: Percent of total	Number of plant	Crude iodine consumed: Thousand pounds	Crude iodine consumed: Percent of total
Resublimed iodine	7	194	5	6	120	3
Potassium iodide	12	1,505	40	11	1,301	36
Sodium iodide	2	W	W	5	W	W
Other inorganic compounds	20	1,121	30	19	790	22
Organic compounds	24	944	25	25	1,363	38
Total	[1] 44	3,764	100	[1] 42	3,574	[2] 100

W Withheld to avoid disclosing individual company confidential data; included with "Other inorganic compounds."
[1] Nonadditive total because some plants produce more than 1 product.
[2] Data do not add to total shown because of independent rounding.

Stocks.—Stocks held by firms that convert crude iodine into resublimed iodine and iodine compounds declined 15 percent in 1967. Yearend stocks were 725,937 pounds compared with 855,791 pounds on December 31, 1966.

Prices.—The price of iodine and its compounds remained constant throughout 1966 and 1967. Prices were as follows:

	Per pound
Crude iodine, drums	$1.18
Resublimed iodine, U.S.P., drums, f.o.b. works	$2.20–2.22
Calcium iodate, drums, delivered	1.45–1.60
Calcium iodide, 25-pound jars, f.o.b. works	4.27
Potassium iodide, U.S.P., crystals, drums, 500 pounds or more delivered	1.45
Potassium iodide, U.S.P., crystals, drums, smaller lots, delivered	1.47
Sodium iodide, U.S.P., 300-pound drums, freight equalized	2.13

Source: Oil, Paint and Drug Reporter.

Foreign Trade.—Imports of crude iodine in 1967 were substantially below those of 1966 because of the reduction in receipts for the Government stockpile under the barter program. Imports for consumption decreased 52 percent in volume and 56 percent in value compared with 1966 levels. Imports of resublimed iodine in 1967 were 9,000 pounds compared with 2,000 pounds in 1966. Beginning January 1, 1965, the exports and reexports of iodine were no longer separately classified.

Table 2.—U.S. imports for consumption of crude iodine, by countries

(Thousand pounds and thousand dollars)

Country	1965		1966		1967	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada	-----	--------	-------	--------	30	$29
Chile	2,111	$1,689	4,404	$3,676	2,174	1,834
Hong Kong	-----	--------	11	13	-------	-------
Japan	736	787	2,718	2,245	1,255	1,314
Sweden	-----	--------	-------	--------	(1)	(1)
Total	2,847	2,476	7,133	5,934	3,459	3,177

[1] Less than ½ unit.

World Review.—*Chile.*—In November 1966, the Anglo-Lautaro Nitrate Corp. informed the Chilean Government that increased competition from synthetic nitrates, unfavorable exchange rates on nitrate exports, and high production costs had combined to make continued production at the corporation's Maria Elena operation uneconomic. To avoid closing Maria Elena altogether, the corporation announced it would restructure the operation to produce 200,000 tons of potash nitrate, 189,000 tons of sodium sulfate, and 1,000 tons of iodine.[3]

According to the Servicio de Mines del Estado, Chilean iodine production during 1966 was 3,231 short tons. This was an increase of 23 percent over the 1965 output. With the change in the production schedule of its Maria Elena plant and the expansion of iodine production facilities at its Pedro de Valdivia plant, the Anglo Lautaro Nitrate Corp. expects to have facilities capable of producing 4,079 short tons of iodine annually.[4]

Japan.—Elemental iodine production in 1966 amounted to 2,895 short tons compared with 2,417 tons in 1965, an increase of approximately 20 percent.

Technology.—To determine if the violence of hurricanes can be lessened, such storms were seeded with silver iodide in a project conducted by the Department of Navy and the Environmental Science Services Administration, Department of Commerce.[5]

Iodine concentrates and products are now manufactured by a "cold process" in which a solution of iodine and iodide are added to unheated detergent. Products prepared by this process are extremely stable with respect to available iodine content and are unique in that essentially no organic carbon-iodine bonded fragments are formed. The addition of iodide has a profound effect on detergent-iodine complexing. Certain nonionic detergents intensify iodine color at concentrations below 10 parts per million, rivaling starch as an iodine indicator.[6]

LITHIUM[7]

Outputs of domestic lithium mineral source materials were the largest ever reported. Imports of lithium minerals, more than 90 percent of which came from Southern Rhodesia almost tripled those of 1966.

Legislation and Government Programs.—The Government-held stock of lithium hydroxide, monohydrate, remained at 6,497 short tons.

Domestic Production.—Outputs of spodumene flotation concentrate from pegmatite and lithium carbonate from brines were larger than ever reported. 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. American Potash & Chemical Corp. recovered lithium carbonate from brines at Trona, Calif. Keystone Chemical Corp., Keystone, S. Dak., produced a small quantity of amblygonite from the Ingersoll Mine and also shipped some lepidolite.

The processors of lithium raw materials to lithium primary products were Foote Mineral Co., Sunbright, Va., and Silver Peak, Nev.; American Potash & Chemical Corp., Trona, Calif.; and Lithium Corporation of America, at Bessemer City, N.C. Production data were not available for publication. Lithium Corporation of America, Inc., merged with Gulf Sulphur Corp. to form a new organization, Gulf Resources and Chemical Corp. Lithium Corporation of America thus became a subsidiary of the new organization.

Consumption and Uses.—Figures on consumption of lithium mineral raw materials and lithium primary products were not available for publication.

Domestic spodumene flotation concentrate and lithium carbonate from brines were processed into numerous chemicals for a wide variety of applications. The major uses were in ceramics, greases, air conditioning, polymers, alloying, and organic synthesis, and there was a growing use in aluminum metal production. Research for new lithium applications included the development of lightweight,

[3] U.S. Embassy, Santiago, Chile. State Department Airgram A-498, Feb. 13, 1967, p. 11.
[4] U.S. Embassy, Santiago, Chile. State Department Airgram, A-183, Oct. 11, 1967, p. 40.
[5] Chemical Week. Hurricanes Seeded With Silver Iodide v. 101, No. 8, Aug. 19, 1967, p. 43.
[6] Schmidt, W., and M. Winicou. Detergent-Iodine Systems. Soap and Chemical Specialities, August 1967, pp. 61–64.
[7] Prepared by Donald E. Eilertsen.

high-energy batteries for driving automobiles electrically to reduce air pollution caused from gasoline-driven vehicles. Domestic spodumene and imported lithium minerals were used in the ceramic and glass industries.

Prices.—Lithium metal, 99.8 percent pure, was quoted at $9 to $11 per pound throughout 1967.[8]

Table 3.—Prices of selected lithium products in 1967

(Per pound)

Item	January to March 12, 1967	March 13 to yearend 1967
Lithium metal, 100-pound lots, delivered	$7.50	$7.50
Lithium carbonate:		
Drums, ton lots	.50	----------
Drums, carlots, truckloads, delivered	----------	[1] 0.425– .45
Lithium chloride:		
Chemically pure, anhydrous, drums, ton lots	1.27	----------
Technical, anhydrous, drums, carlots, tuckloads, delivered or works, freight allowed	.87	----------
Anhydrous, carlots, truckloads, delivered	----------	[2] .825– .875
Lithium fluoride:		
Barrels, ton lots and more, delivered	1.61	----------
10,000 pounds, minimum, delivered	----------	[3] 1.56 – 1.65
Lithium hydride:		
Powder, drums, 500-pound lots or more, works	9.50	----------
Carlots, truckloads, delivered	----------	7.10
Lithium hydroxide, monohydrate, drums, carlots, truckloads, delivered	.575	.535
Lithium nitrate, technical, drums, 100-pound lots	1.15– 1.25	[4] 1.15 – 1.55
Lithium stearate, drums, carlots, works	.475	[5] .475– .49
Lithium sulfate, drums, 100-pound lots	1.15– 1.25	[6] 1.15 – 1.30

[1] $0.45 until March 26; $0.425 until December 3; and then $0.425–$0.445.
[2] $0.825 until December 3; $0.852–$0.875 until December 17; and then $0.825–$0.85.
[3] $1.56 until March 26; $1.56-$1.61 until December 17; and then $1.56–$1.65.
[4] $1.15–$1.25 until March 26; and then $1.25–$1.55.
[5] $0.475 until March 19; and then $0.49.
[6] $1.15–$1.25 until March 26; and then $1.20–$1.30.
Source: Oil, Paint and Drug Reporter.

Foreign Trade.—Quantitative data were not available on the exports of lithium minerals and lithium metal, alloys, and compounds.

Imports of lithium minerals rose sharply in 1967 after a 2-year slump. As usual the largest supply, 91 percent in 1967, came from Southern Rhodesia. Imports of lithium materials, other than those shown in table 4, were as follows:

[8] Metals Week. v. 38, No. 1–52, January-December 1967.

Item	*Pounds*	*Value*	*Country*
Lithium (unspecified form)	1,650	$1,030	United Kingdom.
Lithium stearate	80,000	9,791	Netherlands.
Lithium compounds	290	6,225	Mostly from United Kingdom.
Lithium salts	61,240	95,469	Canada.

Table 4.—U.S. imports for consumption of lithium minerals, by country of origin and U.S. customs district

Country of origin and U.S. customs district	1966		1967	
	Short tons	Value	Short tons	Value
Brazil: Baltimore	-----	----------	45	$5,009
Canada: St. Albans	-----	----------	2,333	44,391
Rhodesia, Southern:				
Baltimore	7,856	$242,016	22,424	668,603
Charleston	-----	----------	1,131	48,065
South Africa, Republic of: New York	1,404	17,458	-------	--------
Total	9,260	259,474	25,933	766,068

World Review.—*Australia.*—The Government abolished restrictions on the export of lithium minerals to all Communist countries except mainland China in September. Lithium has been on the strategic list of materials for 16 years.

Brazil.—A large deposit of petalite was discovered near Aracuai, on the Piaui River in the Jequitinhonha Basin in Minas Gerais. The first 100 tons of petalite from the Nesinho mine was accumulated for shipment to a glass factory at Sao Paulo for use in glass for television tubes.

Canada.—Data on Canadian lithium deposits and occurrences were compiled, largely from publications, private reports, and personal communications with many geologists, engineers, and prospectors.[9]

Rhodesia, Southern.—Bikita Minerals (Private) Ltd. which experimented with froth flotation treatment of low-grade quartz-lepidolite ores, began to produce lepidolite concentrate continuously. The concentrate contained 4.5 percent Li_2O and was low in iron. The planned annual output was 2,500 tons.[10]

Tabe 5.—Free world production of lithium minerals, by countries [1]

(Short tons)

Country	Mineral produced	1963	1964	1965	1966	1967 p
North America: [2] Canada	Spodumene (Li_2O content)	322	528	507	127	283
South America:						
Argentina	Lithium minerals	1,583	799	686	287	NA
Brazil	Amblygonite	-----	------	[3] 28	-----	NA
	Spodumene [3]	28	------	7,512	e 100	NA
Surinam	Amblygonite	[3] 568	NA	NA	NA	NA
Africa:						
Mozambique	Lepidolite	115	------	83	-----	NA
Rhodesia, Southern	Eucryptite	r 1,142	806	e 705	NA	NA
	Amblygonite	52	------	-------	NA	NA
	Lepidolite	16,157	22,943	e 17,700	NA	NA
	Petalite	29,946	36,449	e 29,900	NA	NA
	Spodumene	2,235	6,965	e 15,300	NA	NA
Rwanda	Amblygonite	406	325	-------	-----	NA
South Africa, Republic of	Lithium minerals	417	179	958	337	e 400
South-West Africa, Territory of	Amblygonite	128	13	39	30	NA
	Lepidolite	86	407	298	365	NA
	Petalite	865	798	1,332	1,344	NA
Uganda	Amblygonite	53	22	22	-----	NA
Oceania: Australia	Petalite	437	233			
	Amblygonite	22	------	347	1,112	NA
	Spodumene	24	58	-------	-----	----

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Compiled mostly from data available April 1968.
[2] U.S. figure withheld to avoid disclosing individual company confidential data.
[3] Exports.

Table 6.—South-West Africa: Exports of lithium mineral concentrates

Year	Amblygonite		Lepidolite		Petalite	
	Short tons	Value	Short tons	Value	Short tons	Value
1964	-------	-----------	542	$12,211	1,151	$26,425
1965	669	NA	170	3,564	1,110	r 23,971
1966	13	$1,260	598	17,819	1,327	r 32,028

r Revised. NA Not available.

Technology.—Foote Mineral Co.'s large lithium brine operation at Silver Peak, Nev., which started in 1966, was described. The lithium-bearing sediments in the area extend about 8 miles in length and 4 miles in width and various reserve estimates range from 500,000 to 50 million tons of lithium chloride. The brine extracted from approximately 20 wells which are 300 to 800 feet deep, contains 6.2 percent Na, 0.8 percent K, 0.04 percent each of Mg and Li, 0.05 percent Ca, 0.71 percent SO_4, and 10.06 percent Cl. The brine is pumped to

[9] Mulligan, Robert. Geology of Canadian Lithium Deposits. Canada Geol. Survey, Econ. Geol. Rept. 21, 1965, 131 pp.

[10] Metal Bulletin (London). Bikita Producing Lepidolite. No. 5206, June 16, 1967, p. 23.

a series of evaporation ponds, where about 90 percent of annual evaporation occurs in 5 months. The concentrated brine, containing 3 to 4 percent lithium chloride, is pumped 2 miles to a processing plant in Silver Peak, where calcium and magnesium are first removed and the remaining solution then reacted with soda ash to produce crude lithium carbonate. This product is washed and dried and readied for shipment to customers.[11]

Widespread interest in reducing air pollution caused by gasoline-driven automobiles led to accelerated research on experimental lithium batteries for electric cars.

MEERSCHAUM [12]

Domestic consumers of meerschaum remained dependent on imports for their supplies. Turkey remained the primary world producer with an output of 148,000 pounds in 1967. Production statistics were not available for the other producing countries, Tanzania, Kenya, and the Somali Republic.

Imports of meerschaum for consumption declined 13 percent in quantity, to 11,707 pounds, and 18 percent in value, to $19,443, in 1967. Turkey supplied 88 percent of the imports. The remainder came from France and West Germany. The material continued to be used primarily for smokers' articles such as pipes and cigar and cigarette holders. Additional meerschaum is imported in the form of manufactured products for which no statistics are collected.

QUARTZ CRYSTAL

ELECTRONIC-GRADE [13]

The consumption of raw quartz crystal, both natural and manufactured, declined almost 9 percent from that of 1966. However, the consumption of manufactured quartz increased 29 percent. The production of finished units showed a substantial decrease.

Legislation and Government Programs.—The General Services Administration was authorized under Public Law 89–310 passed in October 1965 to dispose of quartz crystal from the Strategic and Critical Stockpile. Disposals during 1967 consisted of 65,236 pounds of specification-grade, and 50,814 pounds of non-specification-grade, material. At yearend the stockpile contained 5,441,479 pounds of specification and non-specification grade material. About 78 percent of this quantity was specification grade.

Domestic Production.—No domestic production of natural electronic-grade quartz crystal was reported to the Bureau of Mines in 1967. At yearend six companies reported the production of manufactured quartz for use by the electronic industry. These companies were P. R. Hoffman Co., Carlisle, Pa.; Quality Crystals, Inc., Cortland, Ohio; Sawyer Research Products, Inc., Eastlake, Ohio; Thermo Dynamics, Corp., Shawnee Mission, Kan.; Thermal Kinetic Corp., Tucson, Ariz.; and Western Electric Co., Inc., North Andover, Mass. The major domestic producers were Sawyer Research Products, Inc., and Western Electric Co., Inc. Sawyer reported sales of 87,000 pounds of manufactured quartz and Western Electric continued to produce quartz for its own and affiliated companies use.

Consumption and Uses.—Consumption of raw quartz crystal declined from 363,209 pounds in 1966 to 332,028 pounds in 1967. The consumption of manufactured quartz increased from 79,550 pounds in 1966 to 102,636 pounds in 1967. About 22.5 million finished quartz crystal units were produced from raw quartz crystal consumed during the year.

The data reported in table 7 are based on reports received in 1967 from 39 crystal cutters in 14 States. Finished piezoelectric units were produced by 37 of the cutters; the others produced only semifinished blanks. Of these cutters nine cut natural

[11] Shay, F. B. Low Cost Lithium From Brine at Silver Peak, Nevada. Pres. at 96th Annual AIME Meeting, Los Angeles, Calif., Feb. 21, 1967, 5 pp.
[12] Prepared by Benjamin Petkof.
[13] Prepared by Benjamin Petkof.

quartz only, 13 cut synthetic only, and 17 cut both natural and synthetic. Twenty consumers in four States used 77 percent of the total raw quartz crystal consumption. Pennsylvania was the leading quartz consumer with 51 percent of the total, followed by Kansas, Illinois, and Massachusetts.

Table 7.—Salient electronic- and optical-grade quartz crystal statistics

	1965	1966	1967
Imports of electronic- and optical-grade quartz crystal..thousand pounds..	324	265	220
Value..thousands..	$913	$596	$498
Consumption of raw electronic-grade quartz crystal....thousand pounds..	315	363	332
Production, piezoelectric units, number..thousands..	17,832	27,463	23,340

Piezoelectric units were manufactured by 54 producers in 19 States. Of these, 17, worked from partially processed quartz crystal blanks and did not consume raw material. Twenty plants in four States supplied 71 percent of the total output of finished crystal units. Oscillator plates comprised 83 percent of production. The remainder included filter plates, telephone resonator plates, transducer crystals, and miscellaneous items.

Prices.—The price ranges of electronic-grade quartz crystal, which remained essentially unchanged from those reported in the 1964 Minerals Yearbook.

Foreign Trade.—Imports of electronic- and optical-grade crystal decreased 17 percent in quantity, to 219,897 pounds, and 16 percent in value, to $498,257, from 1966 figures. The average value of imports was $2.27 per pound. Brazil maintained its status as the major world producer, supplying 75 percent of U.S. imports for consumption. Canada provided 24 percent and the remainder came from Argentina, France, and Japan. Quartz crystal imports, valued at less than $0.50 per pound, totaled 829,684 pounds valued at $232,245. This material, generally referred to as lasca, was used for the manufacture of fused quartz and as feed material for the production of manufactured quartz crystal.

Exports of raw quartz, both natural and manufactured, decreased from 145,562 pounds valued at $1,142,366 in 1966 to 112,935 pounds valued at $968,907 in 1967. About 75 percent of the material was shipped to Japan, India, the United Kingdom, Italy, and Israel.

World Review.—*Brazil*—Since 1963, exports of Brazilian quartz have been increasing and, in 1966, reached 7.17 million pounds valued at $2.43 million. However, 95 percent of exported material, in 1966, consisted of low-value lasca.[14]

Technology.—The production of man-made quartz with a Q-factor of up to 2 million, equivalent to that of natural quartz crystal has been reported. This will permit the replacement of natural quartz in high-frequency oscillators and other instruments requiring precise and stable frequencies. The addition of lithium nitrite to the sodium hydroxide growing solution increased the Q to 1 million. Additional improvement was made by special conditions of temperature, pressure and slower growth rates.[15]

STAUROLITE[16]

Staurolite, a complex silicate of iron and aluminum, is used as sand-blast abrasive and, to a lesser extent, as an ingredient in certain portland cement mixes. In some deposits, right-angle twinning of the crystals has created striking "fairy crosses" of this mineral that are valued as semiprecious stones for amulets. U.S. commercial production of abrasive-grade staurolite, in 1967, was confined to Florida, where the material was 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 declined 5 percent in 1967, while sales, even though substantially higher than in 1965, were about 8 percent less in both value and volume than in 1966.

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[14] Bureau of Mines. Mineral Trade Notes. Quartz Crystal. Brazil. v. 65, No. 3, March 1968, p. 35.
[15] Frequency. Man-Made Quartz Crystal With Q of Two Million. v. 5, No. 2, March-April 1967, p. 8.
[16] Prepared by J. Robert Wells.

STRONTIUM [17]

Domestic Production.—There was no output of strontium minerals in the United States for the eighth consecutive year. Imports for consumption were the smallest in 13 years. Quantitive data were not available on the production of strontium metal, alloys, and compounds. Firms that consumed imported celestite and produced various strontium compounds included E. I. du Pont de Nemours & Co., Inc., Grasselli, N.J.; Foote Mineral Co., Exton, Pa.; and FMC Corp., Modesto, Calif.

Legislation and Government Programs.—The Government sold 2,263 short tons of stockpile-grade, and 287 tons of non-stockpile-grade, celestite during 1967, At yearend, Government stockpiles contained 17,179 tons of stockpile-grade, and 28,731 tons of non-stockpile-grade, celestite.

Consumption and Uses.—Strontium metal and its alloys were used as getters for removing traces of gas from vacuum tubes. Strontium compounds were used to produce the brilliant red color in tracer bullets, for distress-signal rockets and flares, and for fireworks. The compounds were also used in ceramics, medicines, greases, plastics, and in making high-purity zinc. Strontium ferrite magnets, new on the market, were developed for use in separators in beneficiation plants, in lifting devices, in direct current motors, and in speakers.[18] Strontium-silicon, a new inoculant, was used to improve the quality of gray-iron castings.[19]

Data were not available on the quantities of strontium minerals, metal, alloys, and compounds consumed.

Prices.—Oil, Paint and Drug Reporter quoted the following prices: Strontium sulfate, (celestite)—air floated, 90 percent, 325 mesh, bags, works, at $56.70 to $66.15 per ton; strontium carbonate—pure, drums, 5-ton lots or more, works, at 35 cents per pound; drums, 1-ton lots, works, at 37 cents per pound; and technical, drums, works, at 19 cents per pound; and strontium nitrate—bags, carlots, works, at $11 per 100 pounds; and bags, less carlots, works, at $12 per 100 pounds. These quoted prices have not changed since 1955.

The average value of imported strontium minerals at foreign ports was approximately $21 per ton.

Foreign Trade.—Imports of strontium minerals, practically all celestite, totaling 5,612 tons were the smallest since 1954.

Other imports for consumption follow: Strontium carbonate, precipitated—8 pounds, valued at $897, from the United Kingdom; other strontium compounds—502 pounds, valued at $1,371, from the United Kingdom, and 15,000 pounds, valued at $3,190, from West Germany.

World Review.—*Canada.*—Drilling and surface exploration of a celestite deposit discovered in 1963, at Enon Lake in Cape Breton County, Nova Scotia, indicated 0.8 to 1 million tons of 75 percent strontium sulfate (celestite) in a gently dipping bed. The deposit appears on the newly issued map of Nova Scotia that shows 32 minerals in their geological setting.[20]

[17] Prepared by Donald E. Eilertsen.

[18] Tatnall, R. Francis. Westinghouse Expands Strontium Ferrite Magnet Production. Ceramic Age, v. 82, No. 5, May 1966, pp. 35–39.

[19] American Metal Market. New Strontium-Silicon Inoculant Stops "Chill" In Gray Iron Castings. V. 73, No. 92, May 12, 1966, p. 18.

[20] Northern Miner. Largest Celestite Deposit Indicated in Nova Scotia. No. 15, July 6, 1967, p. 17.

Table 8.—U.S. imports for consumption of strontium minerals, [1] by countries

Country	1966 Short tons	1966 Value (thousands)	1967 Short tons	1967 Value (thousands)
Canada	--------	-------	14	$5
Italy	11	$3	6	1
Mexico	6,434	117	3,148	37
United Kingdom	5,072	147	2,444	75
Total	11,517	267	5,612	118

[1] Strontianite or mineral strontium carbonate and celestite or mineral strontium sulfate.

Table 9.—Free world production of strontium minerals, by countries [1] [2]

(Short tons)

Country	1963	1964	1965	1966	1967
Argentina	595	33	659	NA	NA
Italy	721	504	705	659	NA
Mexico	r 6,918	r 6,020	r 2,888	r 6,267	NA
Pakistan	424	297	497	590	NA
United Kingdom	10,102	19,077	10,695	NA	NA
Total [3]	r 18,760	r 25,931	r 15,444	r 7,516	NA

r Revised. NA Not available.
[1] Strontium minerals are produced in Germany, Poland, and the U.S.S.R., but data on production are not available.
[2] Compiled mostly from data available May 1968.
[3] Total is of listed figures only; no undisclosed data included.

Technology.—Experiments were reported on the thermal reduction of zinc oxide with carbon monoxide in the presence of the strontium oxide. The addition of strontium oxide was found to hasten the reduction of zinc oxide to zinc.[21]

A method was developed for recovering strontium chloride from brine containing soluble chlorides of strontium, calcium, magnesium, potassium, and possibly sodium chloride and boron salts. The weigh ratios of the calcium to strontium chlorides ranged from 0.7 to 120 and the weight of calcium chloride did not exceed 47.5 percent. The brine was evaporated to remove sodium and most of the potassium and magnesium as carnallite, then cooled to form a solid product, which was leached with hot water to dissolve the strontium, boron, and remaining calcium, and again was then cooled to remove strontium chloride crystals.[22]

WOLLASTONITE [23]

Wollastonite sales in 1967, although less in volume and total value than in 1966, were higher in both respects than in any previous year. The Oxides Division of Cabot Corp., principal supplier in the United States, mined and processed paint- and ceramic-grade wollastonite in Essex County, N.Y. Two other firms produced smaller quantities of the mineral from sources in Riverside and Inyo Counties, Calif.

Nominal per-ton prices for wollastonite were recorded in Oil, Paint and Drug Reporter, unchanged from October 1960 through December 1967, as follows: Fine, paint-grade, bags, carlots, works, $41; less than carlots, ex warehouse, $51; medium, paint-grade bags, carlots, works, $29; less than carlots, ex warehouse $39. Ceramic Industry Magazine, January 1968, page 31, quoted $37 and $22.50 per ton as the respective high and low 1967 prices for wollastonite. As is customary for most industrial minerals, however, actual sales were concluded at prices agreed upon by buyers and sellers without public disclosure.

Technology.—A journal article described the advantages of a service by which a supplier of bulk ceramic materials would provide tile manufacturers with high-wollastonite bodies premixed according to their own formulations.[24] Tile made from high-wollastonite bodies, to which 2 percent of rasorite (similar to borax) has been added, would be amenable, according to published information, to single-layer, fast firing on wire mesh belts.[25]

Although the natural mineral is generally available in sufficient quantity throughout most of the world, the manufacture of synthetic wollastonite, in addition to providing a ceramic ingredient that is dependably uniform in composition, can furnish a use for materials otherwise likely to be wasted. An alumina-from-clay resi-

[21] Jones, T. S., and H. M. Davis. Reduction of Zinc Oxide by Carbon Monoxide in the Presence of Strontium Oxide. Trans. AIME, v. 239, 1967, pp. 244–248.
[22] Goodenough, Robert D. (assigned to The Dow Chemical Co., Midland, Mich.). Recovering Strontium Chloride From Brine. U.S. Pat. 3,329,318, Mar. 8, 1966.
[23] Prepared by J. Robert Wells.
[24] Burkley, Richard L. Preblended Tile Bodies. Ceram. Age, v. 82, No. 11, November 1966, pp. 28–30.
[25] Illing, Arno M. Floor and Wall Tile Research. Am. Ceram. Soc. Bull., v. 45, No. 1, January 1966, p. 22.

due, rich in lime and silica, was processed experimentally to yield a synthetic wollastonite suitable for the manufacture of ceramic tile.[26] A process was devised for treating a mixture of silica sand and limestone with superheated steam to form artificial wollastonite. In another application of the same principle, the unwanted calcite fraction of a wollastonite ore was reacted with silica sand at a high temperature to increase the wollastonite yield from subsequent flotation beneficiation.

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[26] Fahrenberger, U., and D. Harkort. Synthetic Wollastonite—Conditions for Its Formation and Use in the Manufacture of Wall Tile. Keram. Z., v. 18, No. 4, 1966, pp. 228–230; abs. in J. Am. Ceram. Soc., v. 49, No. 8, August 1966, p. 219.

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