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MINERALS YEARBOOK

1963

Volume I of Four Volumes

METALS AND MINERALS (Except Fuels)

Prepared by staff of the
BUREAU OF MINES

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

BUREAU OF MINES • Marling J. Ankeny, Director

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

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

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FOREWORD

The 1963 MINERALS YEARBOOK marks the 82d year in which this publication or its predecessors have been issued by the Federal Government. It also marks the first issue of a fourth volume reviewing world mineral production, consumption, and trade on a country-by-country basis. This new international review volume represents the Bureau's continuing effort to make the Yearbook as useful as possible to industry, Government, and the general public.

Many difficulties had to be surmounted in preparing this new volume. Although it has not been possible in several instances to present international data comparable to those available for the United States, the International Review should nevertheless prove a valuable reference.

The general content of this four-volume edition is as follows:

Volume I contains chapters on metal and on nonmetal mineral commodities except mineral fuels. In addition, it includes a chapter reviewing these mineral industries, a statistical summary, and chapters on mining and metallurgical technology, employment and injuries, and technologic trends.

Volume II contains a chapter on each mineral fuel and on such related products as helium, carbon black, peat, coke, and coal chemicals, and natural gas liquids. Also included are data on employment and injuries in the fuel industries, and a mineral-fuels review summarizing recent economic and technological developments.

Volume III contains chapters covering each of the 50 States, United States island possessions in the Pacific Ocean, the Commonwealth of Puerto Rico, and island possessions in the Caribbean Sea, including the Canal Zone. Volume III also has a statistical summary chapter, identical with that in Volume I, and a chapter on employment and injuries.

Volume IV contains 124 chapters presenting the latest available mineral statistics for more than 130 foreign countries and areas, and 1 chapter reviewing minerals in world economy.

To my knowledge, the Minerals Yearbook is the most comprehensive publication of its kind available. The Bureau will continue its efforts in the years to come to increase the Yearbook's value to its many users. Toward that end, the constructive comments and suggestions of readers will be helpful.

MARLING J. ANKENY, *Director*.

ACKNOWLEDGMENTS

The staff of the Division of Minerals prepared this volume except for the three review chapters and that on Employment and Injuries. The preparation and the coördination of chapters with those in other volumes was under the general direction of Paul Yopes, assistant to the Chief, Division of Minerals. The manuscripts upon which the volume was based were reviewed to insure statistical consistency among the tables, figures, and text between this volume and other volumes, and between this volume and those for former years, by a staff supervised by Kathleen J. D'Amico and including Julia Muscal, Helen L. Gealy, Helen E. Tice, Mary E. Daugherty, Nellie W. Fahrney, Robert E. Anderson, and Joseph Spann.

The statistical data of the U.S. mineral industry have been collected and compiled by the staff of the Division of Statistics under the direction of Rexford C. Parmelee, the Division Chief, and Paul W. Icke, Chief, Branch of Operations. Commodity assignments were as follows:

Albert D. McMahon, Chief, section of nonferrous metals, assisted by Ida Agnew, Hazel B. Comstock, Mary T. Cosgrove, Edith E. den Hartog, Mary E. Graves, Bonita V. Kiper, Kathleen McBreen, Esther B. Miller, Dora D. Rice, Arden C. Sullivan, Mary E. Trought, Ethel M. Tucker, Clarke I. Wampler, Wilma F. Washington.

Isaac E. Weber, Chief, section of ferrous metals, assisted by Mary J. Burke, Violet M. Clarke, Teresa Fratta, Barbara E. Gunn, Madeline E. Jacobs, Nedra C. Knight, James E. Larkin, Helen E. Lewis, Huguette A. Lizotte, Ethel R. Long, Gertrude C. Schwab.

Nan C. Jensen, Acting Chief, section of nonmetallic minerals, assisted by Rose L. Ballard, Betty A. Brett, Ardell H. Lindquist, Jewel B. Mallory, Audrey D. Snyder, Betty I. Stanley, Gertrude E. Tucker.

U.S. import-export data for all commodities were assembled by Elsie D. Jackson.

World production tables and foreign trade tables were compiled under the direction of Berenice B. Mitchell, Supervisory Statistical Officer, Division of International Activities, from many sources including data from the U.S. Foreign Service, Department of State. Helen L. Hunt, Liela S. Price, Pearl J. Thompson, and Virginia G. Huguley assisted in compilation of the world production tables and Corra A. Barry, Bertha M. Duggan, and Victoria R. Schreck assisted on the foreign trade tables.

The author of the chapter on Review of the Mineral Industries was assisted by Jeannette I. Baker and Eddie L. Green.

Figures in the Minerals Yearbook are based largely upon information supplied by mineral producers, processors, and users, and acknowledgment is 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.

The Bureau of Mines has been assisted in collecting mine-production data and the supporting information appearing in the Minerals Yearbook by more than 40 cooperating State agencies. These organizations are listed in the acknowledgment section of Volume III.

CHARLES W. MERRILL,
Chief, Division of Minerals.

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Review of the Mineral Industries[1]
(Metals and Nonmetals Except Fuels)

By Kung-Lee Wang[2] and Edward E. Johnson[2]

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The 1963 performance of the United States economy was impressive. The year was one of continued growth unmarred by a recession. By the end of 1963 the economy's expansion had already lasted almost as long as the 1954–57 upswing, and the net gain in output since the trough in activity in early 1961 compared favorably with most earlier postwar cyclical advances. There was no indication of any slowdown at yearend. Both gross national product (GNP) and national income in 1963 were 5 percent higher than in the previous year. GNP totaled $584 billion, a gain of $28 billion over 1962. Real output of goods and services rose 3.4 percent over the year. Price increases continued to be moderate. Production, employment, personal income, and corporate profits all registered new peaks, but unemployment continued high at 5.5 percent and the prospects for improvement remained poor. The economy again failed to use its full potential.

Current value of mineral production kept pace with the economy. The constant dollar value of mineral production gained more than real GNP because of the relatively stable price of minerals. Mining production achieved a new high in 1963. Steel production totaled 110 million tons, 12 million tons above 1962, making 1963 the first 100-million-ton year since 1957 and lifting the steel-associated minerals group upward. The gain in ferrous metals mining was insufficient to compensate for the decline of nonferrous metals mining, resulting in an insignificant decline in the metal mining total as a whole. The upsurge of construction material minerals output, with an assist from chemical and fertilizer minerals, accounted for peak production of

[1] Some fuels are covered in this chapter but only where specifically indicated and in general where mining-industry data were not available for both nonfuels and fuels components.
[2] Economist.

nonmetals other than fuels. All mineral fuels increased their output and pushed total minerals production to a record high.

Net supply of minerals, metals, and fuels generally increased, and imports and exports also gained. Imports continued to be an important source of new supply. Secondary production maintained its position in metal supply. Consumption of all minerals and related products continued the upward trend of the past few years and increased over 1962. Consumption of nonmetals except fuels continued its consistent growth despite the fluctuation of the economy.

Overall physical stocks declined in 1963. This change was principally attributed to iron ore stocks, and lead and zinc metal stocks depletion. Average unit mine value and implicit unit value of all minerals were unchanged from last year. Mineral process and commodity prices were generally steady. Cost of machinery and materials used in mining increased slightly. Cost of fuel was unchanged, whereas cost of electric energy declined somewhat. Labor cost, adjusted for productivity, increased slightly again.

Mining labor productivity continued the gradual upward trend. Total employment in nonfuel mining industries reversed the downward trend and increased slightly. Total wages and salaries for all employment in the mining industries continued the mild upward trend begun in 1961. Total employment and earnings in mining again lagged behind that of all industries.

Despite the steadily rising trend of all industries, income originating from all mining industries declined again in 1963, and their percentage share of all industries decreased further. The annual profit rate was generally improved over 1962 except for the stone, clays, and glass products industry. However, the profit rate in the minerals industry was still much lower than all manufacturing.

Expenditures for new plant and equipment in the mining industry declined, contrary to the upward trend for all manufacturing. The value of U.S. private investment in foreign mining and smelting industries increased slightly but again lagged behind all industries. Conforming with the all-industry pattern, U.S. mining companies abroad again relied primarily on internally generated funds abroad to finance capital expenditures and operations. Direct foreign investments by U.S. (nonfuel) mining and smelting companies were expected to be lower than in 1962.

Research and development in the mining industry as a whole gained very modestly, and expenditures continued to be minor in comparison with those of other industries. However, the Bureau of Mines continued to make a notable contribution, and, as in previous years, the bulk of the funds for mining research and development was spent on applied research.

Activity under the Defense Mobilization Program was relatively low during 1962. A long-range National Strategic Stockpile disposal program for conventional war was announced. New stockpile objectives were put into effect in July for eight metals, of which aluminum, copper, lead, nickel, and zinc objectives were reduced an average of over 250 percent; metallurgical grade chromite, mercury, and tin objectives were increased.

The U.S. Tariff Commission determined that the U.S. cement industry was likely to be injured by imports from the Dominican Republic. The Tariff Schedules of the United States, Annotated, that simplified and clarified the classification of minerals and mineral products was signed into law on August 31.

The total value of U.S. foreign trade in nonfuel minerals and related products rose 28 percent from that of 1962. Metal ores imports declined, whereas metal products imports gained. Exports of both crude minerals and mineral products gained significantly over those of 1962.

The world economy continued to expand. World minerals industry generally improved; world production of metallic minerals made a modest gain, although that of the United States increased much less. The United States continued to be the world's leading consumer and an important producer of most minerals and related products. World mineral consumption increased at a slower rate than that of the United States. World trade in nonfuel minerals and related products declined slightly in 1963. Iron ore gained, nonferrous ores declined slightly, and metals declined. World stocks continued to decumulate during 1963, with the United States stocks depleting faster. World prices were mixed but weak. Nonferrous ores and metals gained; iron ore declined.

DOMESTIC PRODUCTION

Value of Mineral Production in Current Dollars.—The value of all mineral production (metals, nonmetals, and fuels) in current dollars continued the rising trend that began in 1959 and registered another record high in U.S. mineral history with another 4.2 percent gain over that of 1962. The increases in fuel and nonmetals value were again responsible for the bulk of this increase.

Mineral fuels output rose 4 percent over the previous record year, 1962. All major mineral fuels made substantial gains. Hydrocarbon fuels accounted for over 80 percent of the gain in fuels with bituminous coal and anthracite contributing to the remainder of the gain in fuels. Crude petroleum gained by 2.5 percent over 1962 to approximately $8 billion in 1963. Natural gas rose 8.5 percent to $2.3 billion. Bituminous coal increased 6.4 percent to slightly over $2 billion. Anthracite also advanced over 1962.

Nonfuel minerals value rose 4.5 percent over that of 1962 and achieved another record high. These materials furnished 32 percent of the total value of mineral production. Nonmetals continued to strengthen their relative position in the subgroup with a 4.9 percent gain over that of 1962.

The new record high in the value of construction material output resulted from increased highway and building construction activities, and another good year for chemical and fertilizer minerals was responsible for this new high in nonmetals. Metals made modest gains in 1963 due to increased shipments of lead, zinc, and iron ore and increased average prices of lead and zinc.

Value of Mineral Production in Constant Dollars.—The revised table of value of mineral production in U.S. constant dollars (1957–1959=100) is presented. The enlarged Bureau of Mines index of implicit unit value of minerals produced in the United States[3] was used to deflate the value in current dollars for both total U.S. and State mineral outputs in compiling table 2 and the State tables. The latter are presented in various State chapters in Volume III.

The value of metals production in constant dollars showed an upward trend from World War II and reached a post-war peak in 1957, dropped sharply during the 1958–59 recession, recovered in 1960, and has declined gradually and steadily since. The value of metals output in 1963 increased insignificantly.

The value of nonmetals in constant dollars has been increasing steadily at a slightly increased rate since the end of World War II and registered an alltime high again in 1963 with a 4.8 percent gain above that of 1962. From 1947 to 1963, it had gained 141 percent from $1,791 million in 1947 to $4,314 million in 1963.

The total value of nonfuels in constant dollars recovered from the post-war recession by 1950, continued upward gradually to a post-war peak in 1957, declined in 1958, recovered steadily and strongly, and achieved new record high consecutively each year in 1960, 1961, 1962 and 1963. The 1963 overall gain was 3.4 percent over last year, and nonmetals were responsible for the bulk of all gain in this group.

The total value of mineral fuels in constant dollars recovered from the post-war low in 1949, gained slowly upward through 1953, with a minor dip in 1952, declined modestly in 1954, recovered in 1955, made substantial gain and achieved a post-war high in 1956, drifted downward slightly in 1957, slumped noticeably in 1958, and then started a slow and gradual upward trend through 1961, spurted forward in 1962, made substantial strides in 1963, and achieved a new post-war high with a gain of nearly 5 percent above that of 1962.

The value of all minerals in constant dollars reached a post-war peak in 1948, slumped drastically to post-war low in 1949, recovered in 1950, continued the steady upswing through 1953, declined in 1954, recovered vigorously during 1955 and 1956, reached a high plateau during 1956 and 1957, dropped substantially in 1958, recovered steadily from 1959 throughout 1962, made a new record high in 1962, continued in 1963 with a 4 percent increase over 1962, and registered another new alltime high.

The total value of all minerals in constant dollars followed the general business cycle of the U.S. economy. It ebbed in 1949, rose to its highest plateau in 1956 and 1957, slumped during the 1958 recession, began a gradual recovery toward 1956–57 high, then broke through 1956–57 plateau vigorously and registered consecutively new highs each year for 1962 and 1963 as our economy boomed forward.

Volume of Mineral Production.—The Bureau of Mines index of physical volume of mineral production increased another 4.5 percent in 1962 and achieved another new record high. The metals index rose slightly; a 1.3 percent increase from 1962. Ferrous metals recovered the 1962 loss and gained 3.9 percent from last year. Iron ore and molybdenum were responsible for the increase. Nonferrous

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[3] For details see Index of Implicit Unit Value in Price and Cost Section of the Chapter.

metals were unchanged. The decline of copper, gold, mercury, silver and uranium production was compensated by the increase in lead, zinc, and magnesium production. Nonmetals continued its gradual upward trend at an increasing rate and reached another new high in 1963 with a 5.5 percent increase above that of 1962. Sand, gravel, and stone led the gain of 5.4 percent in construction materials. The increases of clays, potash, and salt production were responsible for the 5.4 percent gain in chemical minerals and other nonmetals. The fuels index rose strongly and with an assist from nonmetals was primarily responsible for the achievement of the alltime high for all minerals index.

The Federal Reserve Board (FRB) mining indexes (tables 4 and 5) showed a similar upward trend. Weight differences between these indexes and the Bureau of Mines index, as well as some differences between them in coverage and base years, can result in relative movement between the indexes. However, the revised FRB indexes followed the revised Bureau of Mines all minerals index closely except for slight difference in metal mining and nonmetal mining.

The major advantage of the Bureau index is that it is available on a comparable basis to 1880. However, FRB indexes are available monthly, on a seasonally adjusted basis, and include basic mineral manufacturing industries which the Bureau index does not cover.

The FRB index of basic mineral manufacturing showed that the iron and steel industry rose nearly 9 percent above that of 1962; nonferrous metals industries, 6 percent; stone, clays, and glass products, 6 percent; and total industries production, 5 percent. Industrial production achieved another new record high in 1963.

The monthly index for all mining declined slightly in January, recovered gradually during the next 2 months, rose to the highest plateau during the next 6 months, drifted downward during the last quarter, and ended with the 1963 average increase of 3 percent over the 1962 figures. Nonfuel mining recovered from the decline in the last quarter of 1962 and went on to 1963 with an average yearly gain of 1.1 percent over 1962. Metal mining began the year very strongly, slowed by May, drifted downward to a low in November, recovered strongly in December, and registered an insignificant loss in the year average from 1962. Stone and earth mineral mining followed the seasonal pattern but moved gradually upward and achieved a record high yearly average gain of 2 percent over that of 1962.

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

(Million dollars)

Mineral groups [2]	1954–58 (average)	1959	1960	1961	1962	1963	Change in 1963 from 1962 (percent)
Metals and nonmetals except fuels:							
Nonmetals	3,211	3,861	3,868	3,946	[3] 4,117	4,318	+4.9
Metals	1,932	1,570	2,022	1,927	1,937	2,006	+3.6
Total	5,143	5,431	5,890	5,873	[3] 6,054	6,324	+4.5
Mineral fuels	11,348	11,950	12,142	12,357	[3] 12,784	13,296	+4.0
Grand total	16,491	17,381	18,032	18,230	[3] 18,838	19,620	+4.2

[1] Includes Alaska and Hawaii.
[2] For details see table 1 in the chapter "Statistical Summary" of the 1963 Minerals Yearbook.
[3] Revised figure.

TABLE 2.—Value of mineral production in the United States, by mineral groups, in 1957–59 constant dollars [1]

(Million dollars)

Year	Nonmetals (except fuels)	Metals	Nonfuel total	Mineral fuels	Total minerals
1940	1,471	1,642	3,113	7,671	10,784
1941	1,828	1,973	3,801	8,298	12,099
1942	1,799	2,281	4,080	8,702	12,782
1943	1,558	2,136	3,694	9,134	12,828
1944	1,441	1,899	3,340	9,922	13,262
1945	1,465	1,599	3,064	9,763	12,827
1946	1,823	1,311	3,134	9,604	12,738
1947	1,791	1,707	3,498	10,602	14,100
1948	1,947	1,772	3,719	11,010	14,729
1949	1,892	1,582	3,474	9,406	12,880
1950	2,203	1,841	4,044	10,394	14,438
1951	2,384	1,964	4,348	11,451	15,799
1952	2,486	1,867	4,353	11,247	15,600
1953	2,541	1,986	4,527	11,371	15,898
1954	2,886	1,645	4,531	10,864	15,395
1955	3,191	1,978	5,169	11,654	16,823
1956	3,381	2,078	5,459	12,638	18,097
1957	3,435	2,085	5,520	12,558	18,078
1958	3,483	1,669	5,152	11,589	16,741
1959	3,789	1,547	5,336	12,120	17,456
1960	3,841	1,893	5,734	12,228	17,962
1961	3,930	1,875	5,805	12,296	18,101
1962	4,117	1,866	5,983	12,627	18,610
1963	4,314	1,871	6,185	13,177	19,362

[1] Excludes Alaska and Hawaii 1940–1953.

TABLE 3.—Indexes of the physical volume of mineral production in the United States, by groups and subgroups [1]

(1957-59=100)

Year	All minerals	Metals						Nonmetals				Fuels
		Total	Ferrous	Nonferrous				Total	Construction	Chemical	Other	
				Total	Base	Monetary	Other					
1959	99.4	84.5	79.6	87.6	87.3	92.6	82.6	105.4	106.4	102.5	103.8	99.6
1960	102.1	107.5	114.2	103.2	105.5	94.9	96.9	108.0	108.2	108.5	103.1	100.3
1961	102.9	103.3	94.6	108.8	113.4	93.7	[2] 92.1	110.3	110.6	112.0	96.8	101.2
1962	[2] 106.0	[2] 106.2	92.1	[2] 115.1	117.8	95.3	[2] 122.0	[2] 115.4	[2] 117.0	[2] 114.0	97.1	[2] 104.0
1963	110.8	107.6	95.7	115.1	118.4	89.1	125.8	121.7	123.3	120.2	102.6	108.8

[1] For description of index see Bureau of Mines Minerals Yearbook 1956, V. 1, pp. 2–5.
[2] Revised figure.

TABLE 4.—Indexes of production of mining, primary metals, clay, glass, and stone products, and total industrial production

(1957–59=100)

Year	Mining	Coal, oil, and gas	Metal, stone, and earth minerals	Metal mining	Stone and earth minerals	Primary metals	Iron and steel	Nonferrous metals and products	Clay, glass, and stone products	Total industrial production
1959	99.7	99.9	98.7	89.1	105.8	100.4	98.7	106.6	108.4	105.6
1960	101.6	99.7	110.7	111.8	109.8	101.3	100.9	102.8	107.8	108.7
1961	102.6	100.9	110.5	111.9	109.4	98.9	96.5	107.5	106.3	109.8
1962	105.0	103.8	110.9	112.6	109.7	104.6	100.6	119.1	111.1	118.3
1963 [1]	107.8	106.9	112.1	112.3	112.1	113.1	109.5	126.3	117.5	124.3

[1] Preliminary figures.

Source: Industrial Production 1957–59 Base, and Federal Reserve Bulletin, February 1964, p. 225 and June 1964, p. 771.

TABLE 5.—Monthly indexes of production, mining, nonfuel mining, metal mining, stone, and earth minerals, seasonally adjusted

(1957-59=100)

Month	Mining [1]			Metal, stone, and earth minerals [2]			Metal mining			Stone and earth minerals		
	1962	1963	Change from 1962 (percent)	1962	1963	Change from 1962 (percent)	1962	1963	Change from 1962 (percent)	1962	1963	Change from 1962 (percent)
January	103.8	103.0	−0.8	108.2	111.1	+2.7	115.9	110.1	−5.0	102.4	111.9	+9.3
February	104.2	104.7	+0.5	111.4	109.7	−1.5	118.2	114.3	−3.3	106.4	106.2	−0.2
March	104.8	105.4	+0.6	113.3	112.6	−0.6	120.0	115.7	−3.6	108.3	110.2	+1.8
April	105.4	107.4	+1.9	115.3	113.9	−1.2	124.4	114.5	−8.0	108.5	113.4	+4.5
May	105.1	108.5	+3.2	116.7	112.8	−3.3	126.2	116.4	−7.8	109.7	110.1	+0.4
June	105.2	109.4	+4.0	114.4	113.0	−1.2	119.4	112.8	−5.5	110.7	113.2	+2.3
July	106.5	111.3	+4.5	113.9	112.1	−1.6	118.3	110.3	−6.8	110.6	113.5	+2.6
August	105.4	111.3	+5.6	111.3	111.6	+0.3	110.7	112.8	+1.9	111.7	110.7	−0.9
September	105.7	110.3	+4.4	107.8	112.5	+4.4	101.1	113.4	+12.2	112.7	111.9	−0.7
October	105.2	109.1	+3.7	105.9	113.1	+6.8	96.8	109.8	+13.4	112.6	115.5	+2.6
November	105.7	107.5	+1.7	106.8	110.3	+3.3	99.1	106.4	+7.4	112.5	113.2	+0.6
December	103.2	106.6	+3.3	105.1	112.7	+7.2	104.1	111.6	+7.2	105.8	113.5	+7.3
Annual average	105.0	[3] 107.8	+2.7	110.9	[3] 112.1	+1.1	112.6	[3] 112.3	−0.3	109.7	[3] 112.1	+2.2

[1] Including fuels.
[2] Formerly nonfuel mining.
[3] Preliminary figure.

Sources: Federal Reserve Board, Federal Reserve Bulletin. Industrial Production Indexes. February 1964, p. 223, June 1964, p. 769. Industrial Production Indexes for 1962, published June 1963.

NET SUPPLY

Net Supply.—Generally, the changes in net supply [4] of minerals and metals were mixed, with more gains than losses. Cobalt, nickel, tungsten, beryl ore, cadmium, uranium concentrate, barite, and mica declined well over 12 percent compared with 1962. Aluminum, tin, and zinc dropped under 5 percent. All major ferrous and nonferrous metals, as well as the nonmetals, made notable gains. These increases were attributable to overall improvement of both domestic production and imports. Of the 36 commodities included in the net supply tabulation, 24 increased and 12 decreased. Exports made insignificant gains during the year. The net supply analysis indicated that 1963 was another relatively good year for the minerals industry.

Source of supply.—Imports continued to be an important source of new supply, particularly metals. Most imports increased in quantity over the previous year, although the percentage may be unchanged or indicate a decline. Secondary production maintained and gained insignificantly in their importance in the net supply of metals and its equivalent.

Source of Imports.—Canada and Mexico expanded their share of U.S. imports for 13 principal minerals, lost in 11, and maintained their position in 8. The major gains were registered in iron imports. Major drops were recorded in platinum, mercury, tungsten, uranium and potash. The East and South Pacific areas maintained their share of the market with some minor changes. Other Western Hemisphere sources lost some part of their market with iron but improved their share of aluminum metal. Other free world sources maintained their share of the market, with some improvement in minor minerals. The Soviet bloc made another appreciable gain in 1963 in supplying chromite and platinum-group metals. Significant shifts in relative sources of imports occurred in iron, chromite, tungsten, zinc, aluminum, cadmium, mercury, platinum, titanium concentrate, uranium, barite, gypsum, and potash. The shift in the source of uranium imports was due to a 43-percent overall decrease of total imports in 1963 from that of 1962. Canada and Mexico, our major sources of imports, bore the brunt of the overall decrease with a 48-percent drop from their 1962 level, whereas other free world countries declined only 38 percent of their 1962 share of the market.

[4] Summary of primary shipments, secondary production, and imports, minus exports.

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TABLE 6.—Net supply of principal minerals in the United States and components of gross supply [1]

(Thousand short tons unless otherwise stated)

Commodity	Net supply			Components as a percent of gross supply (gross supply=100)						Exports as a percent of gross supply	
				Primary shipments [2]		Secondary production [3]		Imports [4]			
	1962	1963	Change from 1962 (percent)	1962	1963	1962	1963	1962	1963	1962	1963
Ferrous ores, scrap and metals:											
Iron (equivalent) [5]	[6] 93,147	100,864	+8	[6] 48	48	[7] 28	[7] 30	[6] 24	22	[6] 4	5
Manganese (content)	[6] 965	1,038	+8	5	6			[8] 95	[8] 94	1	1
Chromite (Cr_2O_3 content)	612	631	+3					100	100	(9)	1
Cobalt (content) thousand pounds	[10] 12,640	[10] 10,717	−15	(11)	(11)	[12] 2	[12] 2	98	98	(9)	(9)
Molybdenum (content) do	34,762	39,012	+12	100	100			(9)	(9)	31	41
Nickel (content)	142	133	−6	9	11	4	3	87	86	(13)	(13)
Tungsten ore and concentrate (W content) short tons	6,447	4,679	−27	61	57			[8] 39	[8] 43	1	1
Other metallic ores, scrap, and metals:											
Copper (content)	[6] 1,779	1,859	+4	58	56	20	19	[8] 22	[8] 25	16	14
Lead (content)	[6] 1,077	1,119	+3	22	23	41	42	[8] 37	[8] 35	(9)	(9)
Zinc (recoverable content)	1,064	1,018	−4	46	50	5	6	[8] 49	[8] 44	4	3
Aluminum (equivalent) [14]	[6] 2,732	2,638	−4	9	11	4	4	87	85	8	9
Tin (content) long tons	[6] 58,097	56,356	−3	(11)	(11)	20	22	80	78	1	3
Antimony (recoverable content) [15] short tons	[6] 37,092	39,337	+6	5	4	52	52	[8] 43	[8] 44	(9)	(9)
Beryl ore (BeO content) do	990	710	−28	2	(11)	3	3	95	97	(9)	(9)
Cadmium (content) [16] do	[6] 5,769	4,834	−16	[6] 33	36	(17)	(17)	[6] [8] 67	64	6	11
Magnesium (content)	74,498	89,112	+20	[18] 85	[18] 82	12	16	3	2	8	4
Mercury 76-pound flasks	[6] 63,405	72,309	+14	41	26	9	15	[8] 50	59	(9)	(9)
Platinum-group metals thousand troy ounces	821	1,423	+73	3	3	[19] 15	[19] 8	82	89	7	4
Titanium concentrate:											
Ilmenite and slag (TiO_2 content)	531	604	+14	79	78			21	22		
Rutile (TiO_2 content)	40	77	+93	18	14			82	86	3	1
Uranium concentrate (U_3O_8 content) short tons	[6] 28,728	23,020	−20	59	62			41	38		
Nonmetals:											
Asbestos	726	724	(9)	7	9			93	91	(9)	[20] 1
Barite, crude	1,597	1,402	−12	54	59			46	41		
Boron minerals and compounds, finished products (gross weight).	354	361	+2	100	100			(9)	(9)	45	48
Bromine and bromine in compounds million pounds	[6] 182	193	+6	100	100			(9)	(9)	[6] 5	5
Clays	47,312	49,586	+5	100	100			(9)	(9)	1	1
Fluorspar, finished	837	832	−1	25	24			75	76	(9)	(9)
Gypsum, crude	[6] 15,410	15,531	+1	[6] 65	65			(6) 35	35	(9)	(9)
Mica (except scrap) thousand pounds	11,498	9,349	−19	3	1			97	99	4	6
Phosphate rock (P_2O_5 content) thousand long tons	[6] 4,702	4,938	+5	99	99			1	1	[6] 21	21
Potash (K_2O equivalent)	[6] 2,557	2,882	+13	89	82			11	18	17	13
Salt (common)	[6] 29,510	31,234	+6	95	96			5	4	2	2

Sulfur, all forms (content) [21] thousand long tons	[6] 5,949	6,218	+5	88	88	----------	----------	12	12	21	21
Talc and allied minerals	756	764	+1	97	97	----------	----------	3	3	6	7
Crushed and broken stone	[6] 653,489	684,876	+5	100	100	----------	----------	(9)	(9)	(9)	(9)
Sand and gravel	[6] 776,369	821,452	+6	100	100	----------	----------	(9)	(9)	(9)	(9)

[1] Net supply is sum of primary shipments, secondary production, and imports, minus exports. Gross supply is total before subtraction of exports.

[2] Primary shipments are mine shipments or mine sales (including consumption by producers) plus byproducts production. Shipments more nearly represent quantities marketed by domestic industry and as such are more comparable to imports. Use of shipment data rather than production data also permits uniform treatment among more commodities.

[3] From old scrap only.

[4] Imports for consumption except where otherwise indicated; scrap is excluded wherever possible both in imports and exports, but all other sources of minerals through refined or roughly comparable stage are included except when commodity description indicates earlier stage. Exports of foreign merchandise (reexports), if any, are included when imports are general.

[5] Iron ore reduced to estimated pig iron equivalent; reported weights used for all other items of supply.

[6] Revised figure.

[7] Receipts of purchased scrap.

[8] General imports; corresponding exports are of both domestic and foreign merchandise.

[9] Less than 0.5 percent.

[10] Sum of secondary production and imports only.

[11] Figure withheld to avoid disclosing individual company confidential data. Figure s not included in net and gross supply.

[12] Consumption of purchased scrap.

[13] Mostly manufactured products and scrap, therefore, impossible to determine net content of nickel.

[14] Calculated from the percentage of bauxite mine production (rather than shipments): bauxite imports, and alumina imports used in producing aluminum metal, and converted to aluminum equivalent. Some duplication occurs because of small quantities of loose scrap imported, which is also reflected in secondary production. To avoid a duplicate adjustment for nonmetallic use, exports of bauxite to Canada were excluded from exports.

[15] Based on recovery from all forms as byproducts from domestic and foreign sources.

[16] Primary shipments are calculated as a percentage of total primary production of metal, as part of the domestic primary output is recovered from foreign raw material sources. The quantities recovered from imported raw materials plus imports of cadmium metal are accounted for under imports.

[17] Secondary statistics are included in the primary statistics to avoid disclosing company confidential data.

[18] Primary production of metal.

[19] Recovery from both old and new scrap.

[20] Reexports included.

[21] Includes sulfur content of pyrites production.

TABLE 7.—Percentage distribution of imports of principal minerals consumed in the United States, by country of origin

Commodity	Canada and Mexico		East and South Pacific [1]		Other Western Hemisphere		Other free world		Soviet bloc [2]	
	1962	1963	1962	1963	1962	1963	1962	1963	1962	1963
Ferrous ores, scrap, and metals:										
Iron (equivalent)[3]	49	54	13	10	35	33	3	3	(8)	-----
Manganese (content)	6	6	1	1	43	40	50	53	-----	-----
Chromite (Cr_2O_3 content)	-----	-----	-----	-----	-----	-----	97	90	3	10
Cobalt (content)	3	6	-----	-----	-----	-----	97	94	-----	-----
Nickel (content)	92	92	-----	-----	-----	-----	8	8	-----	-----
Tungsten ore and concentrate (W content)	9	4	30	6	1	27	60	63	-----	-----
Molybdenum (content)[4]	-----	-----	-----	-----	-----	-----	-----	100	-----	-----
Other metallic ores, scrap, and metals:										
Copper (content)	26	25	70	69	-----	(8)	4	6	-----	-----
Lead (content)	40	40	34	34	3	5	23	21	-----	-----
Zinc (recoverable content)	64	71	18	14	8	4	10	11	-----	-----
Aluminum (equivalent)[5]	7	2	-----	-----	84	95	9	3	-----	-----
Tin (content)	-----	6	4	-----	-----	4	96	90	-----	-----
Antimony (recoverable content)[6]	27	25	9	6	-----	7	64	62	-----	-----
Beryl ore (BeO content)	-----	-----	3	1	55	46	42	53	-----	-----
Cadmium (content) [7]	89	73	5	13	-----	2	6	12	-----	-----
Mercury	25	13	-----	12	-----	2	75	73	-----	-----
Platinum-group metals	47	15	-----	-----	3	3	39	59	11	23
Titanium concentrates: Rutile, ilmenite and slag (TiO_2 content)	57	46	42	47	-----	-----	1	7	-----	-----
Uranium (U_3O_8 content)	61	56	2	1	-----	-----	37	43	-----	-----
Magnesium [4]	-----	37	-----	-----	-----	3	-----	60	-----	-----
Nonmetals:										
Asbestos	93	96	1	(8)	-----	-----	6	4	-----	-----
Barite, crude	63	50	14	18	2	-----	21	32	-----	-----
Fluorspar, finished	75	79	-----	-----	-----	-----	25	21	-----	-----
Gypsum, crude	86	97	-----	-----	14	3	-----	(8)	-----	-----
Mica (except scrap)	-----	-----	-----	-----	14	17	86	83	-----	-----
Potash (K_2O equivalent)	13	4	1	(8)	-----	-----	84	93	2	3
Sulfur (content)	100	100	-----	-----	-----	-----	-----	(8)	-----	-----
Boron [4]	-----	25	-----	-----	-----	-----	-----	75	-----	-----
Bromine [4]	-----	-----	-----	-----	-----	-----	-----	100	-----	-----
Phosphate rock (content)[4]	-----	6	-----	-----	-----	-----	-----	94	-----	-----
Salt [4]	-----	76	-----	-----	-----	15	-----	9	-----	-----
Pyrite [4]	-----	100	-----	-----	-----	-----	-----	-----	-----	-----
Talc [4]	-----	8	-----	-----	-----	-----	-----	92	-----	-----

[1] West coast of South America (Chile, Peru, and Ecuador), New Zealand, New Caledonia, and Australia.
[2] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Poland, Rumania, China, North Korea, and North Viet Nam.
[3] Includes iron ore, pig iron, and scrap.
[4] Omitted in 1962.
[5] Based on recovery from all forms from foreign sources.
[6] Excludes antimony from foreign silver and lead ores.
[7] Metal and flue dust only.
[8] Less than 0.5 percent.

Source: U.S. Department of Commerce, Bureau of Census. U.S. Imports of Merchandise for Consumption. Rept. FT. 110, 1962 and 1963. Imports that are less than 5 percent of net new supply are omitted.

CONSUMPTION

Patterns.—Domestic consumption of minerals continued the upward trend of the past few years and generally increased over 1962. Significant declines were registered in 1963 for tungsten, cobalt, cadmium, and titanium-ilmenite. These dropped 19 percent, 9 percent, 8 percent, and 5 percent, respectively. Smaller declines were noted for five other commodities—asbestos, barite, manganese, mica, and tin. Despite the increase of iron and steel production, the consumption of most of the minerals associated with steelmaking declined whereas the consumption and imports of ferroalloys (not appearing in the tables) increased. The major exceptions to this were iron ore, molybdenum, and nickel, which gained 13 percent, 5 percent, and 5 percent over 1962, respectively. This was caused by the tendency of using more imported ferroalloys in iron and steelmaking as substitution for many of the domestic produced steelmaking associated minerals.

Consumption of nonferrous metals and ores made overall gains in 1963. Mercury rose 19 percent; silver, 18 percent; platinum, 16 percent; aluminum, 12 percent; titanium-rutile, 10 percent; refined copper, 9 percent; magnesium, 8 percent; antimony, bauxite and zinc slab, 7 percent; and refined lead, 5 percent. Consumption of nonmetals generally improved. Gains were registered for fertilizers and chemical minerals. Potash rose 13 percent; sulfur, 7 percent; salt, 6 percent; and phosphate rock, 5 percent. Nonmetals used in construction generally gained over 1962. Cement, crushed stone, clay, and sand and gravel rose 5 percent and gypsum, 1 percent.

Estimated 1975 Consumption[5].—The Bureau of Mines estimated U.S. consumption of major mineral products for 1975. These estimates reflected a growing demand based on such factors as population and labor force increases, changing technology and innovation, rising gross national product, and projection of construction activity. New estimates were added and revisions made to adjust for new or additional information.

Estimated 1975 uranium (U_3O_8) consumption was revised upward from 5,500 short tons to a range of 8,900 to 14,000 short tons by the Atomic Energy Commission. This new estimate reflects principally the projected requirements of civilian nuclear power plants that are based on a plutonium recycle mode of power generating operations. This estimate does not include any military requirements or exports of uranium.

Estimated cement consumption was revised upward 20 percent because of the anticipated changing character and methods of construction activity. The revised 20 percent increase of estimated bismuth consumption was due to the increasing usage in industrial chemical industries, especially in making plastics. Projected silver consumption was revised upward by 107 percent chiefly because of increased demand for coinage.

Value of Apparent Consumption in Constant Dollars.—A new table of apparent consumption of minerals in constant dollars published

[5] The Projections of Major Economic Trends for the Year 1975 is included for reference.

by the Bureau of Census in "Raw Materials in the U.S. Economy: 1900–61" [6] is presented here. The value of apparent consumption in constant 1954 dollars was derived by multiplying the average 1954 price of the mineral commodity by the quantity of apparent consumption for the respective years.

The apparent consumption of total minerals in constant dollars has varied with the fluctuations of the economy. Mineral consumption in relation to GNP in constant 1954 dollars has declined gradually from 5 percent in 1947–48 to about 4 percent in the early 1960's. In other words, the rate of growth of mineral consumption is relatively slower than the growth of the GNP.

The value of metals consumption in 1954 dollars reached a peak in 1948 and has been on a downward trend since then. The lows in 1950, 1951, and 1961, which should have been good years, were due principally to the large net outflow of gold bullion to Europe and elsewhere. Gold exports in these years were $509 million, $610 million, and $782 million, respectively. The share of metals consumption of total mineral consumption has declined from 26 percent in 1947–48 to about 15 percent in 1960. The consumption of metals fluctuated with general economic activity, and its growth rate has been much slower than the growth of the general economy.

On the other hand, the apparent consumption of nonmetals except mineral fuels has grown consistently with population. It was not

TABLE 8.—Reported consumption of principal metals and minerals in the United States

Commodity	1962	1963	Change from 1962 (percent)
Antimony [1] ... short tons	15,452	16,532	+7.0
Barite, crude ... thousand short tons	1,210	1,200	−0.8
Bauxite ... thousand long tons, dried equivalent	10,577	11,318	+7.0
Beryl [2] ... short tons	7,758	7,934	+2.3
Chromite ... thousand short tons, gross weight	1,131	1,187	+5.0
Cobalt ... thousand pounds	11,268	10,263	−8.9
Copper, refined ... thousand short tons	1,600	1,744	+9.0
Fluorspar, finished ... do	653	736	+12.7
Iron ore ... thousand long tons, gross weight	99,562	112,535	+13.0
Lead ... thousand short tons	1,110	1,163	+4.8
Magnesium, primary ... short tons	[3] 47,320	51,240	+8.3
Manganese ore ... thousand short tons, gross weight	[3] 1,865	1,842	−1.2
Mercury ... 76-pound flasks	65,301	77,963	+19.4
Mica splittings ... thousand pounds	6,728	6,687	−0.6
Molybdenum, primary production [4] thousand pounds, Mo content	35,674	37,478	+5.1
Nickel, exclusive of scrap ... short tons	118,677	124,478	+4.9
Platinum-group metals, sales to consumers ... thousand troy ounces	866	1,003	+15.8
Silver [5] ... million troy ounces	[3] 187.8	221.5	+17.9
Tin ... long tons	79,085	78,303	−1.0
Titanium concentrate:			
Ilmenite and slag ... thousand short tons, estimated TiO_2 content	600	568	−5.3
Rutile ... do	30	33	+10.0
Tungsten concentrate ... thousand pounds of contained tungsten	13,691	11,061	−19.2
Zinc, slab ... thousand short tons	1,032	1,105	+7.1

[1] Includes primary content of antimonial lead produced at primary lead smelters and antimony content of alloys imported.
[2] Beryl ore of 10–12 precent BeO content.
[3] Revised figures.
[4] Comprises ferromolybdenum, molybdic oxide, and molybdenum salts and metal.
[5] Total consumption for coinage, industry, and the arts.

[6] Raw Materials in the U.S. Economy: 1900–61, U.S. Department of Commerce, Bureau of Census, Working Paper No. 6, 1963, pp. 107–117.

subject to the fluctuations of the economy and has increased its share of total mineral consumption from 10 percent in 1947 to 16 percent in 1961. As for its relation to real GNP, nonmetals consumption increased 20 percent gradually from 1947 to the late 1950's and stabilized there through the early 1960's. This indicates that the growth of nonmetals consumption has been at a relatively faster rate than GNP growth.

The apparent consumption of mineral fuels is also less sensitive or responsive to the fluctuations of the state of the economy. The growth of mineral fuel consumption has been slower than GNP. The amount of consumption has increased from $9 billion in 1947 to $13 billion in 1961. Mineral fuels increased their share of total mineral consumption from 64 percent in 1947 to 76 percent in 1961.

Shipments and Orders.—Seasonally adjusted shipments of the primary metals industry recovered from the low of July 1962 and continued upward to a peak in May 1963, slowed in September, and then recovered in the last quarter which resulted in the years' total shipments reaching the highest level in history. Shipment of the stone, clays, and glass products industry declined slightly from 1962. Net new orders in the primary metals industry surged upward and reached a peak for 1963, second only to 1959. At yearend, unfilled orders of the primary metals industry declined nearly 5 percent from 1962.

TABLE 9.—Apparent consumption of metals and minerals in the United States [1]

Commodity	1962	1963	Change from 1962 (percent)
Aluminum [2] ... thousand short tons	[3] 2,705	3,020	+11.6
Asbestos, all grades ... do	726	724	−(4)
Boron minerals and compounds [5] ... thousand short tons, gross weight	354	361	+2.0
Bromine and bromine in compounds ... million pounds	183	192	+4.9
Cadmium, primary ... thousand pounds, Cd content	[3] 12,579	11,560	−8.1
Clays ... thousand short tons	47,312	49,586	+4.8
Gypsum, crude [6] ... million short tons	15,410	15,531	+0.8
Phosphate rock ... thousand long tons, P_2O_5 content	[3] 4,702	4,938	+5.0
Potash ... thousand short tons, K_2O equivalent	[3] 2,557	2,882	+12.7
Salt, common ... thousand short tons	[3] 29,510	31,234	+5.8
Sulfur, all forms ... thousand long tons, S content	[3] 6,244	6,685	+7.1
Talc and allied minerals ... thousand short tons	756	763	+.9

1 Covers commodities for which consumption is not reported.
2 Includes 1962 shipments to government of 41,544 short tons; 1963, 24,293 short tons.
3 Revised figure.
4 Less than .05 percent.
5 Reported as finished products.
6 Computed as crude mined plus crude imports for consumption less crude exports less the change in stocks.

TABLE 10.—Estimated United States consumption of major mineral products for 1975

Mineral products	Quantity
Ferrous:	
Steel ingot ... million short tons	[1] 130
Pig iron ... do	85
Ferrous scrap ... do	55
Iron ore ... million long tons	150
Manganese ore ... thousand short tons	3,000
Chromite ores:	
Metallurgical grade ... do	1,850
Refractory grade ... do	650
Chemical grade ... do	200
Molybdenum ... million pounds	63
Tungsten ... short tons	1,250
Nonferrous:	
Bismuth ... thousand pounds	[1] 2,400
Copper, primary, refined ... thousand short tons	2,000
Lead ... do	1,350
Zinc, slab ... do	1,400
Aluminum ... do	7,200
Alumina ... do	12,000
Bauxite ... do	25,000
Antimony, primary ... short tons	11,000
Antimony, secondary ... do	20,000
Silver ... million troy ounces	414
Platinum ... thousand troy ounces	1,100
Titanium, ilmenite including titanium slag ... thousand short tons	1,600
Titanium, rutile ... do	150
Uranium (U_3O_8 content) ... short tons	[1 2] 8,900–14,000
Nonmetals:	
Asbestos ... thousand short tons	1,000
Cement ... million barrels	[1] 600
Clays ... thousand short tons	59,700
Lime ... do	22,000
Phosphate rock (P_2O_5 content) ... do	9,000
Potash (K_2O content) ... do	6,000
Sulfur ... do	8,000
Salt ... million short tons	50
Crushed stone ... do	1,200
Sand and gravel ... do	1,300

[1] Revised figure.
[2] Faulkner and McVey, U.S. Atomic Energy Commission, "Fuel Resources and Availability for Civilian Nuclear Power for 1964–2000", table 4. See text for explanation of new estimate.

TABLE 11.—Value of apparent consumption of minerals in the United States by major mineral products and groups, in 1954 dollars [1]

(Million dollars)

Commodity	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
All minerals	14,011	15,177	12,969	13,801	14,431	15,942	16,017	15,249	16,891	17,866	17,877	17,070	17,919	18,243	17,214
Nonfuel, total	5,027	5,515	4,324	4,032	3,930	5,403	5,135	4,660	5,276	5,566	5,622	5,047	5,346	5,414	4,183
Metals, total	3,639	3,975	2,863	2,303	2,025	3,479	3,157	2,580	2,967	3,102	3,133	2,603	2,679	2,723	1,439
Ferrous, total	833	1,047	916	1,156	1,304	1,215	1,577	1,215	1,433	1,416	1,491	1,060	1,156	1,191	979
Iron	461	609	532	665	815	635	818	551	718	712	762	580	619	735	504
Ferroalloy metals	372	438	384	491	489	580	759	664	715	704	729	480	537	456	475
Manganese	134	151	136	182	183	195	270	195	213	220	259	167	172	197	195
Tungsten	37	41	33	84	52	94	144	144	140	134	74	40	36	45	40
Other	201	246	215	225	254	291	345	325	362	350	396	273	329	214	240
Nonferrous, total	2,806	2,928	1,947	1,147	721	2,264	1,580	1,365	1,534	1,686	1,642	1,543	1,523	1,532	460
Monetary, total	1,894	1,913	868	−140	−362	870	185	192	261	333	362	480	419	435	−646
Gold	1,817	1,810	760	−264	−460	774	85	85	161	167	163	312	349	380	−680
Silver	77	103	108	124	98	96	100	107	100	166	199	168	70	55	34
Base, total	715	739	771	941	830	984	959	812	901	961	939	769	782	796	808
Copper	490	493	505	617	592	621	652	518	613	642	580	456	524	560	563
Lead	128	152	174	209	129	216	167	170	165	177	192	185	143	130	140
Zinc	197	94	92	115	109	147	140	124	123	142	167	128	115	106	105
Other, total	197	276	308	346	254	407	437	363	374	390	340	295	322	302	299
Bauxite	25	37	38	41	43	53	68	71	71	78	91	99	101	97	102
Other metals	172	239	270	305	211	354	369	292	303	312	249	196	221	205	197
Nonmetals, total	1,388	1,540	1,461	1,729	1,905	1,924	1,978	2,080	2,309	2,464	2,489	2,444	2,667	2,691	2,744
Construction, total	862	949	913	1,061	1,173	1,212	1,230	1,346	1,503	1,580	1,634	1,670	1,795	1,818	1,851
Dimension stone	43	49	46	53	53	52	54	63	67	64	64	65	66	61	65
Crushed and broken stone	394	425	420	473	532	553	568	582	671	719	779	787	840	901	905
Sand and gravel	267	296	295	343	372	401	405	503	536	565	568	619	661	638	680
Fire clay	40	44	39	43	53	51	47	40	48	53	48	39	44	44	39
Common clay and shale	26	30	25	32	33	32	34	36	40	41	37	37	42	41	41
Gypsum	26	31	28	35	36	34	35	37	44	44	41	41	51	45	43
Other construction	66	73	61	82	94	89	88	85	96	94	98	81	92	87	79
Chemicals	367	373	352	421	472	502	528	527	565	639	630	559	620	638	650
Potash	37	41	40	54	62	67	75	75	78	79	83	77	87	90	95
Phosphate rock	51	46	48	57	56	67	66	70	61	77	63	71	74	77	85
Sulfur and pyrite	98	109	101	119	128	131	131	130	141	165	153	135	137	148	152
Other chemicals	181	177	163	191	226	237	256	252	285	318	331	276	322	323	318
Other nonmetals	159	218	196	247	260	210	220	207	241	245	225	215	252	235	243
Abrasive materials	19	43	25	43	48	50	50	51	53	58	45	36	48	46	47
Other nonmetals	140	175	171	204	212	160	170	156	188	187	180	179	204	189	196
Mineral fuels, total	8,984	9,662	8,645	9,769	10,501	10,539	10,882	10,589	11,615	12,300	12,255	12,023	12,573	12,829	13,031
Coal	2,981	2,960	2,198	2,590	2,493	2,225	2,177	1,873	2,086	2,179	2,081	1,809	1,878	1,882	1,805
Oil and gas	6,003	6,702	6,447	7,179	8,008	8,314	8,705	8,716	9,529	10,121	10,174	10,214	10,695	10,947	11,226
Crude petroleum	5,197	5,799	5,491	6,064	6,718	6,926	7,242	7,195	7,873	8,375	8,361	8,356	8,681	8,815	9,009
Natural gas	488	549	580	675	806	872	915	952	1,025	1,100	1,167	1,215	1,332	1,413	1,458
Natural gas liquids	318	354	376	440	484	516	548	570	631	646	646	643	682	719	759

[1] Data may not add to totals shown due to rounding.

Source: Raw Materials in the U.S. Economy: 1900–61, compiled from Bureau of Mines data. U.S. Department of Commerce, Bureau of Census, Working Paper No. 6, 1963, Table A–H, pp. 107–117.

TABLE 12.—Value of apparent mineral consumption in the United States as a percentage of gross national product, by mineral groups, in 1954 dollars [1]

Year	Gross national product (GNP) (billions of 1954 dollars)	In percentage of GNP				
		Metals	Nonmetals (except fuels)	Nonfuel total	Mineral fuels	Total minerals
1947	282.3	1.29	0.49	1.78	3.18	4.96
1948	293.1	1.36	.52	1.88	3.30	5.18
1949	292.7	0.98	.50	1.48	2.95	4.43
1950	318.1	.73	.54	1.27	3.07	4.34
1951	341.8	.59	.56	1.15	3.07	4.22
1952	353.5	.98	.55	1.53	2.98	4.51
1953	369.0	.85	.54	1.39	2.95	4.34
1954	363.1	.71	.57	1.28	2.92	4.20
1955	392.7	.75	.59	1.34	2.96	4.30
1956	400.9	.77	.62	1.39	3.07	4.46
1957	408.6	.77	.61	1.38	3.00	4.38
1958	401.3	.65	.61	1.26	3.00	4.25
1959	428.6	.63	.62	1.25	2.93	4.18
1960	439.9	.62	.61	1.23	2.92	4.15
1961	447.9	.32	.61	0.93	2.90	3.84

[1] Data may not add to totals shown due to rounding.

Source: Raw Materials in the U.S. Economy: 1900–61, compiled from Bureau of Mines data. U.S. Department of Commerce, Bureau of Census, Working Paper No. 6, 1963, Table A–H, pp. 107–117.

TABLE 13.—Shipments, net new orders and yearend unfilled orders for selected mineral processing industries

(Million dollars)

Year and month	Shipments				Net new orders			Yearend unfilled orders		
	Stone, clay, and glass products	Primary metals	Blast furnaces	All other primary metals	Primary metals	Blast furnaces	All other primary metals	Primary metals	Blast furnaces	All other primary metals [1]
1959	11,249	32,638	18,433	14,205	35,946	21,301	14,645	89,114	65,774	23,340
1960	11,089	32,433	18,285	14,148	27,382	13,763	13,619	60,571	38,430	22,141
1961	11,034	31,659	17,381	14,278	33,107	18,816	14,291	48,009	29,843	18,166
1962	11,531	34,016	18,264	15,752	32,619	16,790	15,829	53,338	31,848	21,490
1963	11,369	35,325	19,033	16,292	(2)	(2)	(2)	(2)	(2)	(2)
January [3]	934	2,753	1,426	1,327	2,736	1,454	1,282	3,768	2,084	1,684
February	947	2,803	1,488	1,315	3,057	1,724	1,333	4,090	2,366	1,724
March	914	2,887	1,565	1,322	3,357	1,980	1,377	4,383	2,624	1,759
April	941	3,015	1,679	1,336	3,805	2,410	1,395	5,126	3,329	1,797
May	948	3,191	1,838	1,353	3,153	1,829	1,324	5,099	3,318	1,781
June	948	3,148	1,807	1,341	2,650	1,277	1,373	4,737	2,960	1,777
July	962	3,159	1,815	1,344	2,605	1,262	1,343	4,220	2,417	1,803
August	914	2,857	1,479	1,378	2,486	1,198	1,288	3,862	2,150	1,712
September	938	2,742	1,392	1,350	2,712	1,371	1,341	3,822	2,102	1,720
October	986	2,904	1,469	1,435	3,013	1,590	1,423	3,859	2,172	1,687
November	977	2,892	1,512	1,380	2,964	1,529	1,435	3,930	2,193	1,737
December	953	2,981	1,570	1,411	2,938	1,456	1,482	3,930	2,120	1,810

[1] All other primary metals can be obtained by subtracting blast furnaces from primary metals.
[2] Data not available.
[3] Seasonally adjusted data; therefore will not add to 1963 total.

Source: U.S. Department of Commerce. Manufacturers, Shipments Inventories, and Orders: 1947–1963, Revised, Bureau of the Census, Series M 3–1, October 1963, pp. 31–37, 44–48. U.S. Department of Commerce, Survey of Current Business, Office of Business Economics, V. 44, No. 6, June 1964, pp. S–5, S–6.

STOCKS

Indexes of Stocks.—Bureau of Mines index of physical stocks held by mineral manufacturers, consumers, and dealers at yearend declined 5 percent in 1963 under that of 1962 and continued the decumulation of stocks started in 1960. Iron ore stocks dropped 7 percent from last year. Ferromanganese and chromite stocks depletions were responsible for overall drops of 6 percent of other ferrous index. The decrease of lead and zinc stocks accounted for the bulk of the 4-percent loss in base nonferrous stocks whereas aluminum and bauxite stocks depletions were responsible for the 6-percent decline of other nonferrous stocks index. The increase of cement stocks resulted in very modest gains for nonmetals stocks index.

Stocks held by primary producers at yearend decreased 4 points or 3 percent as compared with 1962 figures. Iron ore stocks declined 6 percent. The 10-percent increase of tungsten stocks was insufficient to compensate for the 30 percent drop of molybdenum and resulted in a 5-percent decline of other ferrous stocks from 1962. Nonferrous metal stocks, principally bauxite and mercury, rose 3 percent whereas nonmetal stocks decreased 2 percent.

The following commodities are included in the index of stocks of manufacturers, consumers, and dealers in tables 14 and 15: Aluminum, arsenic, bauxite, bismuth, cadmium, cement, chromite, copper, ferrous scrap and pig iron, fluorspar, iron ore, lead, manganese ore and ferromanganese, mercury, molybdenum primary products, nickel, platinum-group metals, tin, titanium concentrates, tungsten concentrates, and zinc. The index of stocks of primary producers includes the following commodities: Antimony, bauxite, fluorspar, gypsum, iron ore, mercury, molybdenum, phosphate rock, potassium salt, sulfur, titanium concentrates, and tungsten. 1955 primary market prices of each commodity were used as weights in the first index; 1955 average mine values were used in the second.

Value of Inventories.—The value of seasonally adjusted inventories held by firms in the primary iron and steel industry in December was only 0.2 percent higher than that in December 1962, whereas other primary metal industries rose 1.7 percent. The aggregate primary metal industry gained nearly 1 percent above that of last year. The inventories were fairly steady throughout the year and

TABLE 14.—Index of stocks of mineral manufacturers, consumers, and dealers at yearend

(1957–59=100)

Yearend	Total metals and nonmetals [1]	Metals					Nonmetals
		Total	Iron	Other ferrous	Base nonferrous	Other nonferrous	
1959	99	99	99	110	96	95	103
1960	110	110	107	108	108	127	118
1961	[2] 103	[2] 102	99	98	[2] 98	[2] 126	120
1962	[2] 100	[2] 99	[2] 98	90	[2] 101	104	[2] 127
1963	95	93	91	85	97	98	128

[1] Excluding fuels.
[2] Revised figure.

drifted upward toward yearend. The value of inventories held by firms in the stone, clays, and glass products industry increased 4 percent in December over that of December 1962. During the first half of the year the inventories were steady and then crept upward during the second half and declined slightly in November and December.

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

(1957-59=100)

Yearend	Metals and nonmetals	Metals				Nonmetals
		Total	Iron ore	Other ferrous	Nonferrous	
1959	93	99	104	74	106	90
1960	110	154	175	64	161	90
1961	121	134	146	63	169	115
1962	[1] 124	147	164	73	[1] 149	[1] 113
1963	120	139	154	69	153	111

[1] Revised figure.

TABLE 16.—Seasonally adjusted book value of product inventory for selected mineral processing industries

(Million dollars)

Year and month	Stone, clay, and glass products	Primary metals	Blast furnaces, steel works	All other primary metals
1959: December	1,379	5,258	3,099	2,159
1960: December	1,458	5,662	3,389	2,273
1961: December	1,468	5,977	3,691	2,286
1962: December	1,492	5,873	3,528	2,345
1963: December	1,544	5,918	3,533	2,385
January	1,501	5,850	3,506	2,344
February	1,501	5,848	3,499	2,349
March	1,508	5,846	3,498	2,348
April	1,495	5,854	3,492	2,362
May	1,502	5,857	3,489	2,368
June	1,506	5,873	3,494	2,379
July	1,491	5,831	3,459	2,372
August	1,535	5,828	3,455	2,373
September	1,551	5,849	3,496	2,353
October	1,517	5,861	3,500	2,361
November	1,535	5,903	3,532	2,371

Sources: U.S. Department of Commerce, Bureau of the Census. Manufacturers Shipments, Inventories, and Orders: 1947–1963. Revised, Series M 3-1, October 1963, pp. 62–67. U.S. Department of Commerce, Office of Business Economics. Survey of Current Business, V. 44, No. 6, June 1964, p. S–5.

LABOR AND PRODUCTIVITY

Employment.—Total employment in the nonfuel mining industries increased in 1963, thus halting the downward trend apparent since 1960. Quarrying and nonmetal mining employment followed the seasonal pattern but increased over 1962. This gain was sufficient to overcome the drop in metal mining employment, primarily copper mining. Employment in iron mining increased, employment in copper mining continued to decline, and employment in other metal mining (primarily lead and zinc and uranium mining) also declined slightly. The pattern of employment in mineral manufacturing industries was mixed; employment in the fertilizer industry and primary nonferrous metals industries registered a gain of 4 percent and 1 percent over 1962 respectively, whereas employment in cement and iron and steel manufacturing decreased insignificantly.

The following tabulation shows percentage changes in average total employment compared with 1962:

	Percent
All industries	+2.4
Mining (including fuels)	−2.7
Metals and nonfuel minerals	+0.3
Metal mining	−0.5
Nonmetal mining and quarrying	+0.8
Coal mining	−8.6
Crude petroleum and natural gas	−1.9
Mineral manufacturing [1]	−0.4

[1] Based upon categories listed under mineral manufacturing in table 17.

Employment in all mineral industries in 1963 again compared unfavorably with all industries. With the exception of the primary iron and steel industry and nonmetallic mining and quarrying, employment continued the downward trend of 1961.

Hours and Earnings.—Average weekly hours of production workers in the (nonfuel) mining industry was the same as that in 1962. Both hourly and weekly earnings rose about 2.5 percent. Weekly hours of metal mining declined slightly and was compensated by the modest rise made in quarrying and nonmetallic mining. Hourly earnings of iron ore mining was unchanged, whereas copper and other metal mining gained a little and resulted in a small 5-cent increase of hourly earnings in all metal mining. Hourly earnings of non-metal mining also increased. Mineral manufacturing industries registered increases in both weekly hours worked and hourly and weekly earnings in all categories.

Labor Turnover Rates.—Accession rates for all metal mining increased 7 percent from 1962 and achieved a new high with iron ore mining mainly responsible for the gain. Both separation rates and layoff rates declined in metal mining with iron ore mining leading the way. Conforming to the metal mining pattern, the major mineral processing industries registered an overall gain in accession rate and similar losses in both separation rate and layoff rate. This overall trend closely followed the pattern of strong recovery in the mineral industries started in 1962 and exceeded all manufacturing.

Wages and Salaries.—Wages and salaries in the mining industry, including fuels, continued the mild upward trend begun in 1961 with a 1-percent gain over that of 1962, but still lagged behind all industries and manufacturing. Metal mining declined another 2 percent during the year and recorded a new low since 1960, whereas nonmetal mining and quarrying achieved a new high with another gain of 3.2 percent over 1962. Primary metal industries and stone, clays, and glass products made notable gain in 1963, but still dropped behind that of all industries. The average annual earnings of full-time employees in mining and mineral processing industries achieved overall gains in 1963 and followed the gradual upward trend in all industries with nonmetal mining and mineral fuels extraction recording higher rates of increase from 1962 than both all industries and all manufacturing.

Productivity. [7]—Iron mining productivity increased notably while copper mining productivity declined slightly and resulted in a modest increase of metal mining productivity. This productivity trend in recoverable copper and iron metal was reversed from respective mining. These declines indicated that the average grade of copper ore mined in 1963 slightly improved whereas the average grade of iron ore mined was a trifle lower than 1962.

TABLE 17.—Total employment in the mineral industries (nonfuel) in the continental United States by industry

(Thousands)

Year and month	Mining				
	Total nonfuel	Nonmetal mining and quarrying	Metal		
			Total [1]	Iron	Copper
1960	[2] 216.8	[2] 123.0	[2] 93.8	33.2	28.3
1961	[2] 207.2	[2] 119.8	[2] 87.4	[2] 26.9	[2] 29.0
1962	[2] 201.5	[2] 118.7	[2] 82.8	[2] 25.5	28.5
1963:					
January	184.7	106.8	77.9	21.5	28.0
February	183.3	103.8	79.5	22.9	28.0
March	186.4	107.7	78.7	23.1	28.0
April	199.6	118.1	81.5	24.4	28.5
May	206.3	123.3	83.0	26.5	27.9
June	211.0	127.0	84.0	26.9	27.9
July	212.9	128.5	84.4	27.9	27.5
August	212.9	128.2	84.7	28.1	27.5
September	211.1	126.7	84.4	27.9	27.5
October	211.2	127.1	84.1	27.6	27.6
November	206.1	122.6	83.5	27.6	27.8
December	198.7	116.1	82.6	26.7	28.0
Year (average)	202.1	119.7	82.4	25.9	27.9

Year and month	Mineral manufacturing			
	Fertilizers	Cement, hydraulic	Blast furnaces, steel works, and rolling mills	Primary metals, nonferrous smelting and refining
1960	35.5	42.8	[2] 577.1	[2] 70.3
1961	[2] 35.8	[2] 40.2	[2] 526.5	[2] 66.6
1962	[2] 36.6	[2] 40.1	[2] 522.3	[2] 68.1
1963:				
January	36.0	37.0	486.0	67.0
February	37.5	35.4	499.0	66.5
March	41.3	36.3	512.5	66.7
April	48.9	40.0	531.2	67.6
May	44.4	41.0	544.4	68.4
June	36.4	42.3	554.6	69.6
July	33.4	42.7	548.8	70.3
August	33.9	42.6	525.3	70.3
September	36.0	42.0	514.7	70.2
October	36.9	40.9	504.9	69.7
November	35.2	40.1	503.3	69.9
December	36.2	38.2	509.9	69.7
Year (average)	38.0	39.9	519.6	68.8

[1] Includes other metal mining not shown separately.
[2] Revised figure.

Source: U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings. V. 10, No. 2, August 1963 to V. 10, No. 11, May 1964, table B-2. Employment and Earnings Statistics for the United States 1909-1962, Bull. 1312-1, 1963.

[7] 1963 index was not available. Content here is based on preliminary estimates.

TABLE 18.—Average hours and gross earnings of production and related workers in the mineral industries (nonfuel) in continental United States, by industries

Year	Total[1]			Metal mining					
				Total[2]			Iron ores		
	Weekly		Hourly earnings	Weekly		Hourly earnings	Weekly		Hourly earnings
	Earnings	Hours		Earnings	Hours		Earnings	Hours	
1959	[3] $97.58	42.8	[3] $2.29	$102.77	40.3	$2.55	$107.34	37.4	$2.87
1960	[3] 102.86	42.9	[3] 2.40	111.19	41.8	2.66	114.73	39.7	2.89
1961	[3] 105.68	[3] 42.9	[3] 2.57	113.44	41.4	2.74	[3] 115.50	[3] 38.5	3.00
1962	[3] 110.32	[3] 43.2	[3] 2.56	[3] 117.45	41.5	[3] 2.83	[3] 122.19	[3] 39.8	3.07
1963	112.96	43.2	2.63	118.66	41.2	2.88	120.96	39.4	3.07

Year	Metal mining—Continued			Quarrying and nonmetal mining			Mineral manufacturing		
	Copper ores						Fertilizers, complete and mixing only		
1959	105.90	42.7	2.48	[3] 94.13	44.4	[3] 2.12	77.51	43.3	1.79
1960	116.77	44.4	[3] 2.63	96.58	43.7	2.21	79.55	43.0	1.85
1961	119.03	43.6	2.73	100.09	43.9	2.28	[3] 80.94	42.6	[3] 1.90
1962	[3] 120.70	[3] 42.8	2.82	[3] 105.43	[3] 44.3	2.38	[3] 84.12	42.7	[3] 1.97
1963	124.56	43.1	2.89	109.03	44.5	2.45	90.23	43.8	2.06

Year	Mineral manufacturing—Continued								
	Cement, hydraulic			Blast furnaces, steel and rolling mills			Nonferrous smelting and refining		
1959	98.98	40.9	2.42	123.38	39.8	3.10	104.81	41.1	2.55
1960	102.87	40.5	2.54	117.04	38.0	3.08	108.09	41.1	2.63
1961	106.52	40.5	2.63	123.84	38.7	3.20	[3] 110.16	[3] 40.8	[3] 2.70
1962	[3] 112.75	[3] 41.0	2.75	[3] 128.31	[3] 39.0	3.29	[3] 114.95	[3] 41.2	2.79
1963	116.60	41.2	2.83	134.40	40.0	3.36	118.56	41.6	2.85

[1] Weighted average of data computed, using figures for production workers as weights.
[2] Includes other metal mining, not shown separately.
[3] Revised figure.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings, V. 10, No. 9, March 1964, Table C 2. Employment and Earnings Statistics for the United States 1909–62. Bull. 1312-1, 1963.

TABLE 19.—Monthly labor-turnover rates in the mineral industries

(Per 100 employees)

Turnover rate	All manufacturing	Hydraulic cement products	Blast furnaces, steel and rolling mills	Nonferrous smelting and refining	Metal mining	Iron ores	Copper ores
Total accession rate:							
1962 average	[1] 4.1	[1] 3.1	2.6	2.2	2.9	2.4	2.3
1963:							
January	3.6	3.2	4.0	1.7	3.2	3.6	2.6
February	3.3	4.8	4.7	2.1	2.8	4.6	1.4
March	3.5	7.5	4.7	2.1	2.9	3.9	1.6
April	3.9	7.7	4.7	3.2	5.7	12.2	2.1
May	4.0	2.3	3.8	3.4	3.6	5.2	1.5
June	4.8	4.2	2.9	4.1	3.8	2.4	3.7
July	4.3	1.6	1.6	2.2	2.7	1.4	2.0
August	4.8	1.6	1.7	2.6	2.8	1.0	3.1
September	4.8	2.1	2.0	2.5	2.6	1.8	2.2
October	3.9	1.1	2.5	2.2	2.7	1.3	2.7
November	2.9	1.2	2.7	1.7	2.5	2.3	2.1
December	2.5	1.8	3.0	1.5	1.8	1.2	1.6
Average	3.9	3.3	3.2	2.4	3.1	3.4	2.2
Total separation rate:							
1962 average	4.1	3.6	3.7	[1] 2.3	3.5	4.2	2.4
1963:							
January	4.0	8.5	2.5	2.0	3.6	3.5	2.0
February	3.2	4.9	1.8	2.3	2.6	2.8	1.0
March	3.5	1.6	1.5	1.9	3.1	2.1	1.8
April	3.6	1.8	1.6	1.9	3.0	2.8	1.8
May	3.6	1.3	1.6	1.5	3.1	1.7	2.7
June	3.4	1.2	1.8	1.7	2.5	1.2	2.4
July	4.1	1.2	4.2	1.7	2.6	.9	3.1
August	4.7	3.2	4.8	3.1	2.9	1.4	2.6
September	4.9	3.5	4.6	3.6	3.9	2.9	3.7
October	4.1	3.0	4.1	1.9	3.1	3.2	1.7
November	3.8	4.9	2.8	1.9	3.3	5.1	1.4
December	3.7	6.7	2.3	1.9	3.1	4.7	1.4
Average	3.9	3.5	2.8	2.1	3.1	2.7	2.1
Layoff rate:							
1962 average	2.0	2.7	2.8	.9	[1] 1.5	3.3	.8
1963:							
January	2.2	7.7	1.5	1.0	1.3	2.4	.5
February	1.6	4.2	.8	1.3	.9	1.7	.1
March	1.7	1.0	.6	.9	1.4	1.5	.3
April	1.6	1.0	.5	.7	.9	1.8	.2
May	1.5	.4	.4	.4	.8	.6	.8
June	1.4	.4	.7	.4	.4	.4	.3
July	2.0	.3	2.9	.5	.6	.2	1.4
August	1.9	1.4	3.5	1.1	.5	.6	.5
September	1.8	1.0	3.1	.9	.8	1.2	.9
October	1.9	1.8	2.9	.7	1.2	2.4	.2
November	2.1	3.8	2.0	1.0	1.9	4.5	.2
December	2.3	6.1	1.6	1.1	1.9	4.1	.4
Average	1.8	2.4	1.7	.8	1.1	1.8	.5

[1] Revised figure.

Source: U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings. V. 10, No. 3, September 1963 through V. 10, No. 9, March 1964, table D-2. Employment and Earnings Statistics for the United States, Bull. No. 1312-1, issued 1963.

TABLE 20.—Wages and salaries in the mineral industries in the United States

(Million dollars)

Industry	1962	Change from 1961 (percent)	1963	Change from 1962 (percent)
All industries	$297,133	+6.6	$312,148	+5.1
All mining	3,763	+.6	3,798	+.9
Nonfuel mining	1,163	+1.0	1,172	+.8
Metal mining	539	−2.0	528	−2.0
Nonmetal mining and quarrying	624	+3.8	644	+3.2
Fuel mining	2,600	+.4	2,626	+1.0
Manufacturing	94,174	+7.7	98,042	+4.1
Primary metal industries	7,692	+6.8	7,930	+3.1
Stone, clays, and glass products	3,155	+5.4	3,310	+4.9

Source: U.S. Department of Commerce, Office of Business Economics, Survey of Current Business. V. 44, No. 7, July 1964.

TABLE 21.—Average annual earnings in the mineral industries in the United States [1]

Industry	1962	Change from 1961 (percent)	1963	Change from 1962 (percent)
All industries	[2] $5,012	+3.5	$5,190	+3.6
All mining	6,030	+2.5	6,267	+3.9
Nonfuel mining	6,026	+3.5	6,234	+3.5
Metal mining	[2] 6,573	[2] +2.8	6,769	+3.0
Nonmetal mining and quarrying	5,622	+3.8	5,855	+4.1
Fuel mining	6,032	+3.5	6,282	+4.1
Manufacturing	5,715	+3.7	5,911	+3.4
Primary metal industries	6,813	+4.0	7,018	+3.0
Stone, clay, and glass products	5,674	+3.7	5,848	+3.1

[1] Per full time employee.
[2] Revised figure.
Source: U.S. Department of Commerce, Office of Business Economics, Survey of Current Business. V. 44 No. 7, July 1964.

TABLE 22.—Labor-productivity indexes for copper- and iron-ore mining [1]

(1957–59=100)

Year	Copper, crude ore mined per-		Iron, crude ore mined per-	
	Production worker	Man-hours	Production worker	Man-hours
1953–57 (average)	87.2	81.8	97.1	92.2
1958	98.9	103.1	92.5	97.5
1959	110.0	105.8	100.9	101.6
1960	116.9	108.2	122.7	116.3
1961	117.9	111.1	135.8	132.4
1962	125.8	120.7	[2] 152.1	[2] 143.8
	Recovered metal [3] per-			
	Production worker	Man-hours	Production worker	Man-hours
1953–57 (average)	91.7	85.9	109.9	104.3
1958	101.8	106.2	90.6	95.3
1959	105.3	101.3	93.9	94.6
1960	112.9	104.5	112.0	106.2
1961	116.2	109.5	112.8	110.0
1962	124.1	119.1	[2] 121.6	[2] 115.0

[1] Indexes have been revised and adjusted to benchmark indexes derived from the Census of Mineral Industries for the years 1939, 1954, 1958.
[2] Revised figure.
[3] Figures refer to usable ore rather than recoverable metal. For iron usable ore is that product with the desired iron content (by selective mining, mixing of ores, washing, jigging, concentrating, sintering).

PRICES AND COSTS

Index of Mine Value.—The average unit mine value of all minerals (including fuels) remained unchanged for the 5th consecutive year. However, the stability of the index was maintained by the 4-point rise in the metal index above that of 1962 which equalized a 1-point drop in the fuels index. The nonmetals index remained the same.

In the metals subgroup, ferrous metals led with a gain of 4 points, nonferrous increased only 1 point, and total metals rose 4 points. The 4.3 percent increase in average mine value of iron ore was responsible for the rise in the ferrous metals index. Lead and zinc increases accounted for small gains in base nonferrous metals. The 18-percent increase of average mine value of silver accounted for a 7-point gain made in the value of monetary nonferrous metals. Antimony and bauxite increases were responsible for most of the 4-point gain made in other nonferrous metals. In the nonmetal subgroup, the gains that were made in construction and other nonmetals, compensated for the decline in chemical nonmetals. In the mineral fuels subgroup the small decrease of the average mine value of both bituminous coal and crude petroleum accounted for the decline of the total fuels index.

The stability of the average unit mine value index was in accord with the trend of wholesale price indexes: the unit value of the wholesale prices (1957–59=100) was 100.3 in 1961, 100.6 in 1962, and 100.3 in 1963.

The difference between the average unit mine value index and other published indexes was illustrated by the monetary metals index. The U.S. Treasury price of gold had not changed from year to year, which was also true for silver prior to November 1962, but the index had. The variations were caused by movements in the differential smelter purchase price of ores and refined metals prices. The index of mine value was believed to reflect more accurately the actual per-unit mine return.

Index of Implicit Unit Value.—The index of implicit unit value reflected the unit price change implied in the Bureau of Mines Index of Physical Volume of Mineral Production and its value series of total mineral production. Construction of the index is described in the chapter on Review of the Mineral Industries in the 1961 Yearbook—Vol. I.

This year, the index was expanded into more subgroups and was used to deflate the value of mineral production by mineral subgroups for the United States as a whole and for the individual states (State data are presented in volume III chapters) in order to present the value of mineral production in constant dollars.

Prices.—Processed mineral commodity prices were generally steady with no significant changes. Overall annual prices of ferrous metals declined modestly. The drop was attributed to the 10-percent and 4-percent drop of pig iron and ferrous scrap prices. Overall prices of nonferrous metals increased; pig lead and zinc slab gained 16 percent and 3 percent, respectively; there was no change in price of refined copper; and aluminum ingot declined 5 percent. The overall price of metals and metal products gained slightly. Prices of nonmetal products registered an insignificant loss. Construction material prices were steady with sand, gravel, crushed stone, and lime gaining a little while other materials recorded small declines. Fuels and related products again decreased minutely. Fertilizer and chemical raw materials generally gained very modestly. The 1963 price of mineral commodities made insignificant gains from January to December with only nonferrous metals making some noticeable gains.

Costs.—Prices of cost items shown in table 26 were mixed. Explosives and gas fuel rose 3.6 percent and 3.0 percent, respectively, over last year and continued the upward trend. Lumber and construction machinery and equipment also increased modestly. Prices of industrial chemicals and petroleum products continued to decline. From January to December, prices of gas fuel, lumber, and construction machinery, and equipment made noticeable increases.

In general, prices of machinery and equipment used in mining rose over 1 percent from last year. The percentage changes from 1962 for major items were as follows:

	Percent change from 1962
Mining machinery and equipment	+0.6
Construction machinery and equipment	+1.7
Power cranes, draglines, shovels, etc	+2.5
Tractors, other than farm	+2.1

Relative Labor Cost.—The 1963 index of labor cost for metal mining indicated a gain in copper and no change for iron ore. Labor cost per pound of recoverable copper rose to the 1957–59 level. The value of recoverable copper per-man-hour increased 1 percent and recorded a new high. The labor cost per dollar of recoverable copper increased slightly.

Index of Principal Metal Mining Expenses [8].—This index excludes capital costs and contract work expenses; consequently, it does not represent changes in total unit cost of metal mining. It does, however, gage the impact of labor cost, production changes, productivity, and fluctuations in prices of current supplies, fuels, and electric energy used by the mining industry.

TABLE 23.—Index of average unit mine value of minerals produced in the United States, by group and subgroup [1]

(1957-59=100)

Year	All minerals	Metals						Nonmetals				Fuels
		Total	Ferrous	Nonferrous				Total	Construction	Chemical	Other	
				Total	Base	Monetary	Other					
1959	98	102	102	102	103	101	99	101	102	99	100	98
1960	98	105	102	107	109	102	99	102	104	100	101	97
1961	98	103	105	99	98	104	100	102	103	101	101	97
1962	98	[2] 102	104	[2] 101	99	[2] 111	99	[2] 102	[2] 103	99	102	[2] 97
1963	98	106	108	102	100	118	103	102	104	97	104	96

[1] For description of index see Review of Mineral Industries, BuMines Minerals Yearbook, 1959. V. 1, 1960, p. 22–24.
[2] Revised figure.

[8] This index is for iron ore and copper mining only.

A cost index of electric energy is added to this index this year in order to present a more complete picture. Reflecting the small gain in cost of labor (adjusted for productivity), a small increase in cost of supplies, no change in cost of fuels, and a slight decline in power cost, the total cost, excluding capital and contract work, registered another very modest increase in 1963. The small gain in total index was attributed principally to increased labor cost and cost of supplies.

TABLE 24.—Index of implicit unit value of minerals produced in the United States

(1957-59=100)

Year	All minerals	Metals						Nonmetals				Fuels
		Total	Ferrous	Nonferrous				Total	Construction	Chemical	Other	
				Total	Base	Monetary	Other					
1940	38.4	45.8	35.9	54.7	40.3	109.8	71.6	53.3	54.0	54.3	39.3	34.7
1941	41.7	45.1	32.7	57.3	44.0	110.5	67.1	54.1	55.6	54.5	37.1	38.9
1942	43.5	43.8	30.4	57.5	48.3	96.7	67.7	58.7	61.6	57.3	36.0	41.0
1943	46.0	46.2	33.3	58.8	53.1	95.0	63.0	58.8	63.4	57.7	40.3	44.1
1944	47.0	47.4	33.1	61.2	52.4	93.7	61.0	58.0	61.2	59.4	50.5	46.1
1945	47.6	48.4	34.3	63.7	57.6	93.7	65.1	60.6	64.6	62.0	52.1	46.8
1946	54.1	55.6	37.0	73.4	68.3	96.2	78.3	68.2	71.9	66.3	54.6	53.0
1947	67.3	63.5	42.2	82.4	82.1	90.4	68.4	74.7	78.7	73.1	56.6	67.8
1948	82.2	68.8	47.2	88.8	89.5	91.5	70.4	79.7	85.4	72.9	59.3	86.3
1949	81.4	69.6	54.8	84.5	81.6	91.6	74.2	82.4	88.0	73.7	61.2	84.2
1950	81.8	73.4	60.6	84.2	83.9	91.3	80.5	82.7	87.7	75.6	64.8	83.6
1951	85.2	85.1	67.4	101.1	102.9	92.0	91.9	87.2	92.4	79.7	72.6	85.4
1952	85.6	86.6	75.0	96.4	99.0	91.9	83.5	87.0	90.6	81.4	78.4	85.5
1953	90.5	91.2	82.3	97.1	98.6	100.6	88.1	92.5	96.1	88.7	78.6	90.2
1954	92.0	92.3	85.3	97.9	99.9	99.9	86.6	94.7	96.3	95.6	83.2	91.3
1955	94.5	103.9	87.0	118.4	123.7	99.9	90.1	96.4	97.5	98.4	83.2	92.5
1956	96.5	113.5	90.8	133.4	140.3	99.7	98.6	100.3	102.2	98.6	94.1	92.9
1957	100.9	102.5	98.5	104.3	104.6	100.1	104.3	98.6	98.4	101.0	98.5	101.2
1958	99.6	95.5	100.7	92.8	91.6	99.9	96.2	99.5	99.1	100.3	101.0	100.0
1959	99.5	101.5	101.8	102.5	103.7	99.9	97.0	101.9	102.3	98.9	101.6	98.6
1960	100.9	106.8	101.8	110.1	111.7	99.7	98.6	100.7	100.7	99.5	102.9	99.3
1961	101.1	102.8	103.9	103.7	103.4	101.2	98.3	100.4	99.8	101.7	106.5	100.5
1962	101.7	103.8	103.5	106.8	106.1	108.1	103.3	100.0	99.3	100.4	110.1	101.2
1963	101.7	107.2	107.7	109.0	106.9	116.4	112.2	100.1	99.5	99.4	109.4	100.9

TABLE 25.—Price indexes for selected metals and mineral commodities

(1957-59=100)

Commodity	1963 January	1963 December	Change from January (percent)	Annual average 1962	Annual average 1963
Metals and metal products	99.5	101.3	+1.8	100.0	100.1
Iron and steel	98.8	100.0	+1.2	99.3	99.1
Iron ore	93.2	93.2		93.9	93.1
Iron and steel scrap	65.2	67.6	+3.7	69.0	66.5
Semifinished steel products	101.8	103.8	+2.0	101.8	102.3
Finished steel products	101.3	103.1	+1.8	101.4	102.0
Foundry and forge shop products	103.9	104.2	+.3	103.6	103.6
Pig iron and ferroalloys	87.8	80.8	−8.0	91.1	82.1
Nonferrous metals	98.0	101.0	+3.1	99.2	99.1
Primary metal refinery shapes	100.5	105.4	+4.9	100.7	102.1
Aluminum ingot	89.7	91.7	+2.2	95.2	90.2
Copper, ingot, electrolytic	106.1	106.1		106.1	106.1
Lead, pig, common	80.8	96.2	+19.1	74.1	85.8
Zinc, slab, prime western	104.0	117.0	+12.5	105.1	108.5
Nonferrous scrap	95.4	103.9	+8.9	96.7	100.1
Nonmetallic mineral products	101.4	101.3	(1)	101.8	101.3
Concrete ingredients	102.7	103.1	+.4	103.2	103.0
Sand, gravel and crushed stone	103.7	105.4	+1.6	103.4	104.8
Concrete products	102.5	101.4	−1.1	102.6	101.7
Structural clay products	103.7	103.5	−.2	103.5	103.6
Gypsum products	105.0	106.1	+1.0	105.0	105.4
Other nonmetallic minerals	102.2	101.4	−.8	102.2	101.4
Building lime	109.6	110.2	+.5	108.8	110.1
Insulation materials	94.5	90.7	−4.0	94.5	90.7
Asbestos cement shingles	110.8	110.8		110.6	110.8
Bituminous binders (1958=100)	100.0	100.0		100.0	100.0
Fuels and related products and power	100.4	99.3	−1.1	100.2	99.8
Fertilizer materials	100.8	98.4	−2.4	101.9	99.9
Nitrogenates	96.6	92.7	−4.0	97.8	94.3
Phosphates	106.0	107.3	+1.2	106.6	108.2
Phosphate rock	123.4	123.3	(1)	119.4	123.4
Potash	114.7	114.2	−.4	115.5	116.0
Muriate, domestic	111.4	111.4		113.5	113.5
Sulfate	121.4	118.3	−2.6	113.9	117.5
All commodities other than farm and food	100.7	101.2	+.5	100.8	100.7
All commodities	100.5	100.3	−.2	100.6	100.3

[1] Less than 0.1 percent.

Source: U.S. Department of Labor, Wholesale Prices and Price Indexes.

TABLE 26.—Price indexes for selected cost items in nonfuel mineral production

(1957-59=100, unless otherwise specified)

Commodity	1963 January	1963 December	Change from January (percent)	Annual average 1962	Annual average 1963	Change from 1961 (percent)
Coal	98.3	98.3		96.8	96.9	+0.1
Coke	103.6	103.6		103.6	103.6	
Gas fuel (January 1958=100)	120.8	124.8	+3.3	119.2	122.8	+3.0
Petroleum and refined products	98.2	96.1	−2.1	98.2	97.2	−1.0
Industrial chemicals	96.0	94.3	−1.8	96.3	94.8	−1.6
Lumber	95.8	99.1	+3.4	96.5	98.6	+2.2
Explosives	111.8	112.0	+1.8	108.5	112.4	+3.6
Construction machinery and equipment	108.3	111.2	+2.7	107.8	109.6	+1.7

Source: U.S. Department of Labor, Bureau of Labor Statistics, Monthly Labor Review and Wholesale Price Index.

TABLE 27.—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	Contractors air tools, hand held	Mixers, pavers, spreaders, etc.	Tractors, other than farm
1954–58 (average)	89.6	86.8	93.0	90.2	90.9	88.7	90.2	85.8	90.5	88.6
1959	103.6	104.9	100.2	102.9	103.7	104.6	104.0	108.2	104.4	103.9
1960	105.8	106.4	100.3	105.1	106.9	105.4	104.7	108.2	106.7	106.4
1961	107.5	107.8	101.8	105.4	107.8	114.1	104.4	113.5	108.4	108.0
1962	107.8	108.4	103.2	106.1	107.4	113.7	105.3	113.5	110.3	108.5
1963	109.6	109.1	102.6	108.8	108.1	115.1	108.5	113.5	112.1	110.8

Source: U.S. Department of Labor, Wholesale Price Index Section, Bureau of Labor Statistics, Published and unpublished data.

TABLE 28.—Indexes of relative labor costs, copper and iron ore mining [1]

(1957-59=100)

Year	Labor costs per pound of recoverable metal		Value of recoverable metal per man-hour		Labor costs per dollar of recoverable metal	
	Copper	Iron ore	Copper	Iron ore	Copper	Iron ore
1959	102	111	107	96	96	109
1960	105	99	116	107	95	98
1961	104	99	114	111	100	98
1962	[2] 98	[2] 107	126	[2] 111	[2] 93	[2] 101
1963	100	107	127	111	94	101

[1] Computed from data found in U.S. Department of Labor, Employment and Earnings and Wholesale Price Indexes.
[2] Revised figure.

TABLE 29.—Indexes of principal metal mining expenses [1]

(1957-59=100)

Year	Total	Labor	Supplies	Fuels	Electric energy
1959	105	106	102	99	101
1960	102	101	102	100	102
1961	101	100	101	101	103
1962	102	[2] 102	101	100	104
1963	103	103	102	100	103

[1] Indexes constructed by author, using the following weights derived from the 1958 Census of Mineral, Industries: Labor, 59.37; explosives, 2.42; steel mill shapes and forms, 3.51; all other supplies, 25.24; fuels, 5.08; electric energy, 4.38; and data from U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Price Index. Annual and monthly releases and labor cost index. The index is computed for iron and copper ores only because sufficient data is not available for other mining sectors.
[2] Revised figure.

INCOME

National Income Originated.—Despite the steadily rising trend of all industries, income orginating in the mining industry declined again in 1963. Its percentage share of total income for all industries decreased proportionately again and dropped slightly below the former peak of 1958. On the other hand, the rate of decline in 1962 was only 0.5 percent, which was much smaller than the previous 2 years (—3.6 percent for 1962 and —4.4 percent for 1961), whereas the growth rate for all industries had dropped from 6.5 percent in 1962 to 5.0 percent in 1963. Therefore, in 1963 the mining industry improved its relative position to all industries. Mineral processing manufacturers followed the overall upward trend but at a slower rate and consequently, its percentage share of all industries income originated continued to drop modestly and to follow the downward trend which began in 1958.

Profits and Dividends.—The annual profit rate on stockholders equity (after corporate income taxes) was generally improved over 1962 except for the stone, clays and glass products industry which registered a modest decline. The primary iron and steel industry registered a spectacular gain with an increase in annual profit rate of 27 percent over 1962. This increase revised the downward trend which began in 1959, and the iron and steel industry outperformed the growth rate of all manufacturing. However, the absolute profit rate of the primary iron and steel industry was still much lower than all manufacturing and thus, dividend distribution declined 10.5 percent further in 1963. There was little or no change in dividend distribution in 1963 from 1962 in the stone, clays, and glass products industries and chemical and allied products industries, but the nonferrous metals industry increased the amount of dividend distribution in 1963 by 10 percent.

Business Failures.—Failures in the mining industries were the lowest since 1957. The current liability of the mining companies that failed decreased $30 million from 1962 and conformed to the

TABLE 30.—National income originated in the mineral industries in the United States [1]

Industry	Income, million dollars			Change from 1962 (percent)
	1961 [2]	1962 [2]	1963	
All industries	426,932	455,618	478,493	+5.0
Metal mining	893	802	779	—2.9
Nonmetal mining and quarrying	811	854	868	+1.6
Total mining except fuels	1,704	1,656	1,647	—.5
Total mining including fuels	5,526	5,440	5,414	—.5
Manufacturing	119,947	130,845	137,369	+5.0
Primary metal industries	9,638	10,055	10,497	+4.4
Stone, clays, and glass products	4,187	4,317	4,530	+4.9
	Percent			
All industries	100.00	100.00	100.00	
Metal mining	.21	.18	.16	
Nonmetal mining and quarrying	.19	.19	.18	
Total mining except fuels	.40	.36	.34	
Total mining including fuels	1.29	1.19	1.13	
Manufacturing	28.10	28.72	28.71	
Primary metal industries	2.26	2.21	2.19	
Stone, clays, and glass products	.98	.95	.95	

[1] U.S. Department of Commerce, Office of Business Economics, Survey of Current Business. V. 44, No. 7, July 1964. To arrive at national income, depletion charges are not deducted; this affects data for mining industries.
[2] Revised figures.

general trend of the manufacturing and to that of the pattern of all industries.

TABLE 31.—Annual average profit rates on shareholders equity, after taxes and total dividends, mineral manufacturing corporations

Industry	Annual profit rate (percent)			Total dividends (million dollars)		
	1962	1963	Change from 1962 (percent)	1962	1963	Change from 1962 (percent)
All manufacturing [1]	9.8	10.3	+5.1	9,281	9,868	+6.3
Primary metals	6.2	7.1	+14.5	886	840	−5.2
Primary iron and steel [2]	5.5	7.0	+27.3	574	514	−10.5
Primary nonferrous metals [2]	7.5	7.6	+1.3	314	345	+9.9
Stone, clays and glass products	8.9	8.7	−2.2	312	313	+0.3
Chemical and allied products	12.4	12.9	+4.0	1,447	1,446	(3)

1 Except newspapers.
2 Included in primary metals.
3 Less than 0.1 percent.

Source: Federal Trade Commission, Securities and Exchange Commission. Quarterly Financial Report for Manufacturing Corporations, 1st Quarter 1963 and 4th Quarter 1963, tables 4 and 8.

TABLE 32.—Industrial and commercial failures and liabilities

Industry	1961	1962	1963
Mining: [1]			
Number of failures	103	85	84
Current liabilities ....thousand dollars	16,814	48,278	18,269
Manufacturing:			
Number of failures	2,722	2,490	2,325
Current liabilities ....thousand dollars	309,098	351,723	539,930
All industrial and commercial industries:			
Number of failures	17,075	15,782	14,374
Current liabilities ....thousand dollars	1,090,123	1,213,601	1,352,593

1 Including fuels.

Source: Dun & Bradstreet, Inc. Monthly Business Failures, Business Economics Department, Business Conditions Staff, New York, N.Y., January 1962, 1963, 1964.

INVESTMENT

New Plant and Equipment.—Expenditures for new plants and equipment by fuel and nonfuel mining firms declined $40 million compared with 1962, contrary to the upward trend for all manufacturing industries.

The primary nonferrous metals industry increased capital expenditure by 32 percent in 1963 over 1962, and the primary iron and steel industry increased 13 percent as compared with the 7-percent gain for all manufacturing. Stone, clays, and glass products manufacturing, chemicals and allied products industries, and petroleum and coal products industries lagged behind all manufacturing with increases of only 5 percent, 3 percent, and 1.4 percent over 1962, respectively.

Issues of Mining Securities.—The mining industry (including fuels) was the source of only 1.7 percent of all new corporation securities offered. This was comparable to the 1959 low. The percentage distribution between types of security in mining followed the established pattern of principally common stock finance because of the

TABLE 33.—Expenditures on new plant and equipment by firms in mining and selected mineral manufacturing industries

(Billion dollars)

Industry	1961	1962	1963
Mining [1]	0.98	1.08	1.04
Manufacturing	13.68	14.68	15.69
Primary iron and steel	1.13	1.10	1.24
Primary nonferrous metals	.26	.31	.41
Stone, clays, and glass products	.51	.58	.61
Chemicals and allied products	1.62	1.56	1.61
Petroleum and coal products	2.76	2.88	2.92

[1] Including fuels.

Source: U.S. Department of Commerce, Office of Business Economics, Survey of Current Business. V. 43, No. 3, March 1963, p. 7; V. 44, No. 3, March 1964, p. 13.

relatively higher risk involved with the mining industry. The $11 million or 10-percent drop of total gross proceeds in mining industry new securities from 1962 continued the downward trend since 1959. This contrasted rather unfavorably with the 14-percent and 8-percent gains for all corporations and manufacturing, respectively.

Prices of Mining Securities.—The index of common stock annual average prices of other mining (including coal but excluding petroleum) gained 13 percent over 1962. It was the same rate of increase that was achieved for all manufacturing industry, but it was slightly better than the gain made in all composite indexes. The price index of crude petroleum extraction securities made a spectacular increase of 32 percent and boosted the all mining index gain to 26 percent over 1962. This was a new high.

Foreign Investment.[9]—The value of U.S. direct private investment in mining and smelting in foreign countries increased $122 million during 1962; 1963 data are not available. The largest gain ($102 million) was made in Canada with other countries having an aggregate gain of $176 million. Small gains occurred in West Africa ($15 million), in the Republic of South Africa ($10 million), and in Australia and Peru ($6 million each), while most of the rest of the free world suffered a net disinvestment. Net capital outflow movement from the United States accounted for 75 percent of the 1962 increase of direct foreign investment, compared with 53 percent in 1961, and 73 percent in 1960. The 1962 net earnings of subsidiaries and branches

[9] U.S. Department of Commerce, Office of Business Economics, Survey of Current Business, V. 43, No. 8, August 1963, pp. 16–22.

increased $8 million from 1961, and income increased $18 million. In 1962, direct private investment of U.S. foreign mining and smelting industries again lagged behind all industries in all categories—value, net capital flow, earnings, and income.

The 1962 foreign plant and equipment expenditures of American mining and smelting firms, excluding petroleum, was $371 million and was 19 percent higher than 1961. The bulk of the increase was made in Canada (iron ore resources) and West Africa (iron ore and bauxite resources). The projected capital expenditures for 1963 and 1964 are $321 million and $258 million, respectively which indicate a continuous downward trend from 1962. The 1963 and 1964 declines are expected to be principally in Canada and Africa whereas expenditures in Australia are expected to gain modestly.

To finance capital expenditures and working capital, the U.S. mining and smelting companies affiliated abroad, like all other American petroleum and manufacturing companies abroad, relied principally on internally generated funds—earnings and depreciation and depletion charges. Of the total $821 million required funds in 1962, $680 million came from foreign affiliates' own resources—cash flow from depreciation and depletion ($202 million) and from retained earnings ($478 million). The internally generated fund of the American mining and smelting foreign affiliates accounted for 83 percent of fund needs as compared with 87 percent of petroleum extraction industries and 70 percent for manufacturing industries in 1962.

TABLE 34.—Estimated gross proceeds of new corporate securities offered for cash in the United States in 1963 [1]

Type of security	Total corporate		Manufacturing		Mining [2]	
	Million dollars	Percent	Million dollars	Percent	Million dollars	Percent
Bonds	10,873	88.9	3,225	91.0	145	67.8
Preferred stock	342	2.8	47	1.3	(3)	----------
Common stock	1,022	8.3	271	7.7	69	32.2
Total	12,237	100.0	3,543	100.0	214	100.0

[1] Substantially all new issues of securities offered for cash sale in the United States in amounts over $100,000 and with terms to maturity of more than 1 year are covered in these data.
[2] Including fuels.
[3] $300,000.

Source: U.S. Securities and Exchange Commission. Statistical Bulletin, V. 23, No. 5, May 1964, p. 13.

TABLE 35.—Indexes of common-stock annual average prices [1]

(1957–59=100)

Year	Composite [2]	Manufacturing	Mining [3]	Crude petroleum production	Other mining (metal, coal, sulfur)
1959	116.7	116.5	95.0	92.0	105.8
1960	113.9	110.9	73.8	65.8	88.5
1961	134.2	126.7	92.5	84.1	108.4
1962	127.1	118.0	98.0	102.3	90.0
1963	142.3	133.3	123.5	134.8	101.7

[1] Indexes are yearly averages of weekly closing-price indexes of common stock on New York Stock Exchange.
[2] In addition to mining and manufacturing, covers transportation, utilities, trade, finance, and service.
[3] Including fuels.

Sources: Council of Economic Advisers, Economic Indicators (prepared for the Joint Economic Committee). April 1964, p. 34. Also unpublished data from U.S. Securities and Exchange Commission.

TABLE 36.—Direct private investments of the United States in foreign mining and smelting industries in 1962

(Million dollars)

Country and areas	Mining and smelting					All industries				
	Value	Net capital outflow	Undistributed earnings of subsidiaries	Earnings [1]	Income [2]	Value	Net capital outflow	Undistributed earnings of subsidiaries	Earnings [1]	Income [2]
Canada	1,482	75	37	91	53	12,131	312	368	833	476
Latin America, total	1,099	−3	9	147	141	8,472	−32	287	1,028	761
Mexico	127	−5	2	10	8	873	30	24	63	44
Chile	504	4	1	53	52	768	18	11	72	64
Peru	248	6	(3)	30	33	451	14	1	52	51
Europe	49	3	−2	5	7	8,843	811	299	851	526
Africa, total	307	17	7	34	28	1,246	145	45	80	36
West Africa	170	19	−1	10	11	359	26	6	−2	−7
Rhodesia and Nyasaland	71	−4	1	8	8	83	−4	1	9	8
South Africa, Republic of	60	2	6	15	9	353	6	39	72	33
Far East	29	(3)	2	2	1	1,289	85	31	196	164
Oceania, total	41	5	−1	4	4	1,261	113	42	127	75
Australia	42	5	(3)	5	4	1,091	104	33	112	69
All other countries [4]	176	−6	3	83	79	3,903	123	130	1,131	1,013
Total all areas [5]	3,183	91	55	367	314	37,145	1,557	1,202	4,245	3,050

[1] Earnings is the sum of the U.S. share in net earnings of subsidiaries and branch offices.
[2] Income is the sum of dividend, interest, and branch profits.
[3] Less than $500,000.
[4] "All other countries" includes other Western Hemisphere, Middle East, and International.
[5] Excludes Cuba and Soviet bloc countries.

Source: U.S. Department of Commerce, Office of Business Economics, Survey of Current Business. V. 43, No. 8, August 1963, pp. 18-19.

TABLE 37.—Plant and equipment expenditures of direct foreign investments, by country and major industry [1]

(Million dollars)

Area and country	1961 [2]			1962 [2]			1963 [3]			1964 [3]		
	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing
All areas, total	312	1,534	1,697	371	1,633	1,949	321	1,950	2,057	258	1,653	1,971
Canada	165	315	385	193	325	473	155	350	520	115	315	434
Latin American Republics, total	64	267	249	63	257	274	70	276	314	52	272	286
Mexico, Central America and West Indies, total	8	21	47	5	24	51	5	27	82	5	23	100
Mexico	7	2	44	5	2	50	4	4	82	3	2	100
Other countries	1	19	3	(4)	22	1	1	23	(4)	2	21	(4)
South America, total	56	246	202	58	233	223	65	249	232	47	249	186
Argentina	(5)	60	94	(5)	38	115	(5)	24	102	(5)	27	71
Brazil	2	5	62	3	4	63	3	5	80	1	2	63
Chile	20	(5)	6	20	(5)	4	32	(5)	8	25	(5)	8
Colombia	(5)	30	11	(5)	32	7	(5)	31	9	(5)	19	14
Peru	27	10	10	27	9	6	18	10	5	9	10	8
Venezuela	(5)	135	17	(5)	145	25	(5)	173	26	(5)	184	20
Other countries	2	(5)	2	2	(5)	3	1	(5)	2	1	(5)	2
Other Western Hemisphere	23	39	1	32	62	7	30	39	16	38	38	2
Europe, total	1	438	847	4	494	949	4	643	953	2	486	952
Common Market, total	(4)	186	475	(4)	269	547	(4)	386	497	(4)	303	482
Belgium and Luxembourg	(4)	7	21	(4)	9	26	(4)	15	47	(4)	17	61
France	(4)	31	68	(4)	74	100	(4)	50	99	(4)	64	95
Germany	(4)	70	318	(4)	115	360	(4)	155	265	(4)	77	240
Italy	(4)	64	40	(4)	29	39	(4)	110	56	(4)	104	53
Netherlands	----	14	28	----	42	22	----	56	30	----	41	33
Other Europe, total	1	252	372	4	225	402	4	257	456	2	183	470
Denmark	----	19	2	----	30	2	----	45	2	----	15	1
Norway	(4)	7	5	(4)	7	8	(4)	8	12	(4)	8	10
Spain	(4)	3	6	(4)	7	11	(4)	40	15	(4)	15	13
Sweden	----	18	10	----	30	14	----	28	15	----	16	9
Switzerland	----	3	10	----	4	10	----	4	11	----	10	15
United Kingdom	----	170	335	----	125	347	----	110	394	----	95	414
Other countries	1	32	4	4	22	10	4	22	7	2	24	8
Africa, total	47	171	10	69	176	12	50	202	20	35	186	17
North Africa	(4)	111	(4)	(4)	137	(4)	(4)	161	(4)	(4)	134	(4)
East Africa	(4)	9	(4)	(4)	15	(4)	(4)	19	6	(4)	20	5
West Africa	22	34	(4)	43	11	1	32	9	1	24	8	1
Central and South Africa, total	25	17	10	26	13	11	18	13	13	11	24	11
South Africa, Republic of	10	(5)	8	14	(5)	11	15	(5)	13	6	(5)	11
Other countries	15	(5)	2	12	(5)	----	3	(5)	----	5	(5)	----

Asia, total	(4)	195	114	1	178	112	1	331	103	(4)	280	130
Middle East	--	87	12	--	72	6	--	162	2	--	109	3
Far East, total	(4)	108	102	1	106	106	1	169	101	(4)	171	127
India	--	(5)	39	--	(5)	26	--	(5)	32	--	(5)	36
Japan	--	(5)	48	--	(5)	59	--	(5)	52	--	(5)	66
Philippine Republic	(4)	(5)	9	(4)	(5)	12	(4)	(5)	11	(4)	(5)	15
Other countries	(4)	(5)	6	1	(5)	9	1	(5)	6	(4)	(5)	10
Oceania, total	12	64	92	9	76	122	11	68	131	16	45	150
Australia	12	(5)	90	9	(5)	119	11	(5)	125	16	(5)	141
Other countries	--	(5)	2	--	(5)	3	--	(5)	6	--	(5)	9
International shipping	--	45	--	--	65	--	--	41	--	--	31	--

[1] Data may not add to totals shown because of rounding.
[2] Revised figures.
[3] Estimated on the basis of company projections.
[4] Less than $500,000.
[5] Included in area total.

Source: U.S. Department of Commerce, Office of Business Economics, Survey of Current Business. V. 43, No. 10, October 1963, p. 15.

TABLE 38.—Sources of funds of direct (foreign) investment by United States mining industries

(Million dollars)

Year and area	Net income	Funds from United States	Funds obtained abroad [1]	Depreciation and depletion	Total sources
1961:					
Canada	161	9	140	80	390
Latin America	219	−20	−10	102	291
Europe	8	(2)	−2	2	8
Other areas	88	27	−15	24	124
Total	476	16	113	208	813
1962:					
Canada	163	95	−25	95	328
Latin America	246	−28	31	80	329
Europe	5	1	1	1	8
Other areas	64	26	40	26	156
Total	478	94	47	202	821

[1] Including domestic borrowing, increase of accrued liabilities, and other miscellaneous sources.
[2] Less than $500,000.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 43, No. 10, October 1963, p. 18.

TRANSPORTATION

Data on rail and water transportation were unavailable for 1963 because of no publication until late fall of the year after the year reported. 1962 data were available for the first time as presented in the following tables. Mineral commodities transported remained relatively stable in 1962 with only small changes. For rail transportation, mineral fuel shipments, primarily coal, were responsible for the gain, whereas metal and nonfuel minerals shipments declined slightly. An index of average freight rates on rail carloads was unavailable for comparison with the 1961 index. For water transportation, total mineral product shipment gained only 4 percent but less than the 5 percent made in overall tonnage shipped.

Mineral commodities supplied 95 percent of the total Great Lakes traffic, practically the same for the two previous years, but total shipments continued to decline since 1960 because of another drop of iron ore shipments. The continuing downward trend in Great Lakes traffic is attributable partly to the steady decline of the Great Lakes water level which forces the shipping line to carry lighter cargos to avoid running aground. The reduced cargo loads tend to increase the cost and total lake traffic suffers.

Truck Transportation.—Again in 1963, truck transportation was the most important means of transportation of all nonmetals needed in construction. Of the total shipments of the sand and gravel, crushed stone, portland cement, and blast furnace slag industries, the following percentages were by truck: 89 percent, 71 percent, 64 percent, and 69 percent, respectively.

TABLE 39.—Rail and water transportation of mineral products in the United States by products

(Thousand short tons)

Product	Rail [1]			Water [2]		
	1961	1962	Change from 1961 (percent)	1961	1962	Change from 1961 (percent)
Metals and minerals, except fuels:						
Iron ore	77,417	79,036	+2.1	56,668	56,122	−1.0
Iron and steel scrap	[5] 20,078	17,901	−10.8	1,898	1,346	−29.1
Metals and alloys	10,337	10,640	+2.9			
Other ores and concentrates	19,897	20,561	+3.3	3,899	3,878	−.5
Other scrap	1,971	2,142	+8.7			
Slag	4,967	4,654	−6.3	646	614	−5.0
Sand and gravel	62,276	61,956	−.5	58,230	64,620	+11.0
Stone, crushed except limestone	53,056	56,061	+5.7	---	---	---
Limestone, crushed	15,017	14,285	−4.9	26,783	26,889	+.4
Cement	24,347	22,513	−7.5	5,701	6,551	+14.9
Phosphate rock	23,085	22,621	−2.0	2,680	3,014	+12.5
Clays	9,237	9,505	+2.9	1,756	2,012	+14.6
Sulfur	2,893	2,890	−.1	4,095	5,139	+25.5
Other	22,807	24,355	+6.8	[5] 3,887	4,607	+18.5
Total	[5] 347,385	349,120	−.4	[5] 166,243	174,792	+5.1
Minerals fuels and related products:						
Coal:						
Anthracite [3] [4]	14,963	15,156	+1.3	320	573	+79.1
Bituminous [3]	296,884	312,179	+5.2	127,182	136,765	+7.5
Coke [3]	14,328	15,467	+7.9	331	686	+107.3
Crude petroleum	2,027	1,756	−13.4	78,297	80,970	+3.4
Gasoline	6,861	6,187	−9.8	92,515	93,546	+1.1
Distillate fuel oil	6,369	6,209	−2.5	77,989	79,001	+1.3
Residual fuel oil				44,986	45,215	+.5
Kerosene	18,292	18,677	+2.1	9,146	9,314	+1.8
Other				17,969	19,783	+10.1
Total	359,724	375,631	+4.4	448,735	465,853	+3.8
Total mineral products	[5] 707,109	724,751	+2.0	614,978	640,645	+4.2
Grand total, all products	[5] 1,186,385	1,226,660	+3.4	732,825	770,805	+5.2
Mineral products, percent of grand total:						
Metals and minerals, except fuels	[5] 29.3	28.5	−.8	22.7	22.7	---
Mineral fuels and related products	30.3	30.6	+.3	61.2	60.4	−.8
Total mineral products	[5] 59.6	59.1	−.5	83.9	83.1	−.8

[1] Revenue freight originated excluding forwarder and less than carlot shipments, for which data are not available. Source: Interstate Commerce Commission, Freight Commodity Statistics, Class I Steam Railways in the United States, for years ended Dec. 31, 1961 and 1962. Statements 62100 and 63100.
[2] Domestic traffic—all commercial movements between any point in the 50 States or the U.S. territories and possessions and any other points. Traffic with Panama Canal Zone, Virgin Islands, and Defense Department vehicles carrying military cargoes excluded.
[3] Figures for rail shipments include briquets. For water shipments, briquets not reported by type of material; included with "Other".
[4] The rail statistics include anthracite to breakers and washeries (thousand short tons): 1961—5,727.
[5] Revised figure.

Source: Department of the U.S. Army Corps of Engineers, Waterborne Commerce of the United States, calendar year 1961 and calendar year 1962, pt. 5, National Summaries.

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TABLE 40.—Indexes of average freight rates on carload traffic 1960–61 and average revenue per ton, originated or terminated, 1960–62 in the United States

Item	Indexes [1] (1950=100)		Average revenue per ton [2] (dollars)		
	1960	1961	[3] 1960	1961	1962
Products of mines	115	116	3.03	3.03	3.02
Iron ore	138	141	2.34	2.24	2.29
Clay and bentonite	133	132	8.13	8.20	8.38
Sand, industrial	127	127	3.45	3.44	3.31
Gravel and sand, n.o.s	114	113	1.37	1.32	1.33
Stone and rock, broken, ground, and crushed	115	116	1.67	1.67	1.68
Fluxing stone and raw dolomite	140	142	1.94	2.03	2.05
Salt	114	113	6.79	6.77	6.53
Phosphate rock	95	95	1.97	2.00	2.09
Manufactures and miscellaneous	115	113	11.45	11.57	11.67
Fertilizers, n.o.s	111	110	7.75	7.80	7.56
Iron, pig	133	128	5.16	4.98	5.03
Cement, natural and portland	85	83	3.36	3.47	3.34
Lime, n.o.s	124	123	5.86	5.74	5.77
Scrap iron and scrap steel	127	128	4.05	4.11	3.99
Furnace slag	110	113	1.73	2.07	2.02
Nonmineral categories:					
Products of agriculture	112	111	7.90	7.60	7.48
Animals and products	116	113	23.94	23.10	22.05
Products of forests	124	124	7.74	7.84	7.70
Forwarder traffic	122	122	38.92	37.87	37.26
All commodities	116	114	6.67	6.71	6.73

[1] U.S. Interstate Commerce Commission, Bureau of Transport Economics and Statistics. Index of Average Freight Rates on Carload Traffic.
[2] U.S. Interstate Commerce Commission, Bureau of Transport Economics and Statistics. Freight Commodity Statistics, Class I Steam Railways in the United States, Statements 61100, 1960; 62100, 1961; 63100, 1962.
[3] Revised figures.

TABLE 41.—Great Lakes Shipping
(Million short tons in dry cargo ships)

Commodity	1959	1960	1961	1962
Iron ore and concentrates	45.9	68.4	55.1	53.9
Bituminous coal and lignite	32.6	33.1	31.3	32.4
Crushed limestone	23.9	25.5	23.5	22.6
Building cement	2.3	2.1	2.0	2.0
Sand, gravel, and crushed rock	1.6	1.4	.8	.9
All other commodities	10.4	6.2	5.8	5.6
Total	116.7	136.7	118.5	117.4

Source: U.S. Department of Commerce. Maritime Administration. Domestic Oceanborne and Great Lakes Commerce of the United States 1962, p. 19.

TABLE 42.—Truck transportation of mineral products in the United States, by major products
(Thousand short tons)

Year	Sand and gravel		Crushed stone		Portland cement		Blast furnace slag [1]	
	Shipments by truck	Percent trucked of total shipment	Shipments by truck	Percent trucked of total shipment	Shipments by truck 1,000 barrels	Percent trucked of total shipment	Shipments by truck	Percent trucked of total shipment
1959	637,436	87.3	380,653	65.4	128,455	38.3	17,950	66.0
1960	622,988	87.8	417,706	68.0	147,204	47.1	19,492	68.1
1961	672,360	89.4	420,263	68.1	182,121	56.8	17,360	67.6
1962	686,386	88.4	453,869	69.4	204,183	61.5	15,614	66.6
1963	733,680	89.0	484,190	71.0	222,681	63.8	16,259	69.0

[1] National Slag Association.

Source: Federal Bureau of Mines.

FOREIGN TRADE

Value.[10]—Nonfuel mineral imports dropped 11 percent in value over 1962. Metal ores declined 14 percent, and nonmetallic ores lost only 0.5 percent. Mineral fuel imports rose 1 percent, and total minerals suffered a 5-percent decline in 1963 from 1962. The $105 million reduction in imported uranium and thorium ores and concentrates accounted for four-fifths of the decline in nonfuel mineral imports. Imports of nonfuel mineral manufactured products increased 11 percent over 1962. Metals imports gained 14 percent and nonmetals, 1 percent. The increase of ferrous metals and products imports accounted for the bulk of the gain. Petroleum products imports rose 7 percent over the previous year. Total mineral manufactured products increased 10 percent over 1962.

The value of mineral exports rose 20 percent over last year. The increase of coal exports was principally responsible for the 25-percent increase of mineral fuels exports in 1963. The rise of iron and steel scrap exports contributed the bulk of the 19-percent gain in crude metals and ores exports. The rise of fertilizer and chemical minerals was responsible for most of the 7-percent gain in nonmetals. In 1963, mineral manufacturing industry made an overall gain of 10 percent over 1962. Increased exports of ferrous metals products, aluminum, processed diamonds, and petroleum products were responsible for the overall gain.

Tariffs.—On April 19, the Tariff Commission reported the results of an investigation concerning the alleged injury to the U.S. portland cement industry by imports from the Dominican Republic to the United States at less than market value, under the meaning of section 201(a) of the Antidumping Act of 1921, as amended. The Commission determined that the U.S. industry was likely to be injured. The Treasury Department is taking appropriate action.

After substantial review by government agencies and interested domestic importers and foreign producers, the Tariff Schedules of the United States, Annotated (TSUS), was signed into law by the President, effective August 31, 1963. The TSUS is a result of a technical study which by its very nature precluded either liberalization or reduction of imports. The primary objectives of TSUS were clarity and simplification. This new TSUS as it affects minerals and mineral products has simplified the classification system and has corrected classification defects as well as inconsistencies. At the same time, the TSUS has not had any recognizable impact on the volume of mineral imports.

On October 1, in accordance with section 351(d)(1) of the Trade Expansion Act of 1962, which continues the October 1, 1958, modified lead and zinc concession granted thereon in the General Agreement on Tariffs and Trade (GATT), the Tariff Commission submitted to the President a report on the developments in the trade in unmanufactured lead and zinc. Following an escape-clause investigation by the Commission under section 1 of the Trade Agreements Extension Act of 1951, the President imposed import quotas on unmanufactured lead and zinc, effective October 1, 1958. The report presented statistical

[10] Value of foreign trade is based on United Nations SITC Revised Classification.

TABLE 43.—Value of minerals and mineral products imported and exported by the United States, by commodity groups and commodities [1]

(Thousand dollars)

SITC, No. revised	Group and commodity	Imports for consumption			Exports of domestic merchandise	
		1962	January-June 1963 [2]	1963	1962	1963
	Metals (crude):					
281	Iron ore and concentrates [3]	324,728	123,243	323,206	62,833	76,390
282	Iron and steel scrap	6,108	3,549	6,308	146,868	170,200
283	Ores and concentrates of nonferrous base metals	325,380	142,868	299,412	47,819	59,127
283.1	Copper	12,884	6,463	(4)	1,045	638
283.2	Nickel	148	250	(4)	16	5
283.3	Bauxite (aluminum ore) and concentrates	122,190	55,948	(4)	19,874	15,696
283.4	Lead	21,152	10,724	(4)	235	1
283.5	Zinc	40,543	16,929	(4)	46	11
283.6	Tin	13,595	890	(4)	None	None
283.7	Manganese	66,274	33,364	(4)	1,012	926
283.9	Ores and concentrates of nonferrous base metals, n.e.s	48,594	18,299	(4)	47,819	59,127
283.91	Chromium	23,700	9,336	(4)	108	352
283.92	Tungsten	2,870	1,072	(4)	80	69
283.93	Titanium, vanadium, molybdenum, tantalum, zirconium	11,489	4,218	(4)	23,813	40,098
283.99	Other ores and concentrates of nonferrous base metals	10,535	3,718	(4)	25,591	1,334
284	Nonferrous metal scrap	8,782	3,310	(4)	51,312	59,918
285	Silver and platinum ores	18,395	12,406	(4)	None	None
286	Ores and concentrates of uranium and thorium	253,437	117,220	(4)	668	981
	Metals (manufactured):					
671	Pig iron, spiegeleisen, sponge iron, iron and steel powder and shot and ferroalloys	56,026	21,439	58,211	13,782	9,415
671.1	Spiegeleisen	None	None	(4)	59	90
671.2	Pig iron (including cast iron)	24,682	9,434	(4)	8,283	4,479
671.3	Iron and steel powders, shot and sponge	1,613	830	(4)	280	253
671.4	Ferro manganese	16,631	6,639	(4)	629	155
671.5	Other ferroalloys	13,099	4,537	(4)	4,530	4,439
672	Ingots and other primary forms of iron and steel	13,406	7,122	24,930	25,514	31,566
673	Iron and steel bars, rods, angles, shapes and sections	200,556	106,373	233,034	51,574	55,868
674	Universals, plates and sheets of iron or steel (3mm. or more in thickness)	65,906	56,268	138,101	205,085	213,109
675	Hoop and strip of iron or steel	22,778	13,262	25,156	23,685	29,120
676	Rails and railway track construction material of iron or steel	934	358	1,004	19,282	19,238
677	Iron and steel wire (excluding wire rod)	48,517	25,501	55,624	10,096	14,762
678	Tubes, pipes and fittings of iron or steel	98,204	49,804	113,925	100,920	127,174
679	Iron and steel castings and forgings, unworked, n.e.s	6,509	4,175	9,397	21,031	22,329
	Nonferrous metals:					
681	Silver, platinum and other metals of the platinum group	14,308	9,174	31,734	2,964	5,202
681.1	Silver, unworked or partly worked	None	None	(4)	None	None
681.2	Platinum, unworked or partly worked	14,308	9,174	(4)	2,964	5,202
682	Copper	280,628	125,718	296,120	221,937	206,229

682.1	Copper and alloys, whether or not refined, unwrought	234,532	102,206	(4)	201,529	187,939
682.2	Copper and alloys of copper, worked	46,097	23,513	(4)	20,408	18,290
683	Nickel	177,176	99,735	163,783	22,886	23,059
683.1	Nickel and nickel alloys, unwrought	175,925	99,011	(4)	None	None
683.2	Nickel and nickel alloys, worked	1,251	723	(4)	22,886	23,059
684	Aluminum	172,237	83,286	194,966	109,089	118,728
684.1	Aluminum and aluminum alloys, unwrought	128,560	69,026	(4)	66,621	71,875
684.2	Aluminum and aluminum alloys, worked	43,676	14,260	(4)	42,468	46,852
685	Lead	47,590	22,820	46,169	1,423	1,074
685.1	Lead and lead alloys, unwrought	47,116	22,570	(4)	616	413
685.2	Lead and lead alloys, worked	474	250	(4)	807	661
686	Zinc	29,053	13,818	28,926	11,695	11,411
686.1	Zinc and zinc alloys, unwrought	28,478	13,434	(4)	8,050	7,506
686.2	Zinc and zinc alloys, worked	575	384	(4)	3,644	3,905
687	Tin	103,748	58,232	108,739	1,223	4,910
687.1	Tin and tin alloys, unwrought	103,741	58,232	(4)	840	4,225
687.2	Tin and tin alloys, worked	7	None	(4)	383	685
688	Uranium and thorium and their alloys	31	41	55	5,658	23,704
688.0	Uranium depleted in U^{235} and thorium and their alloys	31	41	(4)	5,658	23,704
689	Miscellaneous non-ferrous base metals employed in metallurgy	32,929	16,234	32,324	26,569	25,626
689.3	Magnesium and beryllium	1,269	590	(4)	349	3,559
689.4	Tungsten, molybdenum, and tantalum	1,996	692	(4)	3,621	4,255
689.5	Base metals, n.e.s.	29,664	14,952	(4)	17,886	17,812
	Minerals (non-metallic):					
271	Fertilizers, crude	38,415	24,597	40,173	41,867	44,208
271.2	Natural sodium nitrate	14,208	7,642	(4)	None	None
271.3	Natural phosphates, n.e.s., whether or not ground	3,551	1,659	(4)	38,833	40,726
271.4	Natural potassic salts, crude	18,880	14,330	(4)	1,952	1,781
273	Stone, sand and gravel	15,505	7,045	16,051	10,328	10,479
273.1	Building and monumental (dimension) stone	2,076	893	(4)	1,795	1,669
273.2	Gypsum, plasters, limestone flux and calcareous stone	11,320	5,389	(4)	736	669
273.3	Sand (excluding metal-bearing sand)	479	106	(4)	3,818	4,016
273.4	Gravel and crushed stone (including tarred macadam)	1,630	657	(4)	3,979	4,125
274	Sulphur and unroasted iron pyrites	21,322	11,921	24,430	37,295	34,588
274.1	Sulphur, other than sublimed, precipitated or colloidal sulphur	20,575	11,531	(4)	37,295	34,588
274.2	Iron pyrites, unroasted	747	390	(4)	None	None
275	Natural abrasives (including industrial diamonds)	51,345	24,116	50,513	13,865	16,428
275.1	Industrial diamonds	31,976	15,774	(4)	11,596	3,302
275.2	Natural abrasives	19,369	8,342	(4)	2,269	13,126
276	Other crude minerals	123,865	57,564	118,035	32,668	40,112
276.1	Natural asphalt and natural bitumen	616	274	(4)	2,704	2,696
276.2	Clay and other refractory minerals, n.e.s.	10,402	5,054	(4)	23,155	28,304
276.3	Salt	5,097	1,951	(4)	3,616	4,140
276.4	Asbestos, crude, washed or ground (including waste)	64,150	30,842	(4)	578	1,289
276.5	Quartz, Mica, feldspar, fluorspar, cryolite and chiolite	28,030	12,989	(4)	481	994
276.6	Slag, dross, scalings and similar waste, n.e.s.	30	14	(4)	None	None
276.9	Minerals, crude, n.e.s.[5]	15,540	6,440	(4)	2,133	2,690
	Non-metallic minerals (manufactured):					
661	Lime, cement and fabricated building materials except glass and clay materials	31,253	14,292	31,650	6,642	7,910
661.1	Lime	958	550	(4)	660	565
661.2	Cement	13,709	4,391	(4)	1,853	2,072

See footnotes at end of table.

TABLE 43.—Value of minerals and mineral products imported and exported by the United States, by commodity groups and commodities [1]—Continued

(Thousand dollars)

SITC, No. revised	Group and commodity	Imports for consumption			Exports of domestic merchandise	
		1962	January-June 1963 [2]	1963	1962	1963
661.3	Building and monumental (dimension) stone, worked	12,626	6,808	(4)	501	585
661.8	Building materials of asbestos-cement and fiber-cement and of unfired non-metallic minerals, n.e.s.	3,960	2,541	(4)	6,627	1,608
662	Clay, construction materials and refractory materials	25,826	14,601	29,856	32,484	35,837
662.3	Refractory, bricks and other refractory construction materials	5,766	3,644	(4)	28,301	32,451
662.4	Non-refractory ceramic bricks, tiles, pipes, and similar products	20,061	10,957	(4)	4,183	3,385
667.2	Diamonds (other than industrial diamonds) not set or strung	191,634	106,605	(4)	15,466	35,231
663	Mineral manufactures, n.e.s.	14,363	7,051	13,592	60,194	72,126
664	Glass	57,774	22,697	50,010	37,460	37,915
665	Glassware	25,551	10,746	22,710	52,451	57,362
666	Pottery	57,740	4,955	61,967	2,142	2,000
	Mineral fuels:					
321	Coal, coke and briquettes	4,187	2,072	6,302	384,643	482,058
331	Petroleum, crude and partly refined for further refining	1,070,377	549,334	1,065,107	5,085	4,616
332	Petroleum products	662,257	355,984	707,535	396,468	441,008
341	Gas, natural and manufactured	91,902	54,819	103,755	15,161	17,853
351	Electric energy	None	None	None	None	None

[1] Because of the revision in SITC, data in this table are not comparable to data in similar tables for previous years.
[2] Only data for 3-digit SITC (revised) are available for 1963 on an annual basis. Therefore, semi-annual data were presented.
[3] The revised SITC 3-digit description used here has been modified somewhat from that published in the United Nations' publication (Statistical Papers, Series M, No. 34). This modification does change the content of the United Nations' class.
[4] Not available.
[5] Includes: Chalk; earth colors, etc.; natural barium sulphate and natural barium carbonate; meerschaum, amber, jet; natural steatite; talc; natural arsenic sulphide; crude natural barates; mineral substances, n.e.s.

Source: U.S. Department of Commerce, Bureau of Census. United States, Imports of Merchandise for Consumption, 1962, FT 110 and FT 120 Supplement, and United States Exports of Domestic and Foreign Merchandise, 1962 FT 410 and 1963 FT 120, and FT 420 Supplement and 1963 FT 420. The data for 4-digit and/or 5-digit SITC, were obtained from the Bureau of the Census report to the United Nations, 208 Imports and 508 exports. These data have not been published.
United Nations, Commodity Indexes for the Standard International Trade Classification, Revised. Statistical Papers, Series M, No. 38, Vol. 2, 1963.

data and other information with respect to lead and zinc, with emphasis on developments that have occurred since the Commission's report to the President in October 1962 under Executive Order 10401.

During 1963, the Office of Emergency Planning had two applications under consideration from mineral industries—manganese and chromite ferroalloy manufactures and electrolytic manganese chromite metal manufactures—under section 8 of the Trade Agreements Act, the so-called national defense clause. No decision was made in 1963.

RESEARCH AND DEVELOPMENT

The latest available information on source of funds and its relationship to GNP; and basic research, applied research, and development was 1961 data, which was reported and discussed in the Volume I 1962 Yearbook chapter on "Review of the Mineral Industries."

Overall speaking, the bulk of total funds for research and development has been going to a narrow segment of industry. About 80 percent or more has been and is directed for aircraft and missiles, electronics, and chemical and machinery industries. Much of the research effort was of the end-use variety and was oriented toward defense, national security, and aerospace programs. Only a small fraction of the total research money was directed toward studies on utilization and improvement of metals and minerals including fuels. Even including investigations in such allied fields as solid state physics, the total research expenditure for metals and nonfuel mineral materials barely reached $500 million in 1962. An additional $200 million was spent by industry and Federal Government for development of minerals recovery and processing methods. About $350 million was spent on fuels, principally petroleum refining, exploration, and extraction. An estimated total of $1.05 billion was spent on research and development in the mineral industries in 1962 and accounted for only 6.6 percent of all research and development expenditures.

Bureau of Mines.—Obligations by the Bureau of Mines for research and development during fiscal year 1964 [11] increased 7 percent over the previous year from $29.5 million in fiscal year 1963 to $31.5 million in fiscal year 1964.

Bureau of Mines obligations for total research during fiscal years 1962, 1963, and 1964 were $20.3 million, $23.7 million, and $25.9 million, respectively. During fiscal year 1964, the percentage of total research obligations for engineering sciences was 74.4 percent; physical sciences, 23.6 percent; mathematical sciences, 0.8 percent; biological sciences, 0.6 percent; and social sciences, 0.6 percent. From 1958 through 1963, the Bureau of Mines spent 15 percent of its research and development funds in basic research, 25 percent in applied research, and 60 percent in development.

[11] U.S. Department of the Interior. Bureau of Mines. Scientific Information Activities of the Bureau of Mines. 1963. Reprinted from Scientific Information of Federal Agencies, No. 16, Part II, October 1962 National Science Foundation.

The breakdown by sciences of the Bureau of Mines fiscal yearly gain over previous fiscal years was as follows:

Area of science	1963 over 1962, percent	1964 over 1963, percent
Engineering	16.9	7.0
Physical	17.8	17.3
Mathematical	8.0	14.3
Biological	8.3	15.4
Social	11.6	11.1
Total research	16.9	9.4

During fiscal years 1962, 1963, and 1964, Bureau of Mines obligated expenditures were 4.4 percent, 3.9 percent, and 3.1 percent, respectively, for metallurgical and materials research and development, as compiled by the National Science Foundation [12] of $113 million, $147 million, and $202 million, respectively, and averaged about 1.1 percent of the basic research part of the total. The Bureau of Mines share of the obligated total research expenditure is declining continuously, but maintained the weak fourth position in the Federal Government. During the same years, the Department of Defense declined from the relatively predominant position of 61 percent in 1962 to 52 percent in 1963 and 43 percent in 1964 of total research, whereas the National Aeronautics and Space Administration increased its share from 15 percent in 1962 to 26 percent in 1963 and to a strong second with 40 percent in 1964. Atomic Energy Commission (AEC) spent 15, 14, and 11 percent of the total research.

In basic research, the Bureau of Mines ranks a poor sixth, lagging behind the Department of Defense, AEC, NASA, NSF, and Bureau of Standards in that order.

Scientific and Technical Personnel.—On June 30, 1963, the Bureau of Mines employed 1,464 full-time scientific and technical personnel in research and development; 607 were engineers and 857 were physical scientists and other scientists and technicians, as compared with 1962 employment of 554 engineers and 967 scientists and technicians, a total of 1,521 full-time engineers, scientists, and technicians.

Mineral related industries, including petroleum, employed 18,600 full-time equivalent scientists and engineers in January 1962,[13] or 5.8 percent of the total full-time equivalent in all industries. Stone, clay, and glass products industries employed 1.4 percent of the total; primary ferrous metals industry, 1.0 percent; primary nonferrous metals industry, 0.7 percent; and the petroleum refining and extraction industry, 2.9 percent of the total.

In 1960, the mining industry employed 19,100 engineers and 12,400 scientists. The mining industry employed only 2.4 percent of engineers employed by all industry and 3.6 percent of scientists employed by all industry. The estimated requirement for scientists and engi-

[12] National Science Foundation revised the classification of this subgroup again. Therefore, these data are not comparable to those of previous years. National Aeronautics and Space Administration (NASA) expenditures are included again by this reclassification.

[13] The number of scientists and engineers employed by the mining industry was included in nonmanufacturing industries.

neers as projected to 1970 for the mining industry is 27,900 engineers and 13,800 scientists. This would comprise 2.0 percent of projected total engineers required by all industry and 2.4 percent of projected total scientists required by all industry. The detailed requirements for scientists by occupation are available in table 47.

TABLE 44.—Bureau of Mines obligations for mining and mineral research and resource development [1]

(Thousand dollars)

Fiscal year	Applied research	Basic research	Development	Total
1960	14,392	3,602	6,030	24,024
1961	15,320	3,830	6,386	25,536
1962	16,210	4,045	6,715	26,970
1963 [2]	17,752	3,385	8,335	29,472
1964 [3]	19,012	3,608	8,905	31,525

[1] Data for 1963–64 not strictly comparable with those for other years as definitions of research and development were changed.
[2] Revised figures.
[3] Estimated figures.

Source: Bureau of Mines, Budget Office.

TABLE 45.—Bureau of Mines obligations for total research, by field of science

(Thousand current dollars)

	Fiscal years		
	1962	1963 [1]	1964 [1]
Engineering sciences	15,437	18,040	19,300
Physical sciences	4,415	5,200	6,100
Mathematical sciences	162	175	200
Biological sciences	120	130	150
Social sciences	121	135	150
Total research	20,255	23,680	25,900

[1] Preliminary estimate, based upon old definition.

Source: National Science Foundation, Federal Funds for Science 12, Fiscal Years 1962, 1963, 1964.

TABLE 46.—Federal obligated funds for metallurgy and material research

(Thousand dollars)

Federal agency	Fiscal year 1962		Fiscal year 1963 [1]		Fiscal year 1964 [1]	
	Basic research	Total research	Basic research	Total research	Basic research	Total research
Department of Defense	21,304	68,468	20,743	77,018	23,473	86,786
Atomic Energy Commission	8,969	17,519	10,320	19,850	12,479	22,358
National Aeronautics and Space Administration	1,656	16,983	2,452	38,828	3,226	81,532
Bureau of Mines	348	4,940	408	5,773	450	6,176
National Science Foundation	1,135	1,135	1,562	1,562	2,318	2,318
Department of Agriculture	146	1,421	165	1,542	176	1,584
Department of Commerce	466	651	441	706	511	842
Other		1,962		1,956		110
Total	34,024	113,079	36,091	147,235	42,633	201,706

[1] Estimate.

Source: National Science Foundation.

TABLE 47.—Employment of scientists and engineers, by industry and by occupation, 1960, and projected 1970

Year and industry	Scientists and engineers	Engineers	Scientists: Total [1]	Chemists	Physicists	Metallurgists
1960:						
Mining	31,600	19,100	12,400	2,100	200	500
Petroleum refining and products of petroleum and coal	27,700	17,400	10,400	5,100	300	100
Stone, glass, and clay products	10,200	7,900	2,300	1,500	200	100
Primary metal industries	35,100	25,200	9,900	3,800	200	5,300
All industries	1,157,300	822,000	335,300	103,500	29,900	14,500
Projected 1970:						
Mining	41,700	27,900	13,800	3,700	300	500
Petroleum refining and products of petroleum and coal	41,100	25,900	15,200	7,800	500	100
Stone, clay, and glass products	15,600	12,000	3,500	2,300	300	200
Primary metal industries	57,100	41,000	16,100	6,200	300	8,600
All industries	1,954,300	1,374,700	579,600	169,500	59,300	24,400

Year and industry	Scientists—Continued: Geologists and geophysicists	Mathematicians	Medical scientists	Agricultural scientists	Biological scientists	Other scientists
1960:						
Mining	9,200	200	(2)	100	(2)	100
Petroleum refining and products of petroleum and coal	4,000	400	(2)	100	(2)	300
Stone, glass, and clay products	400	100	(2)	(2)	----------	----------
Primary metal industries	300	200	100	100	(2)	(2)
All industries	23,200	31,400	31,400	39,500	40,700	21,000
Projected 1970:						
Mining	8,600	300	(2)	200	(2)	100
Petroleum refining and products of petroleum and coal	5,300	600	100	200	100	500
Stone, clay, and glass products	600	100	----------	(2)	----------	----------
Primary metal industries	300	300	100	100	(2)	(2)
All industries	29,100	65,100	59,700	66,100	76,600	29,900

1 Data may not add to total due to rounding.
2 Less than 50 cases.

Source: National Science Foundation. Scientists, Engineers, and Technicians in the 1960's. NSF 63-64, Table A-2, p. 35. Prepared by the U.S. Department of Labor, Bureau of Labor Statistics.

DEFENSE MOBILIZATION

Defense Production Act (D.P.A.).[14 15]—The Defense Production Act will expire on June 30, 1964. As of December 31, 1963, $2,195 million of $2,100 million borrowing authority and $108 million in appropriated funds have been allocated to delegated agencies which left $13 million in reserve funds. All of the authorized borrowing authority had been committed by the delegated agencies at the end of 1963 except for $188.9 million which remained available for new programs. The probable ultimate net cost of DPA metals and mineral programs will be $834 million. Adding custodial and adminis-

14 Executive Office of the President, Office of Emergency Planning, Report on Borrowing Authority, December 31, 1963.
15 Joint Committee on Defense Production. 13th Annual Report of the activities of the Joint Committee on Defense Production. House Report No. 1095, 88th Congress, 2nd sess. January 13, 1964, pp. 16–26.

trative expenses and U.S. Treasury interest, the total cost of the DPA program since its inception approximated $1,378 million.

National (Strategic) Stockpile Program.[16]—The report of the Executive Stockpile Committee on Disposing of Excess Stockpile Materials was submitted to the President and approved by him on January 30, 1963. It contained 14 recommendations dealing with disposals of surplus material. The Office of Emergency Planning (OEP) began work on developing a long-range disposal program. One of the recommendations was that disposal plans should be based on maximum objectives and that those objectives be predicated on supply-requirement studies that reflect current strategic concepts and up-to-date information about emergency requirements to meet current military, war-supporting, industrial, and essential civilian needs in the event of both a conventional war and a nuclear war. For conventional war supply requirements, heretofore there was a "basic objective" and a "maximum objective" for each material. Under the new program the basic objectives that assumed some continued reliance on foreign sources of supply in an emergency were abolished. The maximum objectives which completely discounted foreign sources of supply beyond North America and comparable accessible areas were altered. Previously, maximum objectives could not be for less than 6 months normal usage of the material by industry in periods of active demand. The "six-month rule" has been eliminated in establishing the new calculated conventional war objectives. In July 1963 OEP announced new stockpile objectives which provided only for the new conventional war requirements for 12 stockpile materials. Eight of these materials were mineral commodities, and 3 of the 8 objectives increased and 5 decreased as follows:

Mineral commodity		New stockpile objective	Old stockpile objective	Change
Aluminum	1,000 short tons	450	1,200	−750
Copper	do	775	1,000	−225
Lead	do		286	−286
Metallurgical grade chromite	1,000 dry short tons	2,970	2,700	+270
Mercury	1,000 flasks	200	110	+90
Nickel	1,000 short tons	50	323	−273
Tin	1,000 long tons	200	185	+15
Zinc	1,000 short tons		178	−178

Additional studies of other stockpile materials with a view toward establishing new objectives were under consideration late in 1963.

In September 1963, OEP completed the initial part of a study designed to develop rough estimates of an economy's supply requirement for resources following a nuclear attack. The study was made available to interested Federal agencies for evaluation.

On December 31, 1963, the strategic materials held in all Government inventories amounted to $8.6 billion at acquisition cost and $7.6 billion at estimated market value. Of the total materials in Government inventories, $5.0 billion at cost and $4.1 billion at estimated market value are considered to be in excess of stockpile objective. About 80 percent of the total excess is made up of 11

[16] Executive Office of the President, Office of Emergency Planning. Stockpile Report to the Congress. January June 1963 and July December 1963.

mineral products—aluminum, metallurgical grade chromite, cobalt, copper, lead, metallurgical grade manganese, molybdenum, nickel, tin, tungsten, and zinc.

During 1963 OEP authorized 12 new mineral disposal programs to adjust downward the excess and off-grade material from national stockpile and DPA inventory. The major commodities involved were aluminum, low-grade chromite, copper, and titanium sponge. Stockpile disposal of mineral commodities during 1962 was about $85 million, of which $43 million came from the national stockpile and $42 million from DPA inventory. The principal commodities disposed of were tin, aluminum, copper, molybdenum, cadmium and nickel.

Office of Mineral Exploration (OME).[17]—Exploration for new domestic sources of strategic and critical mineral commodities continued to be encouraged by Government assistance under the program established in 1958. Among the 54 applications received from 15 States by OME under the program of matching Government funds in 1963, 16 contracts were executed for gold, silver, molybdenum, bismuth, and tellurium with the gold and silver accounting for 14 of 16 contracts. At the end of 1963, 30 contracts remained in force representing maximum Government participation of $1.3 million. In 1963 there was no change in mineral commodities eligible for exploration assistance.

In-force projects of the Defense Minerals Exploration Administration (DMEA), predecessor to the OME, continued to be administered by the latter agency. Of the 1,159 contracts executed by DMEA, 399 were certified for discoveries and development. The potential value of recoverable minerals and metals in these ore reserves was $1 billion at prevailing market prices. The net cost of the program was $31.7 million. By the end of 1963 future royalty receipts are estimated at $250,000 for 1964, $225,000 for 1965, and $200,000 for 1966.

Barter Program[18] [19] [20]—The value of barter contracts for strategic stockpile material negotiated by the Commodity Credit Corporation (CCC) in 1962 was $80 million; the principal minerals were mica, ferromanganese, beryl ores and concentrates, asbestos, electrolytic manganese, celestite, and selenium. About $83 million of strategic and other mineral materials was delivered to CCC in 1963. There were no additions to the list of mineral materials eligible for barter during 1963.

In accordance with recommendations of the President's Executive Stockpile Committee to report on the Barter program (February 13, 1964), barter emphasis was shifted from transactions involving purchases of strategic and critical materials for stockpile to those which acquire goods which U.S. Government agencies installations in foreign countries would otherwise acquire abroad. Among the major considerations involved in the reemphasis were balance-of-payment conditions and foreign policy considerations. Starting in 1963 the

[17] U.S. Department of the Interior. Office of Minerals Exploration. Tenth and Eleventh Semiannual Report on Exploration Assistance and 1963 Quarterly Statistical Reports of OME.

[18] Joint Committee on Defense Production. 13th Annual Report of the Activities of the Joint Committee on Defense Production. House Report No. 1095, 88th Congress, 2d sess., January 13, 1964, pp. 14–26.

[19] Executive Office of the President, OEP. Stockpile Report to the Congress. January–June 1963 and July–December 1963.

[20] U.S. Department of Agriculture. Foreign Agricultural Service. Office of Barter and Stockpile. Published record.

Department of Agriculture will begin to barter for strategic material in excess of stockpile objectives only when this is determined to be in the national interest. In making these determinations, principal consideration will be given to situations where they are more advantageous to the United States in accepting barter commodities than the sale for additional foreign currencies in U.S. hands or where barter will further U.S. foreign policy objectives.

TABLE 48.—Summary of Government inventories of raw materials, at acquisition cost and at market value

(Million dollars)

Type of acquisition	Inventory, June 30, 1962: Total: Acquisition cost [1]	Inventory, June 30, 1962: Total: Market value [2]	Inventory, June 30, 1962: Excess over stockpile objective: Acquisition cost	Inventory, June 30, 1963: Total: Acquisition cost [1]	Inventory, June 30, 1963: Total: Market value [2]	Inventory, June 30, 1963: Excess over stockpile objective: Acquisition cost
National stockpile (Public Law 520):						
Stockpile grade	5,756	5,437	1,892	5,672	5,302	2,356
Nonstockpile materials	294	150	294	145	78	145
Total	6,050	5,587	2,186	5,817	5,380	2,501
DPA inventory (Public Law 744):						
Stockpile grade	1,104	774	860	1,126	743	919
Nonstockpile materials	392	127	392	374	118	374
Total	1,496	901	1,252	1,500	861	1,293
Supplemental stockpile (Public Law 480):						
Stockpile grade	[3] 1,118	1,019	956	[3] 1,246	1,100	1,049
Nonstockpile materials	23	17	23	30	23	30
Total	1,141	1,036	979	1,276	1,123	1,079
Commodity Credit Corporation inventory (Public Law 608):						
Stockpile grade	94	89	40	25	25	11
Nonstockpile materials	6	6	6	32	32	32
Total	100	95	46	57	57	43
Totals:						
Stockpile grade	8,072	7,319	3,748	8,069	7,170	4,335
Nonstockpile materials	715	299	715	581	251	581
Total	8,787	7,618	4,463	8,650	7,421	4,916

[1] Acquisition cost of inventories includes open-market purchases at contract prices, intradepartmental transfers at market prices prevailing at time of transfer, transportation to first permanent storage location, beneficiating and processing costs, but does not cover cost of research, administrative and interest expenses, accessorial cost, storage, and hauling.

[2] Because of mixed nature of individual commodities (types, quality, and grades) and lack of active trading in these materials, the market value of commodities not meeting stockpile specifications and of inventory not having stockpile objectives was not calculated.

[3] Includes transfer of $27,500,000 material cost and $800,000 accessorial cost from the U.S. Department of the Interior inventory acquired under Public Law 733.

Source: Joint Committee on Defense Production, 12th Annual Report. S. Rept. 1, 87th Congress, 2d Session, January 1963, p. 43, 13th Annual Report. H. Rept. 1095, 88th Congress, 2d Session, January 13, 1964, pp. 9, 27.

TABLE 49.—U.S. Government stockpile disposal of mineral commodities, 1963

Commodity	Sales commitments	
	Quantity	Sales value
National stockpile inventory:		
Brass scrap .... short ton..	394	191, 561
Bronze, silicon and copper scrap .... do....	74	38, 058
Cadmium .... pound..	1, 999, 300	5, 327, 741
Copper, beryllium scrap .... short ton..	11	14, 266
Ferrovanadium .... pound..	65, 447	50, 850
Kyanite .... short dry ton..	476	7, 140
Magnesium ingots .... short ton..	3, 475	2, 118, 012
Molybdenite .... pound..	5, 018, 617	7, 264, 892
Nickel oxide powder .... do....	69, 721	56, 118
Quartz crystals, crude .... do....	130, 695	173, 864
Tin .... long ton..	10, 595	27, 623, 217
Zirconium ores, zircon .... short dry ton..	1, 395	40, 464
Total National stockpile	....	42, 906, 183
Defense Production Act inventory:		
Aluminum .... short ton..	51, 324	23, 175, 144
Cobalt .... pound..	1, 000	1, 500
Copper .... short ton..	15, 994	9, 844, 027
Cryolite, synthetic .... do....	9, 913	1, 423, 006
Lead .... do....	6, 588	1, 154, 295
Nickel .... pound..	7, 032, 824	5, 190, 731
Palladium .... troy ounce..	7, 884	178, 356
Rutile chlorinator sponge .... short ton..	7, 000	91, 840
Titanium sponge .... do....	87	204, 582
Tungsten .... do....	32, 800	536, 086
Total DPA	....	41, 799, 567
Grand total	....	84, 705, 750

Source: Office of Emergency Planning, Stockpile Report to the Congress, January-June 1963, p. 9, and Stockpile Report to the Congress, July-December 1963, p. 9.

WORLD REVIEW

World Economy.[21]—The upward trend of world economy since 1958 continued in 1963. The development of demand and production in the industrial countries of the free world during 1963 was good, particularly in light of the slackening tendencies that had developed toward the end of 1962.

In North America, the sharp upswing in industrial production was apparent throughout 1963. In Western Europe, industrial production halted its downward trend toward the end of 1962 and moved upward steadily, with the United Kingdom outpacing the rest of Europe. In Japan, output recovered from the low in 1962 and rose sharply in 1963. Between 1962 and 1963 the gross national product increased by an average of 4 percent both in North America and Western Europe and by 8 percent in Japan.

The economic development of the less developed areas continued to improve, with an increase in their export earnings and in their terms of trade. In general, this was a reflection of the increased demands of the developed countries, chiefly the United States. At the same time, however, the intensity of their domestic demand for indigenous output slackened slightly and the average rate of growth was smaller than before, with a tendency toward mild inflation.

Industrial output of the Soviet bloc continued to gain but at a

[21] United Nations, World Economic Survey, 1963, Part II, Current Economic Development.

decreasing rate in 1963 compared with the earlier year. Output from the agricultural sector declined and, coupled with the slower growth in the industrial sector, there was a general slowdown of the growth rate of national income.

World Production.—The United Nations (UN) index of world metal mining output showed an increase of 1.7 percent in 1963 over 1962, which was a slight decline from the 2.5 percent gain made in 1962. Within this world grouping, North America gained 0.9 of 1 percent and the United States 0.7 of 1 percent. Latin America gained 7 percent over 1962, which more than offset the loss of 3.6 percent in Europe, and was chiefly responsible for the overall world gain in 1963. Metal output for Asia recorded a small gain.

The UN index of world basic metals increased 6.3 percent in 1963 over 1962. Asia, principally Japan, gained 13 percent; North America, 7.4 percent, with U.S.A., 8.1 percent; and Europe, 2.4 percent. The UN index for nonmetallic mineral products rose 4.7 percent, with 8.7 percent increase in Asia, again primarily Japan; 5.9 percent in North America, with 5.8 percent in the U.S.; and 3.7 percent in Europe.

Free world production of major processed mineral raw materials recorded an overall gain in 1963, with aluminum leading at 10.1 percent, followed by 7.5 percent for crude steel, 6 percent for pig iron, 4.9 percent for lead, 3.6 percent for cement, 3 percent for copper, 1.7 percent for zinc, and no change for tin.

U.S. production and imports of principal minerals and metals were again the dominant and major part of the world supply, following closely the historical trend, and the U.S. total share of the world supply in these commodities was generally slightly higher than in 1962.

World Consumption.—Free world iron and steel industries recovered from the slight decline of demand in 1962 and made vigorous gains in 1963. This increased world consumption of iron ore and most of all of the steel-making additive metal ores such as manganese, nickel, chromite, and molybdenum.

A 6-percent gain in the output of the free world's heavy manufacturing (metal-using) industry in 1963 resulted in an overall increase of 6 percent in the world consumption of nonferrous metals, with the exception of tin. Tin consumption moved up 2 percent and this smaller gain stems from competing metals which are making some inroads into the tin market. United States consumption led the overall increase, with Japanese consumption recovering vigorously from the 1962 decline. Most Western European and Canadian consumption of nonferrous metals recorded modest gains, with some minor declines within the metals group.

Free world copper consumption gained 5 percent in 1963. The large increase in consumption by the United States, United Kingdom, Japan, Italy, and Canada, plus the modest increase of Sweden, were more than sufficient to compensate for the decline of West Germany and Belgium. World consumption of lead increased 6 percent over 1962, with U.S. consumption surging ahead with a 10-percent gain, followed by French and Japanese consumption; the rest of the consumption of Western Europe rose modestly. World zinc consumption was pegged at a 7-percent gain for 1963 over the previous year.

Japan, Canada, the United States, Italy, and the United Kingdom led the vigorous increase, whereas the rest of Western European consumption suffered a slight decline.

Free world aluminum consumption continued its upward trend and made a 9-percent gain over the previous year. The substantial gains made by the U.S. and the U.K., with the help of Italy and Belgium, were responsible for the upsurge. Canada was the only industrialized country where no gain in consumption was reported.

Estimated 1975 Consumption.—The United Nations estimated world consumption of major metals for 1975.[22] The projections made were essentially long-term projections, based on a trend incorporating the relationship between the absorption of the minerals and such independent variables as population, gross domestic product, value added in manufacturing, and changing technology.

The projections were discussed in detail and presented in the following tables of the Volume I 1962 Yearbook chapter on Review of the Mineral Industries: table 57—Estimated world consumption and production of crude steel by regions, 1972–1975; table 58—Estimated consumption and production of crude steel by major countries, over 5 million metric tons, 1972–75; and table 59, Major nonferrous metals: Free world consumption of primary metal, actual 1959 and provisional projections for 1975.

World Trade.—Free-world trade in iron ore in 1963 increased over 1962, with the largest gain reported by Japan, followed by smaller gains by both the United States and the United Kingdom, whereas the European Economic Community countries declined. The aggregate volume of trade increased by 6 percent over that of 1962.

Free world trade of nonferrous ores declined slightly. Japan's small gain was insufficient to overcome the larger decline recorded by the United States and the United Kingdom trade. There was little or no change in the remainder of European trade. World nonferrous metal trade was unchanged in 1963. The 12-percent and 8-percent increases in world aluminum and tin metal trade, respectively, were equalized by the declines of 3 percent, 9 percent, and 1 percent in world trade of copper, lead, and zinc, respectively.

World trade of metallic ores and scrap accounted for 2.5 percent of total world trade during 1962 as compared with 2.9 percent for that of 1961. The developed and industrialized countries in the free world took 82 percent of world exports of metal ores and scrap in 1962, about the same share as for 1961. In 1962, North America, principally the United States, took 28.7 percent of world exports, with Western Europe taking 40.6 percent of the total. The large 1962 decline of Western European and Japanese trade in metal ores and scrap outweighed the modest gain achieved by North America and the resulting 10-percent drop in total trade developed.

World trade of base metals accounted for 8.1 percent of total world trade during 1962 compared with 8.4 percent in 1961. The free world developed countries took 66 percent of total world exports of base metals in 1962, the same percentage as of the 1961 exports. Western Europe took 48 percent of 1962 world exports, whereas

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[22] United Nations, Economic Commission for Europe. Long-Term Trends and Problems of the European Steel Industry; United Nations Secretariat Report. Study of Prospective Production of and Demand for Primary Commodities—Prospective Demand for Nonagricultural Commodities: Problems of Definition and Projection Methodology, 1962.

TABLE 50.—Indexes of world production of metal-mining, basic metals, and nonmetal mineral products

(1958=100)

Year	Free World [2]	North America [3]	Latin America [4]	Asia: East and Southeast [5]	Europe [6]
	Metal mining [1]				
1959	104	100	103	104	[7] 99
1960	116	114	[7] 117	[7] 122	[7] 109
1961	118	113	[7] 114	129	113
1962	[7] 121	115	[7] 114	[7] 132	111
1963 [8]	123	114	122	133	107
First quarter	116	103	122	126	105
Second quarter	125	120	121	134	112
Third quarter	127	122	124	138	100
Fourth quarter [8]	123	112	123	134	110
	Basic metal industries [9]				
1959	112	115	109	131	107
1960	122	117	112	168	124
1961	123	114	117	202	125
1962	127	121	124	208	123
1963 [8]	135	130	n.a.	235	126
First quarter	131	127	122	212	124
Second quarter	144	147	126	228	128
Third quarter	128	120	130	239	119
Fourth quarter [8]	138	126	n.a.	260	134
	Nonmetallic mineral products industries [10]				
1959	112	115	109	114	109
1960	118	115	114	139	118
1961	121	114	119	156	125
1962	128	119	124	173	133
1963 [8]	134	126	n.a.	187	138
First quarter	112	108	120	174	108
Second quarter	138	129	119	179	147
Third quarter	144	136	131	191	149
Fourth quarter [8]	142	129	n.a.	203	149

[1] Percentage weight (1958) in World Index. North America, 34.6; Latin America, 13.3; Asia, 7.6; and Europe, 15.3.
[2] Excluding Albania, Bulgaria, China Mainland, Czechoslovakia, Eastern Germany, Hungary, Mongolia North Korea, Poland, Rumania, the U.S.S.R. and North Viet-Nam.
[3] Canada and the United States.
[4] Central and South America and the Caribbean Islands.
[5] Afghanistan, Brunei, Burma, Ceylon, China, (Taiwan), Hong Kong, India, Indonesia, Iran, Japan, Republic of Korea, Malaysia, (excluding Sabah), Pakistan, Philippines, Thailand and the Republic of Viet-Nam.
[6] Excluding Albania, Bulgaria, Czechoslovakia, Eastern Germany, Hungary, Poland, Rumania and the U.S.S.R.
[7] Revised figures.
[8] Preliminary figures.
[9] Percentage weight (1958) in World Index. North America, 50.6; Latin America, 5.5; Asia, 5.3; and Europe, 37.8.
[10] Percentage weight (1958) in World Index. North America, 44.8; Latin America, 5.1; Asia, 6.0; and Europe, 40.0.

Source: United Nations Monthly Bulletin of Statistics, V. 18, May 1964, pp. VIII–XVI.

North America, chiefly the United States, took 15 percent. The 1962 value of world exports to Western Europe was the same as 1961, whereas North America increased its share 13 percent over 1961. This offset all other area declines and resulted in an insignificant increase in 1962 total export trade.

World Stocks.—The rising consumption of free-world metal-using industries again outpaced world metal production and hence, world metal stocks were further reduced in 1963. The average decline of stocks in 1963 was much greater than that in 1962.

TABLE 51.—Comparison of world and United States production and United States imports of principal metals and minerals, 1963

Mineral	World production, thousand short tons unless otherwise stated	U.S. production, percentage of world production	U.S. imports, percentage of world production	Total U.S. production and imports; percentage of world production 1963	Total U.S. production and imports; percentage of world production 1962
Fuels:					
Coal	2,926,032	16	(1)	16	17
Petroleum (crude)..thousand barrels	9,535,434	29	5	34	35
Nonmetals:					
Asbestos	3,200	2	21	23	24
Cement [2]..........thousand barrels	2,201,159	17	(1)	17	20
Diamonds..........thousand carats	36,661	(3)	40	40	45
Feldspar [4].......thousand long tons	1,590	35	4	39	33
Fluorspar	2,340	9	24	33	34
Gypsum	54,000	19	10	29	31
Mica (including scrap) thousand pounds	400,000	55	7	62	59
Nitrogen, agricultural [2 4 5]	13,800	27	9	36	35
Phosphate rock...thousand long tons	50,400	39	(1)	39	42
Potash (K_2O equivalent)	12,000	24	9	33	26
Salt [2]	104,900	29	1	30	30
Sulfur, elemental thousand long tons	12,560	46	11	57	60
Metallic ores and concentrates:					
Bauxite..........thousand long tons	29,835	5	31	36	39
Chromite	4,475	(3)	14	14	30
Copper (content of ore and concentrate)	5,220	23	(1)	23	24
Iron ore..........thousand long tons	509,021	14	7	21	21
Lead (content of ore and concentrate)	-----------	-----------	-----------	-----------	-----------
Mercury...thousand 76-pound flasks	236	8	18	26	24
Molybdenum (content of ore and concentrate).........thousand pounds	91,600	71	(6)	71	68
Nickel (content of ore and concentrate)	384	3	32	35	36
Platinum group (Pt, Pd, etc.) thousand troy ounces	1,530	3	86	89	63
Silver..........do	249,500	14	24	38	47
Titanium concentrates:					
Ilmenite [4]	2,222	40	9	49	42
Rutile [4]	220	5	33	38	33
Tungsten concentrate (60 percent WO_3)..........short tons	64,700	9	2	11	15
Vanadium (content of ore and concentrate)..........do	7,004	55	(6)	55	63
Zinc (content of ore and concentrate)	-----------	-----------	-----------	-----------	-----------
Metals, smelter basis:					
Aluminum	6,095	38	7	45	45
Copper	5,500	24	4	28	28
Iron, pig	-----------	-----------	-----------	-----------	-----------
Lead	2,795	14	8	22	24
Magnesium..........short tons	154	49	2	51	49
Steel ingots and castings	425,310	26	1	27	26
Tin	192	1	23	24	24
Titanium sponge..........short tons	9,800	80	15	95	90
Uranium oxide (U_3O_8)..........do	30,200	47	27	74	86
Zinc	-----------	-----------	-----------	-----------	-----------

1 Less than 1 percent.
2 Including Puerto Rico.
3 None produced.
4 World total exclusive of U.S.S.R.
5 Year ended June 30 of the year stated (United Nations).
6 None imported.

Reversing 1962 stock increases, world copper stocks dropped 7 percent in 1963 and followed the general pattern of declining metal stocks. The United States stocks of copper shrank by nearly 35 percent in 1963 over 1962. On the other hand, stocks held in Western Europe, Japan, and other free-world countries increased about 10 percent. The U.S. decline was principally responsible for the overall world copper stocks decline.

TABLE 52.—Indexes of apparent consumption of selected nonferrous metals in major countries

(Index: Preceding years=100) [1]

Country	1961 (thousand metric tons)					Copper		Lead		Aluminum		Zinc		Tin	
	Copper	Lead	Aluminum	Zinc	Tin	1962	1963	1962	1963	1962	1963	1962	1963	1962	1963
United States	1,327	832	1,796	838	51	109	107	108	110	116	110	111	107	109	101
United Kingdom	529	276	284	258	21	99	106	100	103	101	111	95	105	106	96
Germany, West	562	234	290	306	26	89	99	103	101	104	104	95	96	45	96
France	244	164	201	189	10	100	102	95	109	117	103	98	97	111	99
Belgium	74	47	59	115	2	88	91	96	90	96	119	105	101	129	110
Italy	202	84	105	90	5	106	107	108	101	119	114	118	107	104	106
Sweden	93	44	41	27	1	97	105	111	104	117	104	107	96	115	80
Canada	129	46	114	55	4	107	111	97	98	120	99	107	109	114	110
Japan	373	123	191	243	15	82	115	93	106	96	103	100	117	97	115
India	68	27	29	70	5	114	101	136	117	168	157	121	106	100	98
World [2]	4,080	2,292	3,331	2,586	160	100	105	104	106	114	109	105	107	100	102

[1] Data for 1963 are in some cases preliminary.
[2] Excluding centrally planned economies.

Source: Compiled by the United Nations Secretariat, Bureau of General Economic Research and Policies on the basis of data in International Tin Council, Statist Bulletin, June 1964; International Lead and Zinc Study Group, Monthly Bulletin of Statistics, August 1964; British Bureau of Nonferrous Metals Statistics, World Nonferrous Metal Statistics, May 1964; American Bureau of Metal Statistics, Yearbook of American Bureau of Metal Statistics, 43rd Annual Issue.

There was a sharp decline of 28 percent of free-world zinc stock over that of 1962 and by year end the world zinc stock reached a new low. The United States and Western Europe accounted for the large drop of world zinc stock.

Decumulation of world stocks of lead began in 1961, reached a new low in 1963, with an additional 20-percent decline from 1962. The United States again was chiefly responsible for most of the decline, whereas Western Europe stocks were unchanged.

World tin stock declined 18 percent from the previous year in order to meet the continued deficit between slowly rising consumption and static production. Decumulation of tin stock in Western Europe

TABLE 53.—World trade in major nonferrous metals

Commodity	Distribution of 1960 export value (percent)	Index [1] [2] Preceding year=100	
		1962	1963 [3]
Aluminum	18	111	112
Copper	60	97	97
Lead	6	104	91
Zinc	7	102	99
Tin	9	102	108
Aggregate nonferrous metals	100	101	100

[1] Based on export data, excluding centrally planned economies.
[2] The group included reflect movements in the trade of commodities tested, weighted by their 1960 export values, the distribution of which is shown.
[3] Preliminary figures, based on less than 12 months' returns.

Source: United Nations. World Economic Survey, 1963, and unpublished data.

TABLE 54.—Foreign trade of iron ores and nonferrous ores and metals in selected industrial nations [1]

Country	Imports		Exports	
	Iron ore	Nonferrous ore and metals	Iron ore	Nonferrous ore and metals
1961 value:				
Total (million dollars)	1,332	3,020	114	1,304
United States (percent of total)	19	21		28
European Economic Community (percent of total)	43	54	100	54
United Kingdom (percent of total)	15	23		18
Japan (percent of total)	23	2		
1962 value: [2]				
Total (million dollars)	1,341	4,184	211	1,522
United States (percent of total)	24	34	30	29
European Economic Community (percent of total)	39	40	51	50
United Kingdom (percent of total)	13	20	19	19
Japan (percent of total)	24	6		2
1963 value: [2]				
Total (million dollars)	1,362	4,126	203	1,583
United States (percent of total)	24	32	37	30
European Economic Community (percent of total)	37	41	43	50
United Kingdom (percent of total)	13	20	20	17
Japan (percent of total)	26	7		3

[1] Gross imports, material later reexported or imports originating within the EEC., not excluded from data.
[2] Not directly comparable with 1961 as data derived from different sources.

Source: 1961—United Nations Commodity Survey. 1962, pp. 87, 89. 1962–63—from foreign trade journals of respective countries.

TABLE 55.—World trade by regions of metallic ores and metal scraps (SITC, revised 28)

(Value in million U.S. dollars f.o.b.)

Exports	World		Developed areas [1]		Under-developed areas [2]		North America		Latin America		Western Europe [3]		Middle East [4]		Australia, New Zealand, South Africa		Central Africa [5]		Japan		Other Asia [6]		Eastern Europe [7] and U.S.S.R.		Asiatic Communist areas [8]		Other countries [9]	
	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962
World	[10] 3,850	[10] 3,450	[10] 3,230	[10] 2,820	76	98	970	990	27	31	1,600	1,400	1	1	[11] 6	[11] 6	2	----	660	480	41	64	480	485	4	1	----	----
Developed areas [1]	2,120	1,820	2,040	1,750	27	26	510	570	16	14	1,120	980	1	1	2	3	----	----	405	200	10	11	23	25	----	----	----	----
Underdeveloped areas [2]	1,220	1,150	1,140	1,030	48	71	450	415	11	17	440	385	1	----	4	3	----	----	250	225	250	225	30	54	1	----	----	----
Africa [11]	400	370	370	345	2	2	140	135	----	1	210	190	1	----	2	3	----	----	18	17	----	1	1	5	----	----	----	----
North America	1,190	930	1,170	910	24	21	390	445	15	12	425	310	----	----	1	2	----	----	345	155	8	8	2	1	----	----	----	----
Latin America	475	470	450	445	13	11	235	235	13	11	165	145	----	----	----	----	----	----	53	64	----	----	10	11	----	----	----	----
Australia, New Zealand, South Africa	245	225	215	205	2	2	115	120	----	----	50	51	----	----	----	1	----	----	52	37	1	1	----	1	----	----	----	----
Other Asia [9]	145	135	120	89	23	45	44	28	2	3	18	15	----	----	----	----	----	----	57	46	21	42	----	----	----	----	----	----
Eastern Europe [7]	425	435	48	41	----	----	2	2	----	----	45	37	----	----	----	----	----	----	2	2	----	----	360	380	3	----	----	----
Asiatic Communist areas [8]	73	46	3	2	1	----	----	----	----	----	3	2	----	----	----	----	1	----	----	1	----	----	69	43	----	----	----	----

[1] North America; Western Europe; Australia, New Zealand, and South Africa; and Japan.

[2] Sum of regions other than Developed areas, Eastern Europe, Mainland China, Mongolia, North Korea, and North Viet-Nam.

[3] All European countries including Turkey and Yugoslavia but excluding the U.S.S.R. and Eastern European Communist countries.

[4] Aden, Cyprus, Jordan, Iraq, Israel, Lebanon, Syria, Libya, Ethiopia, Sudan, U.A.R.

[5] Africa less Morocco, Algeria, Tunisia, Libya, U.A.R., Sudan, Ethiopia, Somalia, and South Africa.

[6] Sterling Asia and other Asia, except Japan and Asiatic Communist areas.

[7] Albania, Bulgaria, Czechoslovakia, Eastern Germany, Hungary, Poland, and Rumania.

[8] Communist China, Mongolia, North Korea, and North Viet-Nam.

[9] Includes Morocco, Algeria, and Tunisia.

[10] Includes exports of fissionable material by South Africa, not all of which could be analyzed by destinations.

[11] African continent and associated islands.

Source: United Nations, Monthly Bulletin of Statistics, April 1964, Special Table B pp. XV–XVI.

TABLE 56.—World trade by regions of base metals (SITC, revised 67, 68 less 681)

(Value in million U.S. dollars f.o.b.)

Exporters	Destinations																											
	World		Developed areas [1]		Underdeveloped areas [2]		North America		Latin America		Western Europe [3]		Middle East [4]		Australia, New Zealand, South Africa		Central Africa [5]		Japan		Other Asia [6]		Eastern Europe [7] and U.S.S.R.		Asiatic Communist area [8]		Other countries [9]	
	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962	1961	1962
World	11,240	11,330	7,470	7,490	2,020	1,920	1,470	1,660	670	560	5,440	5,440	305	320	245	225	170	160	305	165	740	750	1,580	1,740	100	91	140	115
Developed areas [1]	8,370	8,290	5,940	5,990	1,800	1,660	1,130	1,320	590	465	4,380	4,380	280	285	220	200	165	160	205	90	630	625	550	580	36	28	140	110
Underdeveloped areas [2]	1,420	1,420	1,290	1,270	105	120	340	340	34	50	860	840	1	3	25	29	2	2	65	56	70	66	10	16	2	4	1	1
Africa [10]	690	690	620	630	56	41	39	38	10	7	520	540	----	1	28	25	18	17	32	26	29	14	10	11	----	----	1	1
North America	1,740	1,690	1,330	1,250	390	430	490	570	200	165	690	590	27	26	41	53	8	12	115	38	142	207	22	5	1	----	9	9
Latin America	550	560	530	510	22	41	220	225	21	40	295	275	----	----	----	----	----	----	14	10	1	----	------	1	----	----	----	----
Western Europe [3]	5,990	5,800	4,310	4,340	1,110	890	520	550	340	240	3,620	3,660	235	240	130	96	130	115	45	29	275	198	510	540	25	14	125	98
Australia, New Zealand, South Africa	235	235	185	180	44	46	36	42	2	4	62	79	----	2	40	35	18	17	47	24	20	20	1	1	1	1	3	3
Japan	410	570	115	220	265	295	89	160	43	58	16	46	18	19	10	14	12	14	----	----	191	200	17	37	9	13	1	1
Other Asia	235	240	190	175	40	50	100	91	5	4	57	52	1	2	3	6	----	----	31	36	33	57	1	4	2	3	----	1
Eastern Europe [7] [11]	1,340	1,500	220	225	105	125	1	1	47	47	190	210	18	28	----	----	1	2	30	13	38	46	930	1,050	62	60	1	1
Asiatic Communist [8] area [12]	115	115	18	17	10	10	------	------	----	----	13	13	3	2	----	----	----	----	4	4	7	8	88	84	----	----	----	----

[1] North America; Western Europe; Australia, New Zealand and South Africa; and Japan.

[2] Sum of regions other than: Developed Areas, Eastern Europe, China Mainland, Mongolia, North Korea and North Viet-Nam.

[3] All European countries including Turkey and Yugoslavia but excluding the U.S.S.R., Albania, Bulgaria, Czechoslovakia, Eastern Germany, Hungary, Poland and Rumania.

[4] Aden, Cyprus, Jordan, Iraq, Israel, Lebanon, Syria, Libya, Ethiopia, Sudan, U.A.R.

[5] Africa less Morocco, Algeria, Tunisia, Libya, U.A.R., Sudan, Ethiopia, Somalia and South Africa.

[6] Sterling Asia and other Asia, except Japan and Asiatic Communist Areas.

[7] Albania, Bulgaria, Czechoslovakia, Eastern Germany, Hungary, Poland, and Rumania.

[8] Communist China, Mongolia, North Korea, and North Viet-Nam.

[9] "Rest of World" plus Morocco, Algeria and Tunisia.

[10] African continent and associated islands.

[11] Certain cells contain considerable contributions estimated by means of the import data of trading partners.

[12] Estimated order of magnitude.

accounted for the bulk of the decline, with a small assist by the United States.

Data pertaining to aluminum stocks are confined to the United States producers. Increasing industrial demand for aluminum outpaced the 10-percent increase in output. At yearend, producers stocks declined 28 percent over 1962 and reached a new low, to about one-seventh the level in 1958.

World Prices.—The United Nations price index of nonferrous metals moving in international trade recovered from the small drop in 1962, moved forward again slowly and steadily, and was approaching the record high reached in 1960 by yearend. The metal ore index drifted downward by 3 percent from 1962, and the total minerals index (including fuels and metals ores only) remained the same as the previous 2 years with some signs of rising toward the end of 1963.

The increase of world steel production in 1963 was coupled with a greater gain in iron ore output and resulted in a softening of export prices of iron ore and several of the steelmaking additives. The buoyant increase of nonferrous ores was insufficient to offset the weakening of ferrous ores.

TABLE 57.—Price indexes of free world commodity trade

(1958=100)

Year	Primary commodities [1]	Total minerals [2]	Metal ores	Nonferrous metals
1959	97	94	97	111
1960	97	93	98	114
1961	95	92	100	110
1962	94	92	99	109
1963	100	92	96	110
1st quarter	97	92	96	108
2nd quarter	101	92	96	109
3rd quarter	99	92	95	110
4th quarter	104	93	96	112

[1] Does not include nonferrous metals.
[2] Includes fuels and metal ores.

Source: United Nations Monthly Bulletin of Statistics, June 1964, Special Tables C-1.

TABLE 58.—Export price indexes of major primary mineral commodities

(1962=100)

	1963	Fourth quarter 1963
Ferrous metal and ores:		
Chromium ores	90	90
Iron ores	95	93
Manganese ores	90	91
Nickel and ore	99	100
Nonferrous metal and ores:		
Aluminum	100	102
Bauxite	100	100
Copper and ore	101	101
Lead and ore	113	131
Tin and ore	102	113
Zinc and ore	113	128
Mineral fuels:		
Coal	104	106
Petroleum	100	100

Source: Bureau of General Economic Research and Policies, United Nations Secretariat. Based on prices compiled by the United Nations Statistical Office.

Export prices of both lead and zinc metals and ores remained strong in the course of 1963 and increased 13 percent over 1962. The fourth quarter average prices were 28 percent and 31 percent over the 1962 average for lead and zinc, respectively. At yearend, the prices were still rising. Other nonferrous metals and ores also increased in price, with a last-quarter upward trend.

Ocean Freight Rates.—Indexes of ocean freight rates continued the increasing trend begun during the third quarter of 1962 and moved back to the level of 1958 by the second quarter, declined during the third quarter, and turned strongly upward in the last quarter. The former record high of 1957 was surpassed, and the index ended the year with a substantial gain over 1962.

TABLE 59.—Indexes of Ocean Freight Rates

(1958=100)

Year	Trip charter freight-rate indexes[1]		
	General cargo	Ore	Fertilizers
1959	107	100	91
1960	111	103	97
1961	118	103	105
1962	98	79	96
1963	120	99	97
First quarter	105	84	85
Second quarter	117	100	106
Third quarter	117	92	95
Fourth quarter	145	120	(2)

[1] United Kingdom indexes based upon weighted average of quotations by all nations on routes important to United Kingdom tramp fleet in 1951.
[2] Rate not determined.

Source: United Nations Monthly Bulletin of Statistics, March 1964, special table E, p. 30.

Review of Metallurgical Technology

By Kenneth B. Higbie [1] and Rollien R. Wells [2]

METALLURGICAL ACTIVITY in 1963 was again dominated by the insatiate demands of research and development conducted in conjunction with the nation's defense and aerospace programs. An increasing effort was noticeable throughout the year, however, to apply to the commercial field many of the processes and techniques that have been developed by government-sponsored research. Particularly effective has been the Industrial Applications Program of the National Aeronautic and Space Agency through which many of the technological advancements made during the course of NASA research and development have been published and released to the public.

POWDER TECHNOLOGY

Powder metallurgy techniques for fabricating metals, not long ago declared outmoded because of improved casting and shaping methods, have since made an astonishing comeback. Traditionally mechanical pressing of powder shapes has been employed when melting and casting was difficult or impossible, when phase relationships needed to be sidestepped, or when machining costs could be avoided. Hence, it has long been used for producing relatively small special shapes of high-melting metals and alloys. Small iron parts produced with a punch and die have been common for many years, but powder metallurgy techniques are now applicable to a wide range of materials and items. Hard-to-handle materials including refractory metals and their alloys are now rolled, forged, or extruded from billets made by sintering isostatically compacted powders. The major element of the powder metallurgy industry still comprises iron shapes, however, and two-thirds of the annual 100,000 tons of powder metallurgy products are made of iron. The largest single user of powder-forming techniques is the automobile industry which currently consumes 14,000 to 16,000 tons of iron powder per year. A typical 1963 model auto contained more than 100 pressed powder parts (e.g., transmission gears, timing gears, sprockets, ball joint suspensions) totaling 5 to 7 pounds per car. Some of these powders are used in self-lubricating parts of porous copper and copper alloys containing as much as 20 volume-percent lubricating oil. The expanded use of powder techniques, coupled with

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continued improvements in fabrication, is largely responsible for the 50,000-mile warranties offered for one manufacturer's 1964 car.

Powder metallurgy received a notable endorsement by the Canadian government as indicated by its decision to make 5-cent coins from high-density strip rolled directly from sintered pure nickel powder. The soft, uniform-grained nickel is reported to have lessened the expensive die replacement that normally contributes much to the inherent cost of coin stamping.

Reynolds Metals Co. announced a new rolling method, called the Compacted Sheet Process, by which aluminum sheet products can be made by rolling coarse acicular particles obtained by pouring metal into a spinning, perforated cylinder. These particles are collected pneumatically, screened and either stored or passed directly into a vertical air furnace, where they are heated by a counter flow air current. Then they drop into a hopper situated between the rolls in a rolling mill turned on its side to provide a vertical, rather than horizontal pass. The hopper guides the particles into the nip, where roll pressure metallurgically bonds the hot particles together forming a strip that is of full theoretical density. The strength of conventional alloys fabricated from the new type of particles was found to be at least equal to that obtained from conventionally processed alloys.

Enthusiastic advocates of powder fabrication declare that the real potential of the technique lies in the high-tonnage production of sheet from low-carbon steel, stainless steel, and copper. One process now in the pilot-plant stage involves direct reduction of iron and direct rolling of iron powder. Appreciable savings in scrap generation and processing costs are predicted if finished sheet can be rolled continuously from a green sheet compact slightly oversize rather than intermittently from much thicker ingots.

Much of the revived interest in powder fabrication techniques is due to improved methods of producing the basic powder material. Today, virtually all metals and many compounds are available in powder form. Metal powders are defined as particles in the size range from 0.1 to 1,000 microns. Above 1,000 microns, metal particles are known as shot. Below 0.1 micron, the particles usually are termed dust or ultrafine powder. Powders have been made by many conventional techniques including physical disintegration (commonly in a ball mill), chemical decomposition and reduction from solids and gases, gaseous condensation, and electrochemical means. The National Research Corp., Cambridge, Mass., announced a new process for the production of the ultrafine powders by gaseous condensation in which a wide range of metals reportedly can be prepared in sizes ranging from 0.03 to 0.06 microns. The process involves melting the starting metal and vaporizing it in a vacuum. The vapors are condensed and collected in specially constructed conical chambers. Another new process for making submicron powders is the Hierarc process employed by Vitro Laboratories, Inc. Powders of a number of refractory and nonrefractory oxides, metals, and carbides have been prepared. In this process the material to be pulverized is placed in the anode of a high-intensity electric arc and vaporized at a temperature exceeding 7,000° C. The vapors are then cooled under controlled pressure to produce ultrafine powders averaging less than 0.1 microns. Sherritt

Gordon Mines Ltd., Fort Saskatchewan, Canada, produces powders of copper, cobalt, and nickel by a hydrometallurgical process involving hydrogen reduction and precipitation from ammoniacal solutions under pressure. The method is economical and yields powders as fine as 0.2 microns, but it is not applicable to all metals. Sherritt Gordon can also produce composite powders consisting of a nickel coating on a metallic or non-metallic core. Core materials have included such diverse substances as aluminum, copper, tungsten, alumina, tungsten carbide, titanium diboride, glass, graphite, and phosphorus. Ratios of coating-to-core weights can be varied over a wide range.

Methods continue to be sought for producing ultra-pure iron powders from low-grade materials. The Geology Division of the Research Council of Alberta, Canada, in conjunction with the Peace River Mining and Smelting Company, Ltd., has been experimenting with the production of pure iron powders from oolitic hematite ore. The ore is first roasted in a reducing atmosphere and the reduced hydrated iron oxides are dissolved in hydrochloric acid. Insoluble impurities are removed by filtration, and the solution is concentrated by evaporation. Hydrated ferrous chloride crystals are permitted to form and are collected. These crystals are then dehydrated and reduced to iron powder by hydrogen gas.

COMPOSITE MATERIALS

Composites, as defined by the materials scientists, are the result of the physical wedding of two or more construction elements to give a material with properties superior to those of the individual constituents. Common examples are reinforced concrete and automobile tires.

The never ending search for new materials with unusual properties and the availability of a wide range of powders have stimulated the use of powder fabrication methods to produce composites of metals, ceramics, intermetallic compounds, and polymers. Typical of the resulting products are dispersion-strengthened metals in which submicron metal oxide powders are dispersed through metal matrices to restrict slippage along the crystal planes and grain boundaries. One of the newest of these metals investigated by the two major beryllium producing companies is the result of the dispersion of at least 4.25 percent beryllium oxide in a beryllium metal matrix. Forged specimens of the product consistently have a higher tensile strength than commercial beryllium from room temperature through 1,200° F. The outstanding feature of the material is its precision elastic limit (the point at which permanent deformation of 1 to 2 microns occurs). This is four times greater than for the grade of beryllium previously employed for guidance systems. A significant part of aerospace research is directed toward use of the material for jet engine components.

Recently, composites of fiber-reinforced metals, ceramics, and plastics have been the object of much research in the attempt to find better structural materials capable of operating at elevated temperatures. The fiberous phase usually is incorporated into the matrix as whiskers, fine wire, or wool. The cross-sectional size of the fiber has varied from the micron range to several mils. Numerous techniques have been used. For reinforced ceramics a slip of the ceramic is cast into a mold containing the fiber mat and dried, or a mixture of the fiber and ceramic is hot-pressed into a final body. Metal compacts are made similarly. One technique variation includes mixing the fiber with a powder in a vacuum or inert gas atmosphere. Combinations such as tungsten-reinforced stainless steel, alumina-reinforced nickel, and molybdenum-reinforced alumina have been developed and tested. Numerous metal and alloy fibers and whiskers of metallic oxides have been employed in matrices including alumina, silver, nichrome, and silica. General Electric Co. prepared specimens of silver reinforced with alumina (sapphire) whiskers which yielded tensile strengths as high as 232,000 pounds per square inch (psi) for a specimen containing 24 volume percent of whiskers. Individual whiskers had an average tensile strength of about 1 million psi. Further investigation of the potential of sapphire whiskers as a strengthener for metals will be facilitated by the completion of a pilot plant designed to produce the whiskers in limited quantities.

Significant progress has been made recently in producing structural materials having high ratios of strength-to-weight. For example, there has been a remarkable improvement in quality and strength of fiberglass in the last 3 or 4 years, both because of better glass fibers and better methods of bonding the resin to the fibers.

Glass fibers finer than 0.0001 inch in diameter can be bent quite sharply without breaking. In modern practice 204 of these small fibers are spun into threads which are then twisted together in groups of 12 to form a yarn. Impregnated with about 20 percent of an epoxy resin, the yarn can be formed into such objects as the third stage case of the Minuteman Rocket or pressed into common objects such as chair seats or small boat hulls. Tensile strengths of about 275,000 psi can now be realized in manufactured products. Specific strength (strength in pounds per square inch divided by weight in pounds per cubic inch) of present glass material is about 2.7 million inches, which is equivalent to an 800,000 psi steel. Improvements in glass fibers and bonding materials lead to the expectation that the strength of glass-reinforced plastic may approach 500,000 psi in 5 or 6 years. Johns-Manville Corp. introduced a modified form of E type (electrical grade) glass, the most common glass reinforcement which because of its improved clarity and low cost appeals to big users of glass fiber. Pittsburgh Plate Glass Co. has developed hollow glass fibers with a relatively high strength-to-weight ratio. Owens-Corning Fiberglass Corp. developed an "S" type glass with high-strength and high-temperature characteristics ideal for both military and commercial applications. Corning's Y type glass is a high modulus of elasticity fiber which has significantly extended applications in filament-wound rocket cases. It employs beryllium oxide to increase the rigidity that can be maintained at elevated temperatures, thus preventing surface warping and allowing the use of thinner walls.

Improved technology also expanded the use of basic reinforcing materials such as asbestos and graphite. Polypropylene strands are used to give greater structural and impact strength to other plastics; nylon reinforcement of ablative plastics is common.

A new fiber consisting essentially of amorphous boron with a tungsten boride center shows promise of being a superior material for plastic reinforcement. The composite might well find use for construction of space pressure vessels, rocket motor casings, airplane construction parts, and perhaps deep-diving submarines where a high strength-to-weight ratio is of prime importance. The fiber has a modulus of elasticity of more than 60 million psi. Whereas glass fibers suffer degradation during processing to the extent that only 34 to 40 percent of their true strength is realized in the finished article, preliminary tests on the boron fiber indicate that about 85 percent of its strength (500,000 psi) can be retained in a plastic structure.

COATING AND CLADDING

No single area of metallurgical research has received as much attention in 1963 as that of developing a coating for spacecraft capable of withstanding a reentry temperature of 7,000° F. The Asset (Aerothermodynamic/elastic Structural Systems Environmental Test) program was reported to be extended and probably expanded due to the cancellation of the Dyna-Soar program. Late in 1963, it was announced that a proprietary silicon-boron coating perfected by Chromalloy Corp., West Nyack, N.Y., had been selected to shield the structural parts of the Air Force's Asset test vehicles. The new coating (W–3) is a diffusion coating that makes molybdenum resistant to oxidation at high temperatures and eliminates the need for heavy or expensive insulation, ablation protection, cooling systems, or heat sinks. Extensive testing under conditions simulating flight and glide reentry conditions show that the coating forms an integral part of the structure that does not spall, crack, or flake off. The coating was applied to a variety of parts and shapes simulating actual parts of the Asset structure. The base metal used was TZM (molybdenum containing 0.5 percent titanium and a trace of zirconium). While structurally an excellent material, TZM is subject to oxidation. Uncoated, it will oxidize slowly at about 900° F. The oxide volatilizes at 1,200–1,300° F, and at 2,500° F the metal disintegrates catastrophically. With a W–3 coating, however, the same material has withstood at least 2 hours of exposure at 3,100° F. Throughout testing W–3 coated parts maintained dimensional stability and coating thickness. Coating integrity on tubular parts was satisfactory on both interior and exterior surfaces, and drilled sections maintained a uniform coating thickness.

Methods for cladding steels and other common structural materials with refractory metal coatings have created wide interest. One such process, an adaption of high energy rate forming techniques, is known as explosive bonding. This process produces metallurgical bonds even in dissimilar metals and alloys without any intermediate steps, fillers, or the use of heat. The properties of the metals are not changed by the operation, and the clads are uniform in composition and forming properties. Titanium can be bonded to low-carbon steel without the formation of a brittle intermediate phase as is produced by most other types of bonding operations. Alloy metals which would change in composition during a hot-rolling bonding operation, and therefore, develop inferior physical properties, can be bonded in this manner and yet maintain the desired chemical and physical characteristics achieved by prior heat treatment. The process has been used to clad metals ⅛ to 18 inches thick with coatings of 5 mils to 1 inch. The major use of this technique is expected to be in the cladding of process equipment manufactured for the chemical or petrochemical industries.

Announcement was made of another new process for electro-cladding and electro-forming refractory metals. This method utilizes molten salt electrolysis with an alkali metal fluoride electrolyte and a cathode material shaped to the contour of the required end product. Impervious, high-density coatings of molybdenum, tungsten, vanadium, zirconium, chromium, and hafnium have been clad upon electrically conductive base materials such as stainless steel, copper, beryllium, nickel, and graphite. A metallic bond is formed between the electroclad refractory metal and its substrate, thus reducing the temperature differential between the substrate and cladding, and attending differential thermal stresses. The process can be used to coat a material with a refractory metal as thin as 3 to 5 mils, thus extending its service in severe environments. Coherent coatings up to ¼ inch thick have been prepared. If a hollow shell of the refractory metal is required, the cathode mandrel can be separated from the electro-deposited refractory metal article either mechanically or by leaching. The mechanical properties of the electro-formed deposits are claimed to equal or exceed those made from electron beam-melted materials. Possible uses for the cladding process includes the making of jet engine parts, heat-resistant leading edges, reactor control rods, thermionic emitters, and rocket nozzles.

NEW MACHINING METHODS

The traditional method for shaping or smoothing metal parts until the early 1950's was moving a sharp tool over the surface with a force higher than the shear strength of the work article. With the advent of titanium and the entire family of reactive refractory metals and alloys, the machinist was faced with an ever increasing number of strange materials that were tough, hard, and expensive to machine. Metal removal by nontraditional methods became the subject of increased research and development, and now standard machining is supplemented by a number of processes, some of which were mere laboratory curiosities a decade ago. Spark machining utilizes electrical capacitors discharging across a very short working gap (usually less than 0.001 inch) to vaporize a small quantity of metal from the cutting area. The volatilized metal is caught in a spray of cutting oil and swept away from the working area. Although individual discharges remove only tiny portions of materials, they can be applied 500,000 times per second and thus comprise an effective machining tool.

Another method of machining by vaporizing metal employs a focused beam of electrons. This method has the disadvantage that all work must be performed in a vacuum. It is best suited for intricate miniaturized work, and probably cannot be adapted to mass production of large items. Power densities of about 10 billion watts per square centimeter can be delivered to very small areas at the work face. Bursts of power 1 millionth of a second in duration can be used to drill holes as small as 0.0005 inch diameter and to mill slots as small as 0.001 inch wide in almost any material. Holes up to 0.05 inch diameter can be drilled almost instantaneously in materials up to the same thickness.

The laser, an ingenious device for converting electrical energy into an intense beam of monochromatic light, has been employed for machining on a laboratory basis. Widespread use of this tool is dependent upon the development of more powerful, more efficient, and cheaper laser devices.

Plasma arcs operate at energy densities far lower than laser or electron beams, but they can provide heating rates 10 times that of oxy-acetylene torches and create arc temperatures of 6,000° to 20,000° C. The plasma arc has been used experimentally on many metals and has shown a capability for cutting thick materials.

Ultrasonic machining is another unique method that has been tested for more than a decade. It is now widely used for such different materials as metals, carbides, glass, quartz, and plastics. This method employs high frequency mechanical vibration generated by a magnetostriction oscillator. The tool transmits the energy to small abrasive particles which effect the cutting. Symmetrical as well as irregular shaped holes ranging from 0.001 inch to 3.5 inches in diameter have been drilled to depths of 5 inches with such a device.

Chemical milling has been used for several years by the aircraft industry. Essentially this is controlled corrosion. Portions of the metal which are to be left untouched are masked with a material impervious to a solvent (acid or strong base), while the areas to be milled are left uncovered. Immersion in a suitable solvent for a predetermined time will produce etching or selective milling.

A new method, electrochemical machining (ECM), recently has been developed. For ECM the (anode) workpiece (any electrically conducting material to be modified) is connected to the positive terminal of a direct current source. The cathode is a tool or pattern of conductive material having the three-dimensional contour of the desired shape. A suitable conducting solution (electrolyte) is flowed over the surface of the anode to sweep away the metal atoms released by electrolysis. The effective gap between the tool and the workpiece must be maintained between 0.001 and 0.02 inch. Penetration rates as high as 0.25 inch per minute have been achieved when machining iron, but rates of 0.125 inch per minute are more practical for refractory metals. ECM has been tested extensively for shaping, cavity sinking, and hole drilling, and to lesser extent for broaching, turning, and cut off. Round holes are made most easily. However, the best use of ECM apparently is for forming irregular holes. Once a tool is developed, it can be reused indefinitely without need to compensate for wear—because there is none. Thus, each part that is produced by ECM will duplicate exactly the previous one. Cost savings are reported resulting from a reduction of machining time, tool replacements, and elimination of secondary deburring and polishing operations.

MAGNETIC PULSE FORMING

One of the newer methods developed for use in space technology and now being adapted to commercial operations is magnetic pulse forming. This process, whereby metal parts are shaped in split seconds without physical contact of any kind, is based upon the ability of certain materials to withstand momentary stresses well above their static fracturing stress when subjected to an impulsive load. In magnetic forming, as in most types of really high energy-rate forming, the metal undergoes severe plastic deformation. This presumably is caused mainly by shear mechanisms that result in grain boundary distortion, slip, and shock twisting.

By storing electrical energy equivalent to 5–10,000 ft. lbs. in banks of electrical capacitors and then, by means of special switches, dumping this energy into an induction coil in less than 100-millionths of a second, an intense magnetic field is set up which forces metal to expand or contract against dies.

Magnetic forming of small parts can achieve high production rates with precise controllability and reproducibility. It is highly reliable for forming aluminum, brass, copper, steel, tungsten, molybdenum, and other conductive metals. Even metals with one-tenth the conductivity of copper respond instantaneously to magnetic fields when plated with copper or wrapped in a "driver" sheet of soft copper or aluminum. Initial applications of this technique have been in assembling, blanking, swaging, shaping, and bulging of electrically conductive metals, chiefly copper and aluminum. The swaging of electrical connectors on electrical cables, sleeves on tubes, and tubes within tubes are quite adaptable to magnetic forming. Remote locking of various items located in hazardous areas, or locations where later accessibility is not desired, are two of the specialized applications visualized.

FUEL CELLS

Fuel cells, devices which produce electrical energy from chemical energy, continued to draw much attention although their full scale use is not expected in the near future. Development of small experimental cells designed for a specific purpose is the aim of most laboratories working on the subject. Impetus is given to the research by requirements of the aerospace program for a lightweight, compact, steady sources of low-voltage electricity to power many of the experimental apparatus being sent into space. To date, research and development programs have yielded five major types of fuel cells.

Hydrogen-oxygen fuel cells are the simplest and most advanced. They operate in a moderate temperature and utilize either acid or alkaline electrolytes. Nickel or carbon electrodes of controlled porosity are employed to get a large effective reaction area. A typical cell consists of two porous electrodes separated by an electrolyte. Hydrogen is supplied to one electrode and diffuses through it. On the anode surface, hydrogen reacts with the electrolyte, giving up electrons to the electrode and ions to the electrolyte. The hydrogen ions migrate through the electrolyte to the surface of the other electrode. There they form water by combining with electrons that have traveled the external circuit and with oxygen diffused through the electrode. Current densities obtained are on the order of 50 to 500 amperes per square foot of electrode, and operating voltages are 0.5 to 0.9 volt per cell.

Numerous types of hydrogen-oxygen cells have been developed. One high-temperature system contains an electrolyte of molten sodium and lithium carbonates mixed in magnesium oxide. The cathode is a thin film of silver paint, and the anode is a foil strip of palladium-silver alloy. Hydrogen serves as the fuel, and the cell operating temperature is 930° F. Single experimental cells have produced a constant output of about 12 watts per square foot for more than 4,000 hours. The largest fuel-cell setup tested in 1963 was a sodium-amalgam system using sodium as fuel and sodium hydroxide as electrolyte. It produced electricity at the rate of 75 amperes per square foot. The Navy awarded a contract to build a 200 kilowatt unit employing a nickel-boride electrode rather than expensive platinum or palladium electrodes. Laboratory test cells using a porous nickel-boride anode were successfully run for 4,500 hours using hydrazine and oxygen as the fuel in an acid electrolyte.

Redox fuel cells are a type of hydrogen-oxygen cells, but differ in that the fuel and oxidant consumed in the overall reaction are not reacted at the electrodes. A membrane between the electrodes physically separates two electrolyte solutions. Intermediate reactions take place on each side of this membrane; a reaction between the gasified fuel and a liquid electrolyte on one side (reduction) and between air and a liquid electrolyte on the other (oxidation). The liquid electrolyte contacts both the solid electrodes and the membrane permitting ions to move readily. Electrical and material balance in the system is maintained by the migration of hydrogen ions across the separating membrane.

Another type of cell, hydrocarbon fuel cells usually operate above 500° C with molten carbonates as the electrolyte held in a sponge-like matrix of magnesium oxide. Metallic electrodes are in direct contact with the "solid" electrolyte matrix. The usual fuel is a hydrocarbon such as gasoline that is cracked inside the cell to produce hydrogen and carbon monoxide. These gases are diffused into the cell at one electrode and react with ions in the molten carbonate to form water and carbon dioxide while releasing electrons to the electrode. Pure oxygen or oxygen from the air picks up the electrons at the other electrode to produce ions that migrate through the electrolyte to complete the circuit.

Ion-exchange membrane fuel cells contain a conducting plastic membrane which substitutes for the normal liquid phase electrolytes. Hydrogen and air enter chambers on opposite sides of the ion-permeable membrane, and penetrate the porous electrode to contact the surfaces of the membrane. On the hydrogen side, the electrons are given up, collected in the electrode, and conducted to the load. The hydrogen ions travel through the solid electrolyte to the other surface of the membrane where they combine with the returning electrons in the presence of oxygen, resulting in the formation of water and the release of useful energy. The water is removed as formed.

Biological fuel-cell systems in which a life process is part of the overall conversion of chemical energy to electricity are being investi-

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gated. A bio-system involving hydrolysis of urea to ammonia and the use of bacteria instead of enzymes as the biological catalyst has produced about 3 amperes per square foot while operating at 120° F and at a *p*H of 9. Biological fuel cells in spacecraft may someday serve to decompose human wastes while generating part of the waste disposal system's power needs.

The principal application for fuel cells is likely to be in uses involving propulsion or motion. The cells are at least twice as efficient as internal combustion engines and offer advantages leading to high torque at low speeds, minimum air-pollution, and near-zero fuel consumption when idling. NASA chose a hydrogen-oxygen fuel cell for use in the Apollo project. The cell is to weigh half a ton, which is only 1/6 the weight of silver-zinc batteries capable of delivering the same amount of energy.

Future roles for the fuel cell may include the generation of energy for normal industrial applications. It was estimated that to produce 5-mil electric power a fuel cell must not cost more than $150 per kilowatt installed and must operate at about 50 percent efficiency. At present, high-temperature cells fueled by hydrogen and carbon monoxide cost about $3,000 to $15,000 per kilowatt.

TAPE BATTERY

Late in the year research efforts on a new power packaging concept were revealed by Monsanto Research Corp. Development studies aimed toward producing a dry tape fuel cell were sponsored by the Space Power Program of NASA. This hybrid between a conventional battery and a fuel cell is based on the concept of a porous tape to which anodic material is applied on one side and cathodic material on the other. Electrolyte is added just before the tape is fed through two current collectors. This method avoids the loss of charge during storage and may make possible the use of normally incompatible chemicals. Initial research yielded a wet-tape fuel cell based upon the power system silver peroxide, silver, zinc, and potassium hydroxide. The basis of the pseudo-battery is the passing of two tapes through a pair of electrodes, one zinc and one silver. One of the tapes is wetted by a saturated solution of potassium hydroxide and the other is coated with silver peroxide. The passing of these two tapes through and in contact with the electrodes results in the electric current. Further research is planned to expand the technology and applications.

NEW ALLOYS

Each year about 50 new alloys are developed and are touted by their producers. Most of them fail to replace established competitive materials. In 1963, at least four of the new alloys showed promise enough to create expectations of expanded use.

A platinum-cobalt permanent magnet alloy was developed during the year which unlike most permanent magnet alloys was ductile and could be fabricated into rod and fine wire for applications where magnet design is restricted to a small length-to-diameter ratio (2:1 or less). The alloy containing 50 percent platinum and 50 percent cobalt, by atomic weight, possessed a high coercive force (over 4,000 oersteds) and a high energy product. Developed by the Hamilton Watch Co., the alloy was used in permanent magnets for miniature relays, field bucking and focusing magnets, for x-band helix traveling-wave tubes, and gyro torque magnets. Both the relay and syncon communication satellites contained two traveling-wave tubes each of which used platinum-cobalt magnets to supply the magnetic field required for collimating the electron beam. The high platinum content of this alloy makes it highly resistant to corrosion. Other uses have been in medical research where magnets are employed in contact with body fluids.

Lockalloy, a beryllium-base alloy containing 10 to 40 percent aluminum, was announced by Lockheed Missiles and Space Co. in conjunction with The Dow Chemical Co. and The Beryllium Corp. Properties of the new alloy make it attractive for structural applications, and weight savings up to 35 percent over standard aluminum alloys can be achieved. It is easier to form than unalloyed beryllium. Sheet at room temperature has a modulus of elasticity of 28 to 33 million psi, depending on composition and temper; extrusions have a modulus of 33 to 36 million psi. At 800° F the values for both sheet and extruded shapes drop to only 26 million psi. The material exhibits good ductility with a bend angle of 50 to 90 degrees. It has a potential for use in construction members of the upper stages of space vehicles, aircraft brakes, gyro cages, and computer memory drums.

Another alloy designed to save weight in aerospace structures was La 141 X, developed by Brooks and Perkins, Inc. of Detroit, Mich. The alloy comprises a magnesium base containing about 15 percent lithium and minute amounts of copper, nickel, and other metals. It has a specific gravity of 1.35 as compared with 1.8 for otherwise similar light-metal alloys, thus affording a weight savings of 25 percent. The melting point is about 1,075° F. Use of the alloy to date has been limited to parabolid reflectors, telephone and electronic equipment casings, panels, and other components.

A high-temperature alloy developed by General Electric Co. during the year (G.E. 473) was a tantalum-base material containing 2.5 percent rhenium and 9 percent tungsten. The alloy, after recrystallization at 2,900° F for 30 minutes, has an ultimate strength of 176,800 psi at −320° F, 107,500 psi at 70° F, 30,600 psi at 2,500° F and 14,000 psi at 3,500° F, with yield strengths decreasing from 152,600 to 10,900 psi over the same temperature range. The alloy is believed to be suitable for industrial furnace heating elements, heat shields for reentry vehicles in space, and for nuclear power space probes.

MINERAL DRESSING

As in previous years, investigations in the field of mineral dressing have centered on flotation vs. magnetic roasting methods of beneficiation of iron ores, and increased use of automatic control in milling plants. Autogenous grinding remains a controversial subject with mill men, but many companies are awaiting the development of sufficient plant data before making decisions. The Anaconda Company's new installation of autogenous pebble mills in Butte, Mont., is watched most closely.

The Sixth International Mineral Processing Congress drew 750 participants to Cannes, France, May 26 to June 2. Papers were presented on laboratory techniques, plant operations, comminution, classification, hydrometallurgy processes, flotation theory and practice, and gravity concentration. The papers that created the most interest at this meeting as at smaller meetings were those on autogenous grinding, iron ore flotation, magnetic roasting and separation, and automatic control.

Recovery of scrap mica from tailings of two plants in the southeastern United States was made possible by a flotation method developed by the Bureau of Mines. Feed from the crushing and screening operations contained about 17 percent mica. About 86 percent of the contained mica was recovered in products containing about 98 percent mica. Sulfuric acid, kerosine, and coco amine acetate were the reagents employed. Currently the practicability of the method is being examined for treatment of a California mica ore.

Another flotation process developed by the Bureau of Mines was for the beneficiation of phenacite and bertrandite, beryllium-bearing minerals. Basically, the method employs a fatty acid collector aided by a flocculant to control the froth and to speed the removal of concentrate from the flotation cell. Depressants (fluorides or polyphosphates) are used to help eliminate undesired gangue minerals. High grade beryllium products were made in a continuous laboratory plant with recoveries as high as 88 percent.

A similar method was used by the Bureau to recover pollucite from pegmatitic ores. Coco amine acetate was used as collector, hydrofluoric acid as a depressant, and aluminum sulfate as a froth controller. Although pollucite is the major ore of cesium, only a few tons per year are required to satisfy the small demand for cesium and its compounds.

HYDROMETALLURGICAL PROCESSING

The lack of domestic bauxite deposits has long been the basis for research and development projects by industry and Government for the recovery of alumina from clays, anorthosite, or other abundant high aluminum materials. The Bureau of Mines has been evaluating various acid extraction processes that have been studied on pilot plant scale for the extraction of alumina from clay. Evaluations for sulfuric acid, hydrochloric acid, nitric acid, and potassium alum systems have been completed. These evaluations have been used as guidelines to the industry in their consideration of changes in alumina technology.

The Anaconda Co. has worked for several years on a method for recovering alumina from domestic clays and has obtained several patents on a hydrochloric acid leach process. In this process, the silica in the clay is left behind as an insoluble residue and mixed chlorides of aluminum and iron are dissolved in caustic. Alumina trihydrate precipitates and is calcined. The calcine is sintered with soda ash, releached, reprecipitated and recalcined. Currently, The Anaconda

Co. is producing about 5 tons of alumina per day by this method at its Columbia Falls, Mont., plant. The alumina is used in a portion of the one pot-line of the reduction plant, and the resulting aluminum is sent to normal fabrication facilities and converted into usable shapes and forms. Initial evaluation of the metal indicates no difference between it and aluminum from bauxite by the standard Bayer-Hall method. The company has not released comparative cost data.

North American Coal Corp. closed its pilot plant near Powhattan, Ohio, in which a sulfuric acid leach process was studied. Waste coal shales were calcined and leached, the solution was purified, and aluminum sulfate was precipitated following a process originally developed by Strategic Materials Corp. The ultimate aim was to dehydrate the aluminum sulfate and thermally decompose it to yield alumina and sulfur trioxide. Apparently the method proved to be uneconomic.

A method was developed by the Bureau of Mines for the recovery of rhenium. The properties of this metal, one of the world's rarest, invite attention. Of the metals only tungsten has a higher melting point than rhenium's 3,180° C. Its density of 21 grams per cubic centimeter is exceeded only by that of iridium, osmium, and platinum. Rhenium's electrical resistivity is several times that of tungsten, permitting the use of larger diameter and, consequently, stronger filaments in lamps and tubes. Mechanically, rhenium develops tensile strengths as high as 300,000 psi and it has better ductility than either tungsten or molybdenum. Mechanical properties of tungsten-rhenium and molybdenum-rhenium alloys are outstanding, especially at high temperatures. In recent years, uses have been developed for filaments in mass spectrographs and ion gauges, in magnets for cryogenic conditions, in electrical contacts and resistance heaters, in thermocouples, welding rods and catalysts.

A concentrate of molybdenite obtained from certain copper ores is the principal known source of rhenium. Common industrial practice is to roast the concentrate in air at about 650° C to convert the molybdenum sulfide to the oxide. The rhenium present is oxidized, sublimed at about 350° C, and ultimately collected in the roaster flue dust. The Bureau process involves water leaching of the flue dust, concentration by solvent-extraction techniques and electrodeposition to recover rhenium as metallic flakes containing only 0.1 percent molybdenum and traces of other impurities.

JET SMELTING

The drive of the iron and steel industry for greater efficiency in production has been extremely successful. During the past 20 years, the capacity of blast furnaces has been increased 50 percent and the goal is to gain an equivalent increase within another decade. Upgraded, presintered feed is used industry wide. The Bureau of Mines method of utilizing prereduced pellets is receiving serious consideration. Fuel injection at the tuyeres and enrichment of the blast with oxygen shows both increased capacity and a decrease in the amount of coke required. The trend continues toward basic oxygen refining of the blast furnace product into steel. Presently the installed basic oxygen steel capacity in the United States is about 10 million tons. Almost twice that amount is being constructed or is in the planning stage.

This success of traditional iron and steel making research and development has temporarily greatly reduced the effort to develop so called direct reduction iron processes. Recently, however, the Ontario Research Foundation, Toronto, Canada, reported that after 8 years of development its "jet smelting" process is reaching the point of commercial feasibility. Recent research and improved furnace design indicate fuel requirements far less than previously estimated. One ton of iron may now be produced with 35,000 to 40,000 cubic feet of gas. Jet smelting is a method for producing molten iron directly from fine ore in one step using natural gas as fuel. The basic idea in the process is that very high temperatures and excess rich reducing gas will create a sufficiently fast reduction rate of small particles to accomplish reduction and smelting in a relatively short time and distance. Although this procedure requires a large excess of gas over the theoretical requirements, the waste heat available can be used to provide energy for making the oxygen used in the process; to preheat the fuel, oxygen, and feed; and, if necessary, to prereduce the feed.

An important feature of the O.R.F. jet smelter is the special burner. The inner primary jet combustion chamber burns a stoichiometric mixture of oxygen and natural gas. The result is a higher rate of heat release than that obtained in an ordinary open burner. The combustion products are discharged at a high velocity to react with excess natural gas introduced into the secondary burner chamber to yield a reducing gas that is high in hydrogen and carbon monoxide and low in carbon dioxide and water.

Fine magnetite ore fed through the primary chamber is rapidly heated to high temperature by the oxidizing flame. The hot ore promotes cracking of the secondary gas and is rapidly reduced by the concurrent flow of hot reducing gas. The high velocity stream of reduced iron particles impinges on the previously established bath of molten iron in the furnace hearth. Lime and carbon may be introduced with the feed ore added directly to the bath. The bath is maintained at a high carbon level allowing final reduction to take place in the slag layer. In addition, the high carbon bath permits a lower furnace temperature, thus establishing less severe operating conditions to be withstood by the refractory lining. When sufficient ore has been reduced to iron to raise the bath to a predetermined depth, part of the iron is tapped.

O.R.F. maintains that jet smelting lends itself to small-scale operations—as small as 25 tons per day. It, therefore, may make possible the exploitation of small ore bodies or permit foundries to operate their own iron ore reduction plants. In spite of the improved fuel requirement, there remain two prerequisites—a high grade feed and a plentiful supply of cheap natural gas.

Review of Mining Technology

By James E. Hill[1]

TECHNOLOGY is best nurtured by a sympathetic climate that is a composite of many factors. Necessity is a highly motivating factor, as illustrated by the abnormal surge of technologic development during wartime. Other factors include appropriate timing, economic pressures, available personnel, and in some instances, legislative action. Problems of recent concern to mining technology have been the quality and quantity of available technical personnel and the possibilities of restrictive legislation.

The quality and quantity of technically trained personnel may be inadequate to meet the rapidly increasing complexity of modern technology coupled with the growing demand for qualified personnel. The question of appropriate training was a subject for debate.[2] The curriculum and methods of teaching have changed. Questions have been raised on the relationship of scientist and engineer, interdisciplinary versus specialized curriculum, undergraduate versus graduate training, and the place of the smaller schools versus the large university-research complexes that have developed at some universities. Various aspects of the subject of engineering education for the mining industry were discussed at the meeting on Mining and Mineral Engineering Manpower at the Michigan College of Mining and Technology, November 18–19, 1963. Meanwhile, the trend toward interdisciplinary training gathers momentum as illustrated by the establishment of the School of Engineering Science at Johns Hopkins, the Schools of Engineering and Applied Science at Columbia, Princeton, and Yale, the Division of Engineering and Applied Physics at Harvard and, more recently, the School of Engineering Science at Florida State University which cuts across the conventional areas of civil, mechanical, electrical, and chemical engineering.

Legislative action is another peripheral activity that may affect the climate for technological development. While such action is usually considered restrictive, it may also be promotional because it frequently forces consideration of improved methods or new concepts to comply

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[1] Mining engineer, Office of the Director of Mining Research.

[2] Allison, David E. Educating the Engineer. Internat. Sci. and Technol., No. 18, June 1963, pp. 26–38.

Huggins, William A., George S. Benton, George Nemhauser, and Sheldon K. Friedlander. Design for Learning. Johns Hopkins Mag., v. 14, No. 6, March–April 1963, pp. 33–37, 46–49.

Ragland, Douglas. The Great Engineering Implosion. Min. Eng., v. 15, No. 1, January 1963, pp. 48–52.

Seaborg, Glenn T. Education and the Engineer. Atomic Energy Commission Press Release S–39–63, Dec. 9, 1963, 11 pp.

with a specific legislative requirement. Recently, the mining industry has been concerned with zoning and land use regulations instituted by local, State, and Federal governments. Proposed regulations pertaining to air and water pollution were of direct concern to many mining operations. Mining technology would be affected to some extent by the proposed extension of Federal mine safety responsibilities.

EXPLORATION AND SAMPLING

Based on Canadian experience, it was estimated from a statistical average that the expenditure normally required to find a mine was $7.5 million. This assumed the general exploration sequence of preliminary geological and photogeological study of a district followed by an airborne geophysical survey, then ground geophysical surveys and drilling of the anomalies indicated by the airborne survey.[3] One way to improve the statistical probability of discovery is by geological discrimination in the selection of districts within which to concentrate an exploration effort. Systematic sorting with data processing equipment to indicate the frequency of possible ore control features within a district was tried on the northern end of the Colorado Mineral Belt.[4] Using location, strike, dip, and production as the input data to determine frequencies by data processing methods, the exercise indicated some correlations that could guide selective exploration efforts. The St. Joseph Lead Co., Bonne Terre, Mo., inaugurated a card system for automatic data processing of essential engineering and geologic data.[5] Four cards were used to record exploration data: A master mineralization card, a detail mineralization card, a general hole record card, and a core recovery card. In addition to current use for ore reserve calculations and engineering control, the cards were designed with future research potential in mind. The possibility of statistical analysis as a guide to future ore search was an important research potential. Geologists continued to devise a system for the classification of ore deposits that defined regional geologic settings and geologic environment favorable for mineral exploration.[6] In recent years, the concept of metallogeny has assumed major importance in the exploration planning of Soviet geologists in their search for new mineral deposits.[7] Two main types of metallogenic maps were used: (1) Complex metallogenic maps reflecting the laws of distribution and the relative time and general geologic conditions of formations of deposits of various economic minerals and (2) special forecasting metallogenic maps drawn for a single economic mineral.

A case was made for more general consideration of the induced polarization method for exploring drill holes.[8] The chief application of the method was in the direct detection of disseminated metallic

[3] Bateman, J. D. Exploration Program for Small Mining Companies. Min. Cong. J., v. 49, No. 12, December 1963, pp. 45–48.

[4] Ayler, Maynard F. Statistical Method Applied to Mineral Exploration. Min. Cong. J., v. 49, No. 11, November 1963, pp. 41–45.

[5] Cummings, Bradford. How St. Joseph Lead Processes Engineering, Geologic Data. Eng. and Min. J., v. 164, No. 3, March 1963, pp. 96–101.

[6] Pereira, J. Reflections on Ore Genesis and Exploration. Min. Mag. (London), v. 108, No. 1, January 1963, pp. 9–22.

[7] Bryner, Leonid. Metallogeny in Russia's Drive for Ore Deposits. Min. Eng., v. 15, No. 6, June 1963, pp. 59–62.

[8] Wagg, D. M., and H. O. Seigel. Induced Polarization in Drill Holes. Canadian Min. J., v. 84, No. 4, April 1963, pp. 54–59.

sulfides in quantities from 1 to 20 percent by volume. In spite of the apparent simplicity of drill-hole logging by induced polarization, the method had technical and interpretive complications. However, when its merits were weighed against its limitations and the relatively low cost in relation to the original cost of the drill hole was considered, induced polarization deserved more attention in mineral exploration.

Exploratory drilling activities, in connection with the U.S. Atomic Energy Commission's activities at the Nevada Test Site, developed several techniques of interest for mineral exploration. Modification of drilling equipment and precise control of drilling achieved full recovery and virtually undisturbed samples from near-surface layers of unconsolidated boulder-strewn alluvium.[9] A combination of oilfield and mining core drilling equipment was developed to achieve these results. Oilfield heavy drill collars, rotary stabilizers, and thick vibration-reducing drilling mud were used in combination with precise hydraulic feed control, fast bit rotation, light drilling weight, double-tube swivel core barrel, split-ring sliding core spring, and multistep kerfed bit. Side- and downhole-viewing TV cameras were developed for visual examination of boreholes.[10] The camera probe casing for both cameras was 2.5 inches in diameter.

Research by the Bureau of Mines on sampling theory continued to develop statistical mathematical theory oriented toward mineral sampling and to test possible applications of the developing theory. Computer programs were devised for several mathematical models and test applications.[11]

DEVELOPMENT

The development of a mechanical "mole" to dig through rock has been the result of persistent efforts rather than any spectacular breakthrough. Accumulated evidence indicates that machines already developed are no longer limited to very soft rock formations. A tunneling machine was used to bore more than 20,000 feet of tunnel at the Great Lakes Power Development, Poatina, Tasmania.[12] The rock is a fine-grained homogeneous sediment classed as a mudstone with hand specimens showing a compressive strength of up to 12,000 pounds per square inch. A number of tunnel records were set, including 147 feet of advance for a 3-shift working day of 24 hours, 751 feet in 6 days, and an advance of 1 mile in slightly less than 11 weeks.

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[9] Read, Vernon. Precise Controls Give Full Core Recovery. Min. Eng., v. 15, No. 8, August 1963, pp. 39–41.

[10] Short, N. M. Borehole TV Camera Gives Geologists Inside Story. Min. Eng., v. 15, No. 1, January 1963, pp. 41–47.

[11] Berkenkotter, R. D., and Scott W. Hazen, Jr. Statistical Analysis of Diamond-Drill Sample Data From the Cebolla Creek Titaniferous Iron Deposit, Gunnison County, Colo. BuMines Rept. of Inv. 6234, 1963, 58 pp.

Hazen, Scott W., Jr. Statistical Analysis of Churn-Drill and Diamond-Drill Sample Data From the San Manuel Copper Mine, Arizona. BuMines Rept. of Inv. 6216, 1963, 124 pp.

Hewlett, Richard F. A Basic Computer Program for Computing Grade and Tonnage of Ore Using Statistical and Polygonal Methods. BuMines Rept. of Inv. 6292, 1963, 20 pp.

Hewlett, Richard F. Computing Ore Reserves by the Triangular Method Using a Medium-Size Digital Computer. BuMines Rept. of Inv. 6176, 1963, 30 pp.

[12] Knight, A. W. The Mole Completes Excavation at Poatina. The Hydro-Electric Commission, Hobart, Tasmania, May 28, 1963, 3 pp.

South African Mining and Engineering Journal (Johannesburg, Republic of South Africa). Battering Ram Tunneller Sets New Records, v. 74, pt. 1, No. 3663, Apr. 19, 1963, pp. 893–894.

An average of nearly 13 feet per shift was achieved with a prototype raise-boring machine at the Mather mine of the Cleveland-Cliffs Iron Co.[13] The technique consisted of boring a 12¼-inch pilot hole upward and reaming this hole to 48-inch diameter by pulling the reaming bit down. Most of the rock formation was a hard abrasive graywacke. Successful shaft-boring operations were described in several previous Minerals Yearbooks. A recent development utilized vacuum or suction principles to remove cuttings. A rotary-drilled shaft at station U–12Q of the Atomic Energy Commission's Nevada Test Site used a turbine vacuum and fullfaced bit to sink a 64-inch diameter shaft to a depth of more than 2,100 feet.[14] Using the Gas Turbine Jet Eductor system and special casing jacks were used to run 48-inch casing down the hole, the results indicated that this method is economically feasible in reasonably dry tuff and hard rhyolite cap rock.

A unique subincline shaft system was under development at the Mufulira mine in Northern Rhodesia in preparation for mining the orebodies below the 1,650 level.[15] Planning for a shaft system began over 15 years ago and the system that evolved was expected to cover operation for the next 20 years. Three alternatives were considered: Extension of the present vertical shafts, sinking new subvertical shafts, or sinking subincline shafts. The system selected was three 34.25° subincline shafts, one for rock hoisting, one for men and rock, and one for men and materials. These were to be integrated with a crusher and conveyor transfer system to the vertical hoist system.

DRILLING

Published reports on basic drilling research indicated continued interest by the oil industry. Indentation experiments on dry rocks under confining pressure investigated the effects of tooth angle and pressure on the force required for indentation.[16] Force-per unit penetration increased approximately exponentially with increase in tooth angle and increase in confining pressure up to 10,000 pounds per square inch, beyond which it became essentially independent of confining pressure. Impluse wedge penetration tests on two plastically deforming synthetic rocks indicated that some macroscopic static phenomena may be studied with wax-sand rock models.[17]

Experiments at the Pennsylvania State University investigated the comparative action of indexed chisel blows on a fresh rock surface and on a damaged rock surface simulating actual down-hole conditions.[18] At optimum index distance, the volume of rock broken was about the same for both conditions, but the optimum index distance

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[13] Andelin, Arne J. Raise Boring at the Mather Mine. Min. Cong. J., v. 49, No. 9, September 1963, pp. 24–28.

[14] Johnson, W. H. Big Hole Development Continues. Drilling, v. 24, No. 13, October 1963, pp. 62–69.

[15] South African Mining and Engineering Journal, Johannesburg, Republic of South Africa. The Peterson Shaft System—Unique in World Mining, v. 74, pt. 2, No. 3680, Aug. 16, 1963, pp. 589–594.

[16] Gnick, P. F., and J. B. Cheatham. Indentation Experiments on Dry Rocks Under Pressure. J. Petrol. Technol., v. 15, No. 9, September 1963, pp. 1031–1039.

[17] Garner, N. E., and Carl Gatlin. Experimental Study of Crater Formation in Plastically Deforming Synthetic Rocks. J. Petrol. Technol., v. 15, No. 9, September 1963, pp. 1025–1030.

[18] Hartman, H. L. The Simulation of Percussion Drilling in the Laboratory by Indexed-Blow Studies. Soc. Petrol. Eng. J., v. 3, September 1963, pp. 214–226.

was greater on a damaged surface. Studies of drillability and drilling bits in the U.S.S.R. were reported.[19] Classification of rocks for drillability has followed traditional lines of approach. The Laboratory for Study of Rock Properties classified the rock on the basis of the intrinsic properties of hardness, compressive strength, yield point, coefficient of plasticity, modulus of elasticity, and specific work of contact.

The Panki-Moscow Laboratory of Classification of Rocks for Drillability indexed the rock on the basis of the rate of penetration under optimum drilling conditions. The bench-test results were extrapolated to field conditions by laws of similitude. Drill-bit research was concerned with the design and performance of tricone bits, the selection of diamonds, matrix technology, and diamond-waterway arrangement and development of new bit forms—one type being a paraboloid-shaped abrasion bit fitted with hexagonal rods of a hard material. Other reports in the general field of basic drilling research included a résumé of energy requirements for rock fracture,[20] results of a study of rock surface energy,[21] and rock bit tooth friction.[22]

The Bureau of Mines continued studies of rock drillability and completed a first phase on rotary drilling action with diamond bits.[23] The purpose was to establish a correlation of properties and behavior that could be developed into a universal rock-drillability index for comparison of relative drilling performance and to predict probable drilling action. Ideally, this would be determinable by relatively simple field tests. The general premise was aptly illustrated by a recently reported machinability index for metal working relating determinable physical properties to the cutting action.[24]

Publicity has centered primarily on developing methods of "big-hole" drilling for boring shafts. However, innovations continued to be introduced in drilling and recently developed methods found extended use. The reverse flush airlift drill was developed after World War II and used extensively in the Rhenish brown coal fields to bore dewatering holes.[25] Its use was extended to bore deeper holes in harder rock for mine development openings, ventilation shafts, and conventional water wells. Shafts approximately 6 feet in diameter and 1,500 feet deep were drilled as a matter of regular performance in strata consisting of sand, gravel, and boulder beds and clay and lignite seams. Other drilling advances of general interest included auger and bucket drill attachments for conventional cranes, a technique that combined percussion drilling of a blasthole with bottom chambering by jet piercing, and a "diamond drag bit" for rotary

[19] Delacour, J. Studies of Drillability and Drilling Bits in the U.S.S.R. J. Petrol. Technol., v. 15, No. 10, October 1963, pp. 1080–1086.
[20] Simon, R. Energy Balance in Rock Drilling. Soc. Petrol. Eng. J., v. 3, No. 4, December 1963, pp. 298–306.
[21] Perkins, T. K., and L. E. Bartlett. Surface Energies of Rocks Measured During Cleavage. Soc. Petrol. Eng. J., v. 3, No. 4, December 1963, pp. 307–313.
[22] Cheatham, J. B. Rock-Bit Tooth Friction Analysis. Soc. Petrol. Eng. J., v. 3, No. 4, December 1963, pp. 327–332.
[23] Paone, James, and W. E. Bruce. Drillability Studes. BuMines Rept. of Inv. 6324, 1963, 32 pp.
[24] Datsko, Joseph, and Alexander Henkin. New Insight Into Machinability Gives Shop Men Simple Index. Iron Age, v. 191, No. 23, June 6, 1963, pp. 75–78.
[25] Mining Journal (London). Development in Air Lift Drilling, v. 260, No. 6658, Mar. 29, 1963, pp. 297–299.

drilling in softer formations where maximum efficiency cannot be obtained with roller bits.[26] The blades of the bit have a stepped contour and a hard-faced cutting edge with diamonds set on the gage surface.

Aggressive experimentation and updating of drilling equipment improved quarry drilling for an operator of several stone quarries in the same vicinity.[27] Inclined drilling rehabilitated a high face at one quarry operation and improved bank characteristics at others. Changes in equipment in recent years had increased penetration in feet per hour from 1.56 to 22.3. Truck-mounted drills proved advantageous for servicing several quarries.

FRAGMENTATION

Current technology for rock fragmentation presented a paradoxical situation. Although fragmentation by explosives remained the primary means of breaking rock from the solid, research and development of mechanical mining machines tended to eliminate explosives. On the other hand, developers of peaceful uses for nuclear explosives would both fragment massive volumes of rock and remove the broken material by explosives. A technical feasibility study recommended further evaluation of the practicability, safety, and costs of conducting a series of nuclear explosions to open a 2-mile railway and highway pass through the Bristol Mountains in California.[28] A preliminary review visualized 22 nuclear detonations in series totaling 1,730 kilotons to excavate 68 million cubic yards and create a cut 2 miles long ranging in depth from 100 to 350 feet and having a bottom width of 325 feet. The report was prepared jointly by the Atomic Energy Commission, the California Division of Highways, and the Atchison-Topeka and Santa Fe Railway Co. Similar studies were proposed or in progress for the use of nuclear explosives to strip overburden and to mine by block caving.

A résumé was published on some basic standards to guide blasting design for breaking rock in quarries.[29] Starting with a discussion of the theory of rock breakage by explosives, standards for blasting design were developed taking into consideration such factors as burden, spacing, hole diameter, subdrilling, stemming, and material properties.

Blasting agents replaced dynamite in large underground mines. Following a period of testing, standard blasting procedures for ammonium nitrate-fuel oil were prescribed for Anaconda mines at Butte.[30] Special bombs of ammonium nitrate-fuel oil also were used at these mines for all secondary blasting in slusher drifts and finger raises. At the Climax Molybdenum Co. mine in Colorado, pressure loading systems to place AN-FO facilitated remote loading of large

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[26] Peters, R. I., and D. S. Rowlay. Diamond Drag Bit. Oil and Gas J., v. 61, No. 2, Jan. 14, 1963, pp. 68–72.

[27] Barton, Julian. Drilling Innovations Benefit Quarry Operator. Min. Eng., v. 15, No. 1, January 1963, pp. 34–37.

[28] Atomic Energy Commission. Preliminary Report Recommends Further Study of Concept of Using Nuclear Explosives To Excavate Railway Highway Cut. Press Release F-261, Dec. 23, 1963, 11 pp.

[29] Ash, R. L. The Mechanics of Rock Breakage. Pit and Quarry, v. 56, No. 2, August 1963, pp. 98–100 and 112; v. 56, No. 3, September 1963, pp. 118–122; v. 56, No. 4, October 1963, pp. 126–131; and v. 56, No. 5, November 1963, pp. 109–118.

[30] Mining World. AN-FO Blasting Practice at Butte Mines, v. 25, No. 11, October 1963, pp. 30–33.

charges for long-hole blasting, shooting stubs after pillars were shot, and shooting large blocks of unbroken ore in the cave.[31]

A nonelectric delay-type detonating device was developed for use with blasting agents to eliminate the hazard of static electricity.[32] Known as the Anodet Delay, it consists of a special high-strength cap crimped to a length of low-strength detonating cord. The caps were available in 0- to 30-standard delay periods.

MATERIALS HANDLING: LOADING, TRANSPORTATION, AND HOISTING

The ability of open-pit mining operations to maintain and, in some instances, lower the costs of mining during a period of generally rising costs was attributed in a large degree to improved materials handling practices. These practices were widely publicized and included some innovations but primarily consisted of increasing the size of equipment.[33] Because of space limitations, the problem of improved materials handling in underground mines cannot be solved simply by increasing the size of equipment. The underground mine operator had to search for improved efficiency of equipment and mine systems or new methods. One approach was diesel-powered equipment and combined loading-hauling units or systems. A wide range of diesel-powered loading and hauling machines was included in the Bureau of Mines list of approved equipment.[34]

Development of the White Pine Copper Co. Southwest ore body in northern Michigan used a new design of end loader in conjunction with an extendible conveyor belt to load and transport ore.[35] The end loader had a 2¾-cubic yard bottom discharge bucket to facilitate rapid conveyor belt loading. The loader trammed in reverse to the conveyor loading point. Conveyor extensions were made in 175-foot increments to coincide with crosscut intervals. In 1956, the International Minerals and Chemical Corp. potash mine near Carlsbad, N. Mex., introduced rope-suspended belt haulage. Since then, belt conveyance has been used as an extension of the rail system, but not as a replacement of main rail haulage.[36] Analysis of the two systems indicated that haulage costs are about equal. Each has inherent advantages and disadvantages which allow the combined system to benefit by utilizing advantageous qualities of both systems in the mining system. The Craigmont mine in Canada conducted a systems analysis on every available type of underground locomotive and on an a.c.-powered drive that was not available.[37] The analysis indicated that the latter was superior in every respect. An a.c.-powered locomotive

[31] Smith, A. K. Underground Applications of Ammonium Nitrate. Min. Cong. J., v. 49, No. 5, May 1963, pp. 28–33.

[32] Canadian Mining Journal. Something New in Blasting Caps, v. 84, No. 8, August 1963, pp. 62–63.

[33] Henderson, B. R. How To Boost Open-Pit Productivity. Eng. and Min. J., v. 164, No. 11, November 1963, pp. 72–88.

[34] Davis, Rogers F., Joseph J. Seman, George A. Hindman, and William E. O'Neill. Mobile Diesel-Powered Equipment for Noncoal Mines Approved by the Bureau of Mines. 1951–62. BuMines Inf. Circ. 8183, 1963, 20 pp.

[35] Garfield, L. A., and C. S. Lekowski. Development Drifting With Endloader and Extendible Belts. Min. Cong. J., v. 49, No. 11, November 1963, pp. 27–29.

[36] Johnston, C. E. Rail-Belt Haulage System at I.M.C.'s Carlsbad Operation. Min. Eng., v. 15, No. 3, March 1963, pp. 39–41.

[37] Smortchevsky, N. J. Craigmont's Underground A.C. Locomotive, First in West, Proves Superior. Eng. and Min. J., v. 164, No. 9, September 1963, pp. 90–93.

was designed and built on that basis. A cost comparison of main-line haulage costs by rail, belt, and hydraulic methods for a hypothetical coal mine showed a slight advantage for rail haulage.[38]

A new hydraulic hoist design was developed in the laboratories of Unisearch, a subsidiary of the University of New South Wales, Australia.[39] The unit introduced solids into a pressurized liquid pipeline at accurately controlled and reproducible rates over the complete range of solid-liquid ratios. The solids did not pass through a pump or valve and could have a diameter up to 75 percent of the inside diameter of the conveying pipe.

GROUND SUPPORT AND CONTROL

Determination of rock properties and measurement of underground stresses in rock were the subjects of increased research and scientific discussion in relation to ground support and control. Improved instruments and measuring techniques were developed.[40] The British tested new stress measurement instruments that used strain gages in a special design high-modulus stress plug to register strain and photoelastic measurements on disks or plugs inserted in a borehole. Overcoring was used to produce differential strain readings. Many problems remain to develop theory and to interpret research results for application to actual mine conditions and research efforts were actively directed toward those purposes.[41] Cautious application of theory to mine design coupled with stress measurements under actual mining conditions and model tests related to mining conditions developed data that were applied to mine design. Similar techniques were employed for the design of underground civil and military installations and were prompted by the growing practice of constructing large underground powerplants, missile sites, and protective installations.[42] The theoretical mechanics of rock behavior and design of underground structures were included in the agenda of the 32d Symposium on Shock, Vibration, and Associated Environment, hosted by the Defense Atomic Support Agency at Sandia Base, N. Mex. in April 1963.

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[38] Smith, F. L., and L. W. Koch. Economy of Rail, Conveyor and Hydraulic Transportation Underground. Min. Cong. J., v. 49, No. 8, August 1963, pp. 36–40.
[39] Engineering and Mining Journal. Australians Develop New Hydraulic Hoist, v. 164, No. 3, March 1963, pp. 102–103.
[40] Griswold, G. B. How To Measure Rock Pressures—New Tools. Eng. and Min. J., v. 164, No. 10, October 1963, pp. 90–95.
Hackett, P. Specimen Preparation for Rock Mechanics Research. Mine and Quarry Eng., v. 29, No. 10, October 1963, pp. 438–441.
Mining Journal (London). Measurement of In-Situ Rock Stress, v. 261, No. 6694, Dec. 6, 1963, pp. 544–545.
Morgan, Thomas A., and Louis A. Panek. A Method for Determining Stress in Rock. BuMines Rept. of Inv. 6312, 1963, 7 pp.
Obert, Leonard. An Inexpensive Triaxial Apparatus for Testing Mine Rock. BuMines Rept. of Inv. 6332, 1963, 10 pp.
[41] Barron, K., and G. E. LaRoque. Development of a Model for a Mine Structure. Canadian Min. J., Gardenval, Quebec, Canada, v. 84, No. 8, August 1963, pp. 43–50.
Cook, N. G. W. The Basic Mechanics of Rockbursts. South African Inst. Min. and Met., Johannesburg, Republic of South Africa, v. 64, No. 3, October 1963, pp. 71–81.
Holland, C. T. Pressure Arch Techniques. Mechanization, v. 27, No. 3, March 1963, pp. 45–48.
Long, A. E. Open Pit Slope Stability Research by the Bureau of Mines. Min. Cong. J., v. 49, No. 6, June 1963, pp. 68–71.
Utter, S. Determination of Stresses Around an Underground Opening, Climax Molybdenum Mine. BuMines Rept. of Inv. 6137, 1963, 26 pp.
[42] Bureau of Reclamation Research: Engineering Methods and Materials. A Water Resource Technical Publication, Res. Rept. 1, 1963, pp. 65–68.

The Bureau of Mines designed and installed precast concrete sets to evaluate their use in heavy ground.[43] A Canadian mine used prestressed steel bars as roof bolts to stabilize a steeply dipping hanging wall.[44] A 1⅛-inch diameter bar 22 feet long was grouted into a 3-inch diameter hole inclined slightly downward into the hanging wall. After the grout had set, the bar was placed under tension to a load of 50 tons with hydraulic jacks. A prestressed support system was used in a large hoist chamber at the Bancroft mine in Northern Rhodesia.[45] The system consisted of 4 main steel beams, each with 10 prestressed cables anchored in the hanging wall roof. The load imparted to the cables was transmitted to the surrounding rock, counteracting tensile stress in the roof.

The introduction of hydraulic face supports followed by the development of powered support systems brought about radical changes in European coal mining practice.[46] Experiments with longwall mining in the United States focused attention on these developments. The powered support system offered definite promise for remote automatic control of an underground mining operation.

HEALTH AND SAFETY

A report by the Secretary of the Interior in support of a proposed extension of Federal coal mine inspections to metal and nonmetal mines was submitted as required by Public Law 87–300 (75 Stat. 649). A proposed industry mine safety program was presented with comments on the Secretary's recommendations.[47] The principal point of disagreement was not on the objectives of the program but on the method of implementation. Industry spokesmen advocated promulgation of codes and enforcement on the local and State rather than the Federal level and that voluntary instead of mandatory inspections be stipulated.

Recovery attempts after the fire and explosions at Federal No. 1 mine, Grant Town, W. Va., used new sealing techniques to successfully reopen the mine.[48] Rock wool was blown into place to seal off the fire zone. The entire recovery operation was carefully planned and carried out in cooperation with company, union, State, and Federal Bureau of Mines personnel. Test work was done at the Bureau of Mines Bruceton, Pa., experimental mine, and the Bureau's fluid network analyzer was utilized to evaluate probable changes in the ventilation system that were introduced by recovery operations.

A continual hazard in many mines is the emission of methane with the possibility of ignition and explosion. Studies were made of the factors influencing emissions, the methods of monitoring the gas, and

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[43] Krempasky, G. T. Installation and Evaluation of Precast Mine Supports: A Progress Report. BuMines Rept. of Inv. 6253, 1963, 32 pp.
Krempasky, G. T., and R. C. Cowles. Design and Development of Precast Concrete Mine Supports: A Progress Report. BuMines Rept. of Inv. 6164, 1963, 50 pp.

[44] Marshall, D. Hanging-Walls Controlled at Wilroy. Canadian Min. and Met. Bull., Montreal, Quebec, Canada, v. 56, No. 612, April 1963, pp. 327–331.

[45] South African Mining and Engineering Journal (Johannesburg, Republic of South Africa). Prestressed Support at Bancroft Mine, v. 74, No. 3672, June 21, 1963, p. 145.

[46] Adcock, W. J. Hydraulic Face Supports. Colliery Guardian (London), v. 206, No. 5312, Feb. 7, 1963, pp. 173–179.

[47] Boyd, James. Mine Safety, A Proposal for Industry Action. Min. Cong. J., v. 49, No. 12, December 1963, pp. 38–41.

[48] Coal Age. Fire, Explosions, and Recovery—Federal No. 1 Mine, v. 68, No. 11, November 1963, pp. 78–95.

the possible remedial measures.[49] Progress was made in developing an automatic methane-monitoring system and in draining methane through boreholes in advance of the working face.

Several rock drill manufacturers added mufflers to their machines to reduce the noise level in mining operations. Research was conducted on the source, intensity, and abatement of rock drill noise.[50] The Consolidated Mining & Smelting Co. of Canada, Ltd., began investigations 10 years ago to alleviate noise associated with basic underground mining equipment.[51] The study resulted in the acceptance of approved practices with wide application, including automotive mufflers on vane-type blasthole diamond drills, exhaust lead-off hose on long hole percussion drills and piston-motored corehole drills, and mufflers on hand-held drills, such as airlegs and stopers.

MINING PRACTICE AND PERFORMANCE

Cold weather mining was among the subjects presented at the International Conference on Permafrost at Purdue University.[52] Criteria were given for site selection and construction of surface structures in areas of permafrost. Difficulties in underground mining resulted more from thawing, or from thawing and freezing, than from the original permafrost conditions. Low temperatures result in the freezing of drill water, explosives, and in many instances the broken rock, all of which slow down production or require costly heating of water and air supplies. Advantage can be taken of the freezing temperatures to solidify material by spraying with water as a means of ground support.

Longwall mining methods were inaugurated and proved to be successful at several mines in the United States. The United States Borax & Chemical Corp. used a longwall system to mine potash with a borer-type continuous miner.[53] The method gave a total area recovery of 92 percent and a production rate of 76 tons per total manshift. Longwall systems in U.S. coal mines used a variety of equipment. An Anderton shearer-loader mounted on an armored conveyor was used at the Sunnyside mine in Utah with Dowty Roofmaster

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[49] Brown, J. M. B. Firedamp Emission and Drainage. Colliery Guardian, London, v. 207, No. 5337, Aug. 1, 1963, pp. 158–162; v. 207, No. 5338, Aug. 8, 1963, pp. 176–183; v. 207, No. 5342, Sept. 5, 1963, pp. 306–312.

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Zellers, D. H. Developments in Methane Monitoring. Mechanization, v. 27, No. 3, March 1963, pp. 41–44.

[50] Daly, J. J. Underground Noise Abatement. Min. Cong. J., v. 49, No. 8, August 1963, pp. 71–76.

DeWoody, R. T., J. W. Chester, and William C. Miller. Noise From Pneumatic Rock Drills: Analogy Studies of Muffler Designs. BuMines Rept. of Inv. 6345, 1964, 24 pp.

Miller, William C. Noise From Pneumatic Rock Drills: Measurement and Significance. BuMines Rept. of Inv. 6165, 1963, 30 pp.

Miller, William C. Percussive Drill Noise: Problems and Answers. Eng. and Min. J., v. 164, No. 4, April 1963, pp. 85–87.

[51] Reynolds, J. W. Noise Control at the Sullivan Mine. Canadian Inst. Min., preprint for joint meeting of British Columbia Section and Sullivan Branch, Oct. 3, 1963, 4 pp.

[52] Beistline, E. H. Placer Mining in Frozen Ground. Pres. at Internat. Conf. on Permafrost, Purdue Univ., Lafayette, Ind., November 1963.

Philleo, E. S. Guides for Engineering Projects on Permafrost. Pres. at Internat. Conf. on Permafrost, Purdue Univ., Lafayette, Ind., November 1963.

Pike, A. E. Mining in Permafrost. Pres. at Internat. Conf. on Permafrost, Purdue Univ., Lafayette, Ind., November 1963.

Swingow, G. K. Tunnelling and Subsurface Installation in Permafrost. Pres. at Internat. Conf. on Permafrost, Purdue Univ., Lafayette, Ind., November 1963.

[53] Horne, J. C., and F. L. Pierson. Longwall Mining of Potash With Borer Type Continuous Miner. Min. Cong. J., v. 49, No. 7, July 1963, pp. 21–25.

self-advancing hydraulic props for roof control.[54] The method gave promise of alleviating the bump problem at this mine and showed a productivity rate of 57.6 tons per man-shift during the first quarter of 1963. The Old Ben Coal Corp. No. 21 mine used a bidirectional Eickoff shearer-loader. Two mines of the Eastern Associated Coal Corporation used Westfalia self-advancing roof supports and a bidirectional coal planer. Tons per shift was more than double that obtained with the continuous miner.[55] A résumé of current longwall practice summarized the results at 19 mines in the United States and Great Britain.[56] Seam thickness ranged from 38 to 86 inches, and production per man-shift from 30 to 75 tons (average 48 tons).

The term "concentrated mining" was applied to an experimental method of rapid stope face advance used in South African gold mines. In a well-planned experiment at the Stilfontein mine over 90 percent of the mill tonnage was drawn from 6 stoping connections contrasted with 110 stopes required by the traditional method.[57] Solving two technical problems was essential to the success of the system: First, breaking a larger volume of rock from the stope face and second, providing an efficient means of removing the larger volume of broken rock. A new fuse and ignitor cord that insured accurate timing of sequential blasting and a scraper system were the solutions applied.[58] Three methods of roof control were tried: Controlled stope caving using recoverable steel props and rubber barricades; steel props, rubber barricades, and mat pack support with no caving; and rubber barricades and mat pack support only. The system opened the way to greater productivity through better utilization of manpower, mechanical equipment, and supervision. It also appeared to relieve the stress from the working area by transmitting pressures to a zone in advance of the face.

Although solution mining has been practiced for many years, the recent development of deep salt beds and the possibilities for in situ recovery of some metals focused attention on the technology and economics of this type of mineral recovery. Application of oilfield hydraulic fracturing methods indicated that a salt field could be brought into production by this method in a few months instead of several years as normally required.[59] Trials of hydraulic fracturing by the Diamond Alkali Co. developed data for the design of a solution mining system. An excellent reference on solution mining was provided by the publication of papers presented in May 1962 at the Symposium on Salt, Cleveland, Ohio.[60]

Planning the development of the second level (2075-level) at the San Manuel copper mine in Arizona anticipated extremely heavy ground conditions and profited by experience gained in mining the

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[54] Lindsay, L. T. Longwall Progress, Sunnyside Mine. Min. Cong. J., v. 49, No. 7, July 1963, pp. 51–52.
[55] Jackson, Daniel. Second Longwall System Another Eastern Success. Coal Age, v. 68, No. 8, August 1963, pp. 54–58.
[56] Evans, M. A. Longwalling With Powered Roof Supports. Coal Age, v. 68, No. 9, September 1963, pp. 82–90.
[57] Mining Journal (London). Concentrated Mining at Stilfontein, v. 260, No. 6659, Apr. 5, 1963, pp. 313–320.
[58] Harrison, A. R. The Implications of Concentrated Mining. Optima Johannesburg, Republic of South Africa, v. 13, No. 4, December 1963, pp. 145–153.
[59] Enyedy, Gustav. Improved Hydraulic Fracturing Method Helps Speed Solution Mining of Salt. Eng. and Min. J., v. 164, No. 10, October 1963, pp. 75–79, 87.
[60] Northern Ohio Geological Society, Inc. Symposium on Salt.

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first level.[61] Various methods of support were used on the first level and extensive program of stress measurements was conducted by the Bureau of Mines. In driving over 100,000 feet of development headings on the second level, over 100,000 cubic yards of concrete was placed. A regular sequence of concrete lining repairs was established, using rock bolts, prestressed yieldable steel rings, and cement grouting, if the opening squeezed shut it was reopened and heavy yieldable steel supports were installed.

The mining industry was subjected to criticism and the growing threat of restrictive legislation with respect to water pollution and surface land damage from mining operations. Positive action was taken in an attempt to correct the conditions. A voluntary industry land reclamation policy was announced by Florida phosphate miners in 1961.[62] Mining systems were revised to provide for simultaneous mining and reclaiming. Land restoration provided such recreational areas as lake sites and golf courses and land suitable for farming and residential subdivision. A number of coal mining companies have had reclamation programs for many years.[63] In some instances, reclaimed land was turned into profitable farming operations, the new land being more productive than in its former undisturbed state. However, in areas of rough terrain, such as the mountainous parts of Kentucky, West Virginia, and Pennsylvania, pollution and land reclamation were vexing and difficult problems. The Coal Industry Advisory Committee of the Ohio River Valley Water Sanitation Commission started the compilation and distribution of case histories on acid mine water control practice to help abate the water pollution problem.

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[61] Argall, G. O., Jr. How San Manuel Used First Level Experience To Improve Second Level Mining. Min. World, v. 25, No. 8, July 1963, pp. 18–21.

[62] Excavating Engineer. Florida's Phosphate Mining Country Takes on a New Look, v. 58, No. 1, January 1964, pp. 4–9.

[63] Seastrom, P. N. United Electric Coal Companies Land-Use Program. Min. Cong. J., v. 49, No. 12, December 1963, pp. 26–28.

Technologic Trends in the Mineral Industries

(Metals and Nonmetals Except Fuels)

By Frank L. Wideman[1]

THE TREND towards larger quantities of waste in materials handled at metal and nonmetal mines (excluding fuels) continued. A gain of 10 percent from 1962 in the tonnage of waste removed in mineral operations reflects the kind of technological problems being encountered.

Technology has a major role in the mineral industry in the task of supplying raw materials obtained from resources occurring beneath the surface of the earth and used in manufacturing commodities essential to modern living. Changes in technology are often brought about by such factors as variations in economic conditions, differences in physical properties of raw material, and changes in mineralogical compositions of ore. Mining is usually begun on the richest and most accessible of known deposits, and when these are exhausted, is continued with leaner ores or with less accessible deposits that are either lying at greater depths or are more remote from markets. The increasing difficulties of extraction and depletion of reserves are offset by improvements in extraction technology, improved transportation, and exploration for new deposits. Although depletion has prevailed at many individual mines and in many districts, technology has been the means of providing for increasing demands of an expanding economy with adequate supplies of minerals despite either the changing character or decreasing grade of certain ores. This has been accomplished by various methods applicable to minerals. Among the implements of technology are utilization of lower grade or more complex refractory ores by mass mining, concentration, processing, recovery of byproducts, and mechanization. Better methods to find concealed deposits or to penetrate to greater depths also have been helpful in maintaining a supply of particular minerals.

Deposits of sufficient size that lie near the surface lend themselves to mass production by surface mining, a method dependent on moving large tonnages of material economically. Major technological changes in surface mining have been largely in equipment for loading and transporting material; types of energy used; and in techniques, equipment, and materials for breaking rock. Some advances have been

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through development of new types of equipment, others through alterations of design details. Great progress was made in loading when the steam shovel, traveling on railroad tracks, was replaced by the more mobile, crawler-mounted, revolving shovel using electrical power. Later, diesel driven machinery was placed in an important position in loading. Improvements in transportation resulted by changing from steam to electric trains and more recently, by changing to diesel or diesel-electric driven equipment having large capacities. Changes in drilling equipment, explosives, and mechanical breakage methods have helped to overcome increasing physical difficulties of operation. For various reasons, however, adoption of improvements in mining has not always been uniform. Existent equipment may have been serviceable for a long time, and expected savings may not have been sufficient to offset the high initial cost of replacements; equipment in use may have been well adapted to the size and plan of the mine; or operating conditions may not have been similar to those at the mine where the new technique was successfully applied.

Because of position, size, and physical characteristics; near-surface deposits of several minerals, notably iron and copper, have been particularly adaptable to surface mining. Production of iron ore in the United States by open-pit mining had an upward trend from 1915 to 1938 and received an impetus in the period 1939–41. From 1941 to the present, open-pit iron mining experienced a gradual uniform growth. From its first application on a large scale at the Utah Copper mine in 1907, the ratio of increase for open-cut mining was quite sharp. The decline in the ratio that occurred in 1956–59 was caused by the beginning of large-scale production from three underground mines rather than from slackening of surface mining.

Because very large deposits of iron ore lie near the surface, it is reasonable to assume that the upward trend of surface mining will continue until almost all the iron ore is produced by this method. However, surface mining of copper may slacken and eventually reverse because underground mining will become necessary with the progressively increasing depth of surface mines and the depletion of ore bodies that lie near the surface.

Material Handled.—Producers of metal and nonmetal minerals (excluding fuels) handled 2,870 million tons of ore and waste, 5 percent more than in 1962. The total tonnage of ore produced increased 3 percent, and the tonnage of waste removed increased 10 percent, resulting in a continuation of the trend of an increasing proportion of waste handling.

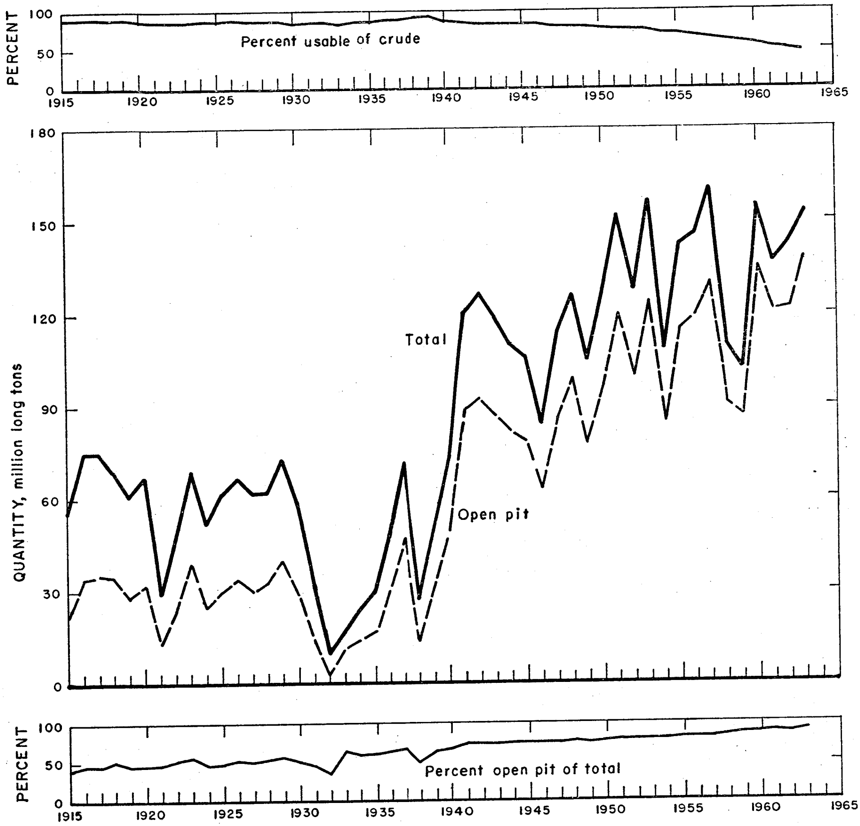

FIGURE 1.—Production of iron ore in the United States and ratio of usable ore to total ore, 1915–63.

Materials handled at metal mines totaled 900 million tons, an increase of 37.2 million tons from 1962. Ore produced was 48 percent of the total material handled, a decrease of 1 percent. Copper and iron ore accounted for 74 percent of the crude ore, unchaged from 1962, and 80 percent (79 percent in 1962) of the total material handled at metal mines. Although 7 percent more material was handled at copper mines the tonnage of ore decreased slightly, attributable to waste removal increasing sharply with the result that ore was 35 percent (38 percent in 1962) of the total material handled. Iron ore production rose and waste removal remained practically unchanged, consequently, ore represented 57 percent (55 percent in 1962) of the total output.

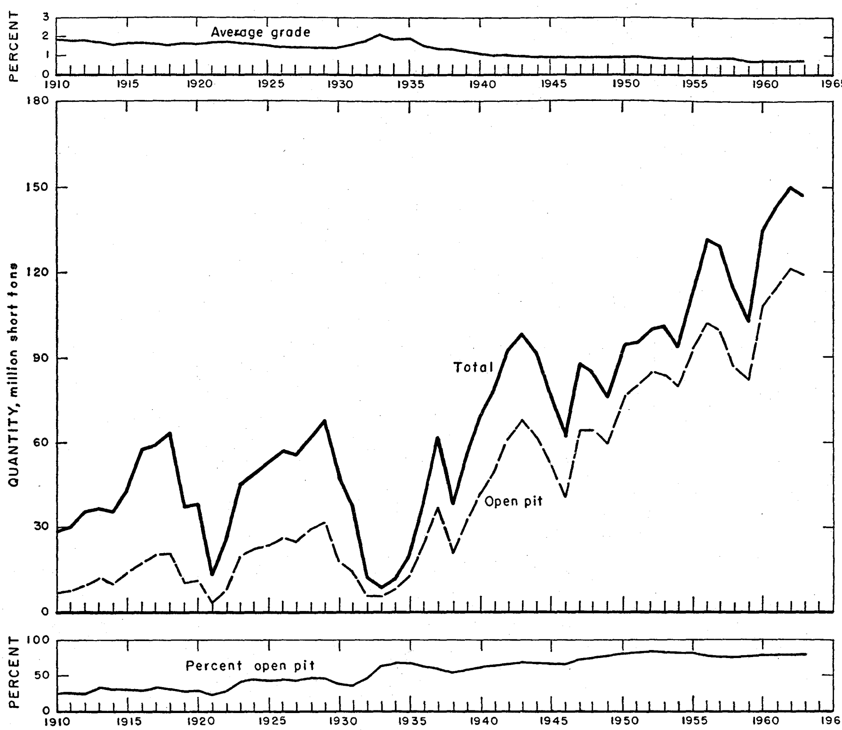

FIGURE 2.—Production of copper ore and its average grade in the United States, 1910–63.

Total output at nonmetal mines was 1,970 million tons, an increase of 94 million tons from 1962. Tonnage of materials handled at sand and gravel pits and stone quarries increased 6 percent and 3 percent, respectively. The output of these plants combined was 81 percent of total nonmetal material handled, about the same as in 1962. Waste was 13 percent (12 percent in 1962) of all material handled in mining nonmetals.

Six States—Arizona, California, Florida, Minnesota, Michigan, and Utah—again reported handling more than 100 million tons of material. Arizona remained in first place with 261 million tons (233 million tons in 1962), and California remained in second place with 243 million tons (229 million tons). Florida replaced Minnesota in third place by producing 234 million tons (203 million tons). Arizona, Florida, Minnesota, and Utah produced more than 100 million tons of material, excluding statistics for sand and gravel. The same five States as in 1962—New Mexico, Michigan, Arizona, Colorado, and Missouri—produced more than 10 million tons at underground mines.

TABLE 1.—Material handled at surface and underground mines, by commodities, in 1963

(Thousand short tons)

Commodity	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Metals:									
Bauxite	1,832	1,037	2,869	239	------	239	2,071	1,037	3,108
Beryllium concentrate	1	31	32	4	9	13	5	40	45
Copper	123,996	277,394	401,390	24,516	216	24,732	148,512	277,610	426,122
Gold:									
Lode	388	3,700	4,088	2,110	1,191	3,301	2,498	4,891	7,389
Placer	38,345	3,480	41,825	9	30	39	38,354	3,510	41,864
Iron ore	154,084	128,048	282,132	17,028	1,633	18,661	171,112	129,681	300,793
Lead	25	278	303	4,204	509	4,713	4,229	787	5,016
Manganese ore	5	1	6	9	1	10	14	2	16
Manganiferous ore	809	572	1,381	------	------	------	809	572	1,381
Mercury	80	105	185	64	1,369	1,433	144	1,474	1,618
Molybdenum	------	22	22	12,785	13	12,798	12,785	35	12,820
Nickel	1,136	344	1,480	------	------	------	1,136	344	1,480
Silver	64	142	206	573	280	853	637	422	1,059
Titanium:									
Ilmenite	21,439	7,606	29,045	------	------	------	21,439	7,606	29,045
Rutile	6,032	3,399	9,431	------	------	------	6,032	3,399	9,431
Tungsten	------	------	------	355	74	429	355	74	429
Uranium	3,495	36,517	40,012	3,942	1,043	4,985	7,437	37,560	44,997
Zinc	350	9	359	9,777	1,057	10,834	10,127	1,066	11,193
Other [1]	2,065	1	2,066	------	1	1	2,065	2	2,067
Total metals	354,146	462,686	816,832	75,615	7,426	83,041	429,761	470,112	899,873
Nonmetals:									
Abrasives [2]	138	45	183	38	------	38	176	45	221
Asbestos	1,566	2,366	3,932	59	10	69	1,625	2,376	4,001
Barite	5,903	3,801	8,984	183	2	185	6,086	3,083	9,169
Boron minerals	1,388	4,408	5,796	1	1	2	1,389	4,409	5,798
Clays	50,816	40,174	90,990	1,583	18	1,601	52,399	40,192	92,591
Feldspar	1,221	73	1,294	39	7	46	1,260	80	1,340
Fluorspar	44	62	106	456	22	478	500	84	584
Gypsum	7,790	8,844	16,634	2,780	41	2,821	10,570	8,885	19,455
Mica	798	165	963	------	------	------	798	165	963
Perlite	383	148	531	2	------	2	385	148	533
Phosphate rock	68,355	116,449	184,804	1,121	46	1,167	69,476	116,495	185,971
Potassium salts	------	------	------	16,415	605	17,020	16,415	605	17,020
Pumice	2,618	140	2,758	------	------	------	2,618	140	2,758
Pyrites	------	------	------	48	------	48	48	------	48
Salt	286	15	301	8,530	951	9,481	8,816	966	9,782
Sand and gravel	822,109	------	822,109	------	------	------	822,109	------	822,109
Sodium carbonate (natural)	------		------	1,401	------	1,401	1,401	------	1,401
Stone:									
Crushed and broken	661,264	71,852	733,116	33,259	262	33,521	694,523	72,114	766,637
Dimension	5,466	2,989	8,455	130	------	130	5,596	2,989	8,585
Sulfur:									
Frasch-process mines	5,604	------	5,604	------	------	------	5,604	------	5,604
Other mines	2	------	2	------	------	------	2	------	2
Talc, soapstone, and pyrophyllite	392	471	863	554	33	587	946	504	1,450
Vermiculite	1,209	2,747	3,956	------	------	------	1,209	2,747	3,956
Other [3]	2,544	7,349	9,893	70	30	100	2,614	7,379	9,993
Total nonmetals	1,639,896	261,378	1,901,274	66,669	2,028	68,697	1,706,565	263,406	1,969,971
Grand total	1,994,042	724,064	2,718,106	142,284	9,454	151,738	2,136,326	733,518	2,869,844

[1] Platinum-group metals, rare-earth metals and thorium and vanadium.
[2] Emery, garnet, and tripoli.
[3] Aplite, diatomite, epsomite, 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 1963

(Thousand short tons)

State	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Alabama	26,223	30,503	56,726	2,080	88	2,168	28,303	30,591	58,894
Alaska	28,809	2,410	31,219	13	28	41	28,822	2,438	31,260
Arizona	87,189	158,251	245,440	14,929	305	15,234	102,118	158,556	260,674
Arkansas	33,599	1,867	35,466	1,170	1	1,171	34,769	1,868	36,637
California	194,739	45,465	240,204	1,637	1,554	3,191	196,376	47,019	243,395
Colorado	24,193	5,483	29,676	14,518	462	14,980	38,711	5,945	44,656
Connecticut	16,236	924	17,160	5	7	12	16,241	931	17,172
Florida	123,031	110,986	234,017				123,031	110,986	234,017
Georgia	30,288	21,648	51,936	894		894	31,182	21,648	52,830
Idaho	16,329	9,336	25,665	1,463	596	2,059	17,792	9,932	27,724
Illinois	72,374	7,057	79,431	3,335	19	3,354	75,709	7,076	82,785
Indiana	44,331	3,866	48,197	1,153		1,153	45,484	3,866	49,350
Iowa	36,296	9,848	46,144	1,549		1,549	37,845	9,848	47,693
Kansas	25,297	723	26,020	2,500	28	2,528	27,797	751	28,548
Kentucky	25,453	2,301	27,754	7,053	76	7,129	32,506	2,377	34,883
Louisiana	21,478		21,478	2,475	136	2,611	23,953	136	24,089
Maine	12,224	7	12,231	7		7	12,231	7	12,238
Maryland	27,212	762	27,974	70	1	71	27,282	763	28,045
Massachusetts	25,830	104	25,934				25,830	104	25,934
Michigan	98,878	15,935	114,813	14,848	624	15,472	113,726	16,559	130,285
Minnesota	146,947	53,937	200,884	1,421	101	1,522	148,368	54,038	202,406
Mississippi	9,329	930	10,259				9,329	930	10,259
Missouri	40,760	5,026	45,786	11,679	267	11,946	52,439	5,293	57,732
Montana	28,941	2,624	31,565	3,181	97	3,278	32,122	2,721	34,843
Nebraska	15,015	1,181	16,196				15,015	1,181	16,196
Nevada	27,744	43,062	70,806	137	59	196	27,881	43,121	71,002
New Hampshire	7,897	5	7,902	6		6	7,903	5	7,908
New Jersey	30,932	2,652	33,584	1,045	158	1,203	31,977	2,810	34,787
New Mexico	19,399	14,767	34,166	19,113	978	20,091	38,512	15,745	54,257
New York	74,756	9,266	84,022	5,834	73	5,907	80,590	9,339	89,929
North Carolina	31,289	477	31,766	119	4	123	31,408	481	31,889
North Dakota	9,757	480	10,237				9,757	480	10,237
Ohio	77,955	9,340	87,295	4,406	422	4,828	82,361	9,762	92,123
Oklahoma	19,921	533	20,454	1,278		1,278	21,199	533	21,732
Oregon	38,100	587	38,687	5	3	8	38,105	590	38,695
Pennsylvania	66,640	13,480	80,120	6,766	1,138	7,904	73,406	14,618	88,024
Rhode Island	2,237	4	2,241				2,237	4	2,241
South Carolina	13,228	3,420	16,648				13,228	3,420	16,648
South Dakota	24,127	3,936	28,063	1,917	1,052	2,969	26,044	4,988	31,032
Tennessee	37,918	3,852	41,770	5,191	277	5,468	43,109	4,129	47,238
Texas	89,004	3,812	92,816	295		295	89,299	3,812	93,111
Utah	44,029	78,337	122,366	1,497	447	1,944	45,526	78,784	124,310
Vermont	5,668	1,015	6,683	191	2	193	5,859	1,017	6,876
Virginia	39,260	2,860	42,120	2,477	76	2,553	41,737	2,936	44,673
Washington	36,511	908	37,419	985	173	1,158	37,496	1,081	38,577
West Virignia	13,254	1,177	14,431	1,830	25	1,855	15,084	1,202	16,286
Wisconsin	50,186	534	50,720	885	5	890	51,071	539	51,610
Wyoming	17,535	38,090	55,625	2,327	172	2,499	19,862	38,262	58,124
Other States [1]	5,694	296	5,990				5,694	296	5,990
Total	1,994,042	724,064	2,718,106	142,284	9,454	151,738	2,136,326	733,518	2,869,844

[1] Delaware, District of Columbia, and Hawaii

TABLE 3.—Material handled at surface and underground mines (excluding sand and gravel and stone), by States, in 1963

(Thousand short tons)

State	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Alabama	6,222	26,471	32,693	1,398	--------	1,398	7,620	26,471	34,091
Alaska	11,411	2,410	13,821	13	28	41	11,424	2,438	13,862
Arizona	68,895	158,189	227,084	14,929	305	15,234	83,824	158,494	242,318
Arkansas	3,355	1,536	4,891	404	1	405	3,759	1,537	5,296
California	44,884	40,235	85,119	560	1,523	2,083	45,444	41,758	87,202
Colorado	1,255	1,507	2,762	14,502	461	14,963	15,757	1,968	17,725
Connecticut	324	137	461	5	7	12	329	144	473
Florida	83,479	109,894	193,373	--------	--------	--------	83,479	109,894	193,373
Georgia	7,639	20,752	28,391	42	--------	42	7,681	20,752	28,433
Idaho	2,717	9,336	12,053	1,463	596	2,059	4,180	9,932	14,112
Illinois	1,922	503	2,425	852	19	871	2,774	522	3,296
Indiana	1,545	415	1,960	839	--------	839	2,384	415	2,799
Iowa	2,173	4,857	7,030	170	--------	170	2,343	4,857	7,200
Kansas	892	96	988	1,016	28	1,044	1,908	124	2,032
Kentucky	1,093	573	1,666	146	6	152	1,239	579	1,818
Louisiana	3,482	--------	3,482	2,475	136	2,611	5,957	136	6,093
Maine	59	4	63	--------	--------	--------	59	4	63
Maryland	590	57	647	6	--------	6	596	57	653
Massachusetts	157	--------	157	--------	--------	--------	157	--------	157
Michigan	17,995	10,381	28,376	14,848	624	15,472	32,843	11,005	43,848
Minnesota	112,460	53,782	166,242	1,421	101	1,522	113,881	53,883	167,764
Mississippi	1,236	597	1,833	--------	--------	--------	1,236	597	1,833
Missouri	6,792	3,352	10,144	4,157	267	4,424	10,949	3,619	14,568
Montana	8,474	2,516	10,990	3,181	97	3,278	11,655	2,613	14,268
Nebraska	149	2	151	--------	--------	--------	149	2	151
Nevada	17,418	43,062	60,480	137	59	196	17,555	43,121	60,676
New Hampshire	147	--------	147	6	--------	6	153	--------	153
New Jersey	3,062	2,520	5,582	1,045	158	1,203	4,107	2,678	6,785
New Mexico	8,489	14,722	23,211	19,113	978	20,091	27,602	15,700	43,302
New York	8,717	7,743	16,460	5,775	72	5,847	14,492	7,815	22,307
North Carolina	4,373	218	4,591	119	4	123	4,492	222	4,714
North Dakota	96	480	576	--------	--------	--------	96	480	576
Ohio	4,453	1,124	5,577	2,316	422	2,738	6,769	1,546	8,315
Oklahoma	1,471	25	1,496	480	--------	480	1,951	25	1,976
Oregon	2,225	440	2,665	5	3	8	2,230	443	2,673
Pennsylvania	2,749	3,635	6,384	4,126	1,097	5,223	6,875	4,732	11,607
South Carolina	1,629	2,851	4,480	--------	--------	--------	1,629	2,851	4,480
South Dakota	495	3,865	4,360	1,917	1,052	2,969	2,412	4,917	7,329
Tennessee	5,868	2,016	7,884	4,245	277	4,522	10,113	2,293	12,406
Texas	12,119	2,462	14,581	295	--------	295	12,414	2,462	14,876
Utah	29,974	77,394	107,368	1,497	447	1,944	31,471	77,841	109,312
Vermont	849	595	1,444	116	2	118	965	597	1,562
Virginia	2,093	62	2,155	1,001	74	1,075	3,094	136	3,230
Washington	618	423	1,041	985	173	1,158	1,603	596	2,199
West Virginia	181	59	240	235	4	239	416	63	479
Wisconsin	784	--------	784	885	5	890	1,669	5	1,674
Wyoming	7,829	37,925	45,754	2,170	166	2,336	9,999	38,091	48,090
Other States [1]	364	--------	364	--------	--------	--------	364	--------	364
Total	505,203	649,223	1,154,426	108,895	9,192	118,087	614,098	658,415	1,272,513

[1] Delaware, District of Columbia, and Hawaii.

Surface Mining Versus Underground Mining.—Surface mining contributed 93 percent of the ore and 95 percent of the total material handled in 1963, both percentages were unchanged from those of 1962. Crude ore and waste handled at surface mines were 82 percent and 98 percent, respectively, of materials handled at metal mines. Nonmetal minerals and waste were 96 percent and 97 percent of the totals produced at nonmetal mines. Four commodities—molybdenum, potassium salts, pyrites, and tungsten—were produced from material entirely mined underground. Four ores—manganiferous, ilmenite and rutile, and nickel—and four nonmetal commodities—mica, pumice, sand and gravel, and vermiculite—were mined by surface methods only. Metals and nonmetals mined principally by underground methods were lode gold, lead, silver, zinc, fluorspar, salt, talc, soapstone, and pyrophyllite. States in which underground mining accounted for substantial percentages of ore production were New Mexico, 50 percent; Colorado, 37 percent; Missouri, 23 percent; and Kentucky, 20 percent.

Average Value Per Ton of Principal Mineral Products and Byproducts.—The measurement of value used in table 4 is the same as is used throughout the Minerals Yearbook. When possible, the measurement is mine output, the form in which the minerals are extracted from the ground. However, for some minerals, the value of the products from auxiliary processing is used. Values for gold, silver, copper, lead, and zinc are assigned according to average selling price of refined metal; mercury is valued at the average New York price for recoverable metal.

Value patterns remained essentially the same as in 1961 and 1962, with unit values for underground ore usually greater than those of surface products. However, unit values for ores of aluminum, copper, lead, and uranium decreased; while unit values for ores of iron, silver, and zinc increased. Changes in unit values of nonmetals were mixed, with values of sand and gravel and crushed stone remaining practically unchanged.

Byproducts continued to contribute to the value of salable products of several mineral commodities. The value of byproducts was more significant in ores of metals of which they contributed 9 percent of the total value. Byproducts enhanced the value of ores of lead 34 percent, silver 29 percent, and zinc 23 percent. Byproducts were 21 percent of the total value of mined fluorspar—the only nonmetal for which byproducts increased the value of the raw material significantly.

TABLE 4.—Value of principal mineral products and byproducts of surface and underground ores mined in the United States in 1963

(Value per ton)

Ore	Surface			Underground			All mines		
	Principal mineral product	Byproducts	Total	Principal mineral product	Byproducts	Total	Principal mineral product	Byproducts	Total
Metals:									
Bauxite	$8.33	$0.05	$8.38	$8.21		$8.21	$8.32	$0.04	$8.36
Copper	4.16	.75	4.91	7.05	$0.83	7.88	4.62	.77	5.39
Gold:									
Lode	5.51	.11	5.62	11.32	.34	11.66	10.42	.30	10.72
Placer	.18		.18	2.40		2.40	.18		.18
Iron ore	3.81		3.81	6.03	.23	6.26	4.02	.02	4.04
Lead	11.20	3.00	14.20	7.73	4.00	11.73	7.75	3.99	11.74
Manganese ore				37.22	2.89	40.11	37.22	2.89	40.11
Manganiferous ore	4.64		4.64				4.64		4.64
Mercury	31.65		31.65	32.77		32.77	32.29		32.29
Molybdenum				5.25	.06	5.31	5.25	.06	5.31
Nickel	4.72		4.72				4.72		4.72
Platinum-group metals	.40	.01	.41				.40	.01	.41
Rare-earth metals and thorium	46.00		46.00				46.00		46.00
Silver	4.43	2.60	7.03	33.61	13.90	47.51	30.68	12.77	43.45
Titanium:									
Ilmenite	.73	.25	.98				.73	.25	.98
Rutile	.21	.22	.43				.21	.22	.43
Tungsten				19.54	4.99	24.53	19.54	4.99	24.53
Uranium	19.56	.11	19.67	20.39	.16	20.55	20.04	.14	20.18
Zinc	21.22	3.65	24.87	10.32	3.32	13.64	10.70	3.33	14.03
Total	3.49	.29	3.78	8.18	1.15	9.33	4.31	.44	4.75
Nonmetals:									
Abrasive stone	85.00	2.33	87.33				85.00	2.33	87.33
Asbestos	4.30	.02	4.32	9.50		9.50	4.55	.02	4.57
Barite	1.40	.01	1.41	7.54		7.54	1.60	.01	1.61
Clays	3.34	.01	3.35	7.30		7.30	3.46	.01	3.47
Diatomite	50.72		50.72				50.72		50.72
Emery	17.00		17.00				17.00		17.00
Feldspar	3.96	.31	4.27	2.21		2.21	3.90	.30	4.20
Fluorspar	21.06	.39	21.45	17.43	5.11	22.54	17.72	4.74	22.46
Garnet	13.95		13.95				13.95		13.95
Graphite	291.00		291.00				291.00		291.00
Gypsum	3.44		3.44	4.23		4.23	3.64		3.64
Kyanite	8.11	.11	8.22				8.11	.11	8.22
Lithium minerals	7.91	.49	8.40				7.91	.49	8.40
Magnesite	3.38		3.38				3.38		3.38
Mica: Scrap	3.24	.40	3.64				3.24	.40	3.64
Olivine	16.71		16.71				16.71		16.71
Perlite	7.15		7.15	9.00		9.00	7.16		7.16
Phosphate rock	1.95		1.95	7.19		7.19	2.03		2.03
Potassium salts				6.13		6.13	6.13		6.13
Pumice	2.52		2.52				2.52		2.52
Pyrites				4.35		4.35	4.35		4.35
Salt	3.87	.72	4.59	6.34		6.43	6.34	.02	6.36
Sand and gravel	1.03		1.03				1.03		1.03
Stone:									
Crushed and broken	1.38		1.38	1.90		1.90	1.41		1.41
Dimension	16.43	.43	16.86	43.14	1.29	44.43	17.06	.45	17.51
Sulfur:									
Frasch-process mines	17.69		17.69				17.69		17.69
Other mines	7.50		7.50				7.50		7.50
Talc, soapstone, and pyrophyllite	5.01		5.01	6.58		6.58	5.93		5.93
Tripoli	4.33		4.33	4.18		4.18	4.24		4.24
Vermiculite	2.95		2.95				2.95		2.95
Other [1]	28.11	.33	28.44	13.70		13.70	21.28	.17	21.45
Total	1.48		1.48	4.66	.04	4.70	1.60	.01	1.61
Grand total	1.83	.05	1.88	6.52	.62	7.14	2.14	.09	2.23
Total nonmetal (excluding stone, sand and gravel)	3.78	.01	3.79	7.25	.07	7.32	4.41	.02	4.43
Total metals and nonmetals (excluding stone, sand and gravel)	3.58	.21	3.79	7.89	.81	8.70	4.34	.32	4.66

[1] Aplite, boron minerals, and sodium carbonate.

TABLE 5.—Crude ore and total material handled at surface and underground mines, by commodities in 1963

(Percent)

Commodity	Crude ore		Total material	
	Surface	Underground	Surface	Underground
Metals:				
Bauxite	88	12	92	8
Beryllium	20	80	71	29
Copper	83	17	94	6
Gold:				
Lode	16	84	55	45
Placer	100		100	
Iron ore	90	10	94	6
Lead	1	99	6	94
Manganese ore	36	64	38	62
Manganiferous ore	100		100	
Mercury	56	44	11	89
Molybdenum		100		100
Nickel	100		100	
Platinum-group metals	100		100	
Rare-earth metals and thorium	100		95	5
Silver	10	90	19	81
Titanium concentrate:				
Ilmenite	100		100	
Rutile	100		100	
Tungsten		100		100
Uranium	47	53	89	11
Vanadium	100		100	
Zinc	3	97	3	97
Total metals	82	18	91	9
Nonmetals:				
Abrasives:				
Emery	100		100	
Garnet	100		100	
Tripoli	42	58	58	42
Aplite	100		100	
Asbestos	96	4	98	2
Barite	97	3	98	2
Boron minerals	100		100	
Clays	97	3	98	2
Diatomite	100		100	
Epsomite	100		100	
Feldspar	97	3	97	3
Fluorspar	9	91	18	82
Graphite	100		100	
Gypsum	74	26	85	15
Kyanite	100		100	
Lithium minerals	100		100	
Magnesite	100		100	
Marl, greensand	100		100	
Mica: Scrap	100		100	
Olivine	100		100	
Perlite	99	1	100	
Phosphate rock	98	2	99	1
Potassium salts		100		100
Pumice	100		100	
Pyrites		100		100
Salt	3	97	3	97
Sand and gravel	100		100	
Sodium carbonate (natural)		100		100
Sodium sulfate (natural)	100		100	
Stone:				
Crushed and broken	95	5	96	4
Dimension	98	2	98	2
Sulfur:				
Frasch-process mines	100		100	
Other mines	100		100	
Talc, soapstone, and pyrophyllite	41	59	60	40
Vermiculite	100		100	
Wollastonite	4	96	3	97
Total nonmetals	96	4	97	3
Grand total	93	7	95	5

TABLE 6.—Crude ore and total material handled at surface and underground mines, by States, in 1963

(Percent)

State	Crude ore		Total material	
	Surface	Underground	Surface	Underground
Alabama	93	7	96	4
Alaska	100		100	
Arizona	85	15	94	6
Arkansas	97	3	97	3
California	99	1	99	1
Colorado	63	37	67	33
Connecticut	100		100	
Delaware	100		100	
District of Columbia	100		100	
Florida	100		100	
Georgia	97	3	98	2
Hawaii	100		100	
Idaho	92	8	93	7
Illinois	96	4	96	4
Indiana	98	2	98	2
Iowa	96	4	97	3
Kansas	91	9	91	9
Kentucky	78	22	80	20
Louisiana	90	10	89	11
Maine	100		100	
Maryland	100		100	
Massachusetts	100		100	
Michigan	87	13	88	12
Minnesota	99	1	99	1
Mississippi	100		100	
Missouri	77	23	79	21
Montana	90	10	91	9
Nebraska	100		100	
Nevada	100		100	
New Hampshire	100		100	
New Jersey	97	3	97	3
New Mexico	50	50	63	37
New York	93	7	94	6
North Carolina	100		100	
North Dakota	100		100	
Ohio	95	5	95	5
Oklahoma	94	6	94	6
Oregon	100		100	
Pennsylvania	91	9	91	9
Rhode Island	100		100	
South Carolina	100		100	
South Dakota	93	7	91	9
Tennessee	88	12	89	11
Texas	100		100	
Utah	97	3	99	1
Vermont	97	3	97	3
Virginia	94	6	94	6
Washington	97	3	97	3
West Virginia	88	12	89	11
Wisconsin	98	2	98	2
Wyoming	88	12	96	4
Total	93	7	95	5

TABLE 7.—Crude ore mined per unit of marketable product at surface and underground mines in the United States, by commodities in 1963

Commodity	Unit of marketable product	Surface			Underground			All mines		
		Crude ore mined (thousand short tons)	Marketable product, units	Ratio of units of crude ore mined to units of marketable product	Crude ore mined (thousand short tons)	Marketable product, units	Ratio of units of crude ore mined to units of marketable product	Crude ore mined (thousand short tons)	Marketable product, units	Ratio of units of crude ore mined to units of marketable product
Metals:										
Bauxite	Thousand long tons	1,832	1,339	1.4:1	239	185	1.3:1	2,071	1,524	1.4:1
Copper	Thousand short tons	122,941	832	148.0:1	23,076	265	87.3:1	146,017	1,097	133.4:1
Gold:										
Lode	Thousand troy ounces	386	61	6.3:1	2,107	680	3.1:1	2,493	741	3.4:1
Placer	Troy ounces	35,214	183,529	191.9:1	10	656	15.2:1	35,224	184,185	191.2:1
Iron ore	Thousand long tons	151,300	63,481	2.4:1	16,411	9,579	1.7:1	167,711	73,060	2.3:1
Lead	Thousand short tons	25	1	20.2:1	4,191	150	27.9:1	4,216	151	27.9:1
Mercury	Thousand flasks	48	8	6.0:1	64	11	5.8:1	112	19	5.9:1
Molybdenum	Thousand pounds	------	------	------	12,782	47,977	.27:1	12,782	47,977	.27:1
Nickel	Thousand short tons	1,136	13	84.8:1	------	------	------	1,136	13	84.8:1
Platinum-group metals	Thousand troy ounces	2,045	11	194.1:1	------	------	------	2,045	11	194.1:1
Rare-earths and thorium concentrates.	Thousand short tons	6	1	7.0:1	------	------	------	6	1	7.0:1
Silver	Thousand troy ounces	63	220	.29:1	565	14,849	.038:1	628	15,069	.042:1
Titanium: Ilmenite	Thousand short tons	21,415	848	25.3:1	------	------	------	21,415	848	25.3:1
Uranium ore	do	2,514	2,694	.93:1	3,434	3,251	1.1:1	5,948	5,945	1.0:1
Zinc	do	349	31	11.0:1	9,718	432	22.5:1	10,067	463	21.7:1
Nonmetals:										
Aplite	Thousand long tons	154	105	1.5:1	------	------	------	154	105	1.5:1
Asbestos	Thousand short tons	1,134	64	18.0:1	58	4	16.3:1	1,192	68	17.9:1
Barite	do	5,730	656	8.7:1	184	167	1.1:1	5,914	823	7.2:1
Boron minerals	do	1,387	520	2.7:1	1	1	1.2:1	1,388	521	2.7:1
Clays	do	50,152	47,463	1.1:1	1,578	1,575	1.0:1	51,730	49,038	1.1:1
Emery	do	7	7	1.0:1	------	------	------	7	7	1.0:1
Feldspar	Thousand long tons	1,218	484	2.5:1	39	11	3.4:1	1,257	495	2.6:1
Fluorspar	Thousand short tons	36	28	1.3:1	424	150	2.8:1	460	178	2.6:1
Garnet	do	100	13	7.6:1	------	------	------	100	13	7.6:1
Gypsum	do	7,743	7,680	1.0:1	2,721	2,708	1.0:1	10,464	10,388	1.0:1
Magnesite	do	527	527	1.0:1	------	------	------	527	527	1.0:1

Mica: scrap	Thousand short tons	788	94	8.3:1				788	94	8.3:1
Perlite	do	379	323	1.2:1	2	2	1.0:1	381	325	1.2:1
Phosphate rock	Thousand long tons	67,871	18,963	3.6:1	1,057	868	1.2:1	68,928	19,831	3.5:1
Potassium salts	Thousand short tons				16,409	2,644	6.2:1	16,409	2,644	6.2:1
Pumice	do	2,608	2,618	1.0:1				2,608	2,618	1.0:1
Pyrites	Thousand long tons				48	42	1.1:1	48	42	1.1:1
Salt	Thousand short tons	286	286	1.0:1	8,218	8,218	1.0:1	8,504	8,504	1.0:1
Sand and gravel	do	822,109	822,109	1.0:1				822,109	822,109	1.0:1
Sodium carbonate (natural)	do				1,386	807	1.7:1	1,386	807	1.7:1
Stone:										
Crushed and broken	do	650,177	647,500	1.0:1	32,493	32,912	.99:1	682,670	680,412	1.0:1
Dimension	do	5,410	2,503	2.2:1	130	41	3.2:1	5,540	2,544	2.2:1
Sulfur:										
Frasch-process mines	Thousand long tons	5,508	4,917	1.1:1				5,508	4,917	1.1:1
Other mines	do	2	2	1.2:1				2	2	1.2:1
Talc, soapstone, and pyrophyllite	Thousand short tons	386	320	1.2:1	545	487	1.1:1	931	807	1.2:1
Tripoli	do	24	24	.84:1	38	38	1.0:1	62	62	1.0:1
Vermiculite	do	1,209	226	5.3:1				1,209	226	5.3:1

TABLE 8.—Material handled per unit of marketable product at surface and underground mines in the United States, by commodities, in 1963

Commodity	Unit of marketable product	Surface			Underground			All mines		
		Total material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable product	Total material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable product	Total material handled (thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable product
Metals:										
Bauxite	Thousand long tons	2,869	1,339	2.1:1	239	185	1.3:1	3,108	1,524	2.0:1
Copper	Thousand short tons	391,089	832	470.9:1	23,282	265	88.1:1	414,371	1,097	378.5:1
Gold:										
Lode	Thousand troy ounces.	4,080	61	67.2:1	3,213	680	4.7:1	7,293	741	9.8:1
Placer	Troy ounces	38,558	183,529	210.6:1	38	656	57.9:1	38,596	184,185	209.6:1
Iron ore	Thousand long tons	275,370	63,481	4.3:1	17,932	9,579	1.9:1	293,302	73,060	4.0:1
Lead	Thousand short tons	25	1	20.6:1	4,641	150	30.9:1	4,666	151	30.9:1
Mercury	Thousand flasks	153	8	19.3:1	1,433	11	131.1:1	1,586	19	84.3:1
Molybdenum	Thousand pounds	-----	-----	-----	12,782	47,977	.27:1	12,782	47,977	.27:1
Nickel	Thousand short tons	1,480	13	110.5:1	-----	-----	-----	1,480	13	110.5:1
Platinum-group metals	Thousand troy ounces.	2,045	11	194.1:1	-----	-----	-----	2,045	11	194.1:1
Rare-earths and thorium concentrates.	Thousand short tons	6	1	7.0:1	-----	-----	-----	6	1	7.0:1
Silver	Thousand troy ounces.	163	220	.74:1	799	14,849	.054:1	962	15,069	.064:1
Titanium: Ilmenite	Thousand short tons	29,021	848	34.2:1	-----	-----	-----	29,021	848	34.2:1
Uranium ore	do	37,807	2,694	14.0:1	4,464	3,251	1.4:1	42,271	5,945	7.1:1
Zinc	do	350	31	11.0:1	10,762	432	24.9:1	11,112	463	23.9:1
Nonmetals:										
Aplite	Thousand long tons	184	105	1.8:1	-----	-----	-----	184	105	1.8:1
Asbestos	Thousand short tons	3,500	64	55.5:1	68	4	19.0:1	3,568	68	53.6:1
Barite	do	8,810	656	13.4:1	186	167	1.1:1	8,996	823	10.9:1
Boron minerals	do	5,783	520	11.1:1	2	1	2.0:1	5,785	521	11.1:1
Clays	do	90,316	47,463	1.9:1	1,596	1,575	1.0:1	91,912	49,038	1.9:1
Emery	do	7	7	1.0:1	-----	-----	-----	7	7	1.0:1
Feldspar	Thousand long tons	1,291	484	2.7:1	46	11	4.1:1	1,337	495	2.7:1

Fluorspar	Thousand short tons	92	28	3.3:1	441	150	2.9:1	533	178	3.0:1
Garnet	do	112	13	8.5:1	--------	--------	--------	112	13	8.5:1
Gypsum	do	16,579	7,680	2.2:1	2,762	2,708	1.0:1	19,341	10,388	1.9:1
Magnesite	do	1,479	527	2.8:1	--------	--------	--------	1,479	527	2.8:1
Mica: Scrap	do	953	94	10.1:1	--------	--------	--------	953	94	10.1:1
Perlite	do	522	323	1.6:1	2	2	1.0:1	524	325	1.6:1
Phosphate rock	Thousand long tons	184,320	18,963	9.7:1	1,103	868	1.3:1	185,423	19,831	9.3:1
Potassium salt	Thousand short tons	--------	--------	--------	16,896	2,644	6.4:1	16,896	2,644	6.4:1
Pumice	do	2,722	2,618	1.0:1	--------	--------	--------	2,722	2,618	1.0:1
Pyrites	Thousand long tons	--------	--------	--------	48	42	1.1:1	48	42	1.1:1
Salt	Thousand short tons	301	286	1.1:1	9,168	8,218	1.1:1	9,469	8,504	1.1:1
Sand and gravel	do	822,109	822,109	1.0:1	--------	--------	--------	822,109	822,109	1.0:1
Sodium carbonate (natural)	do	--------	--------	--------	1,386	807	1.7:1	1,386	807	1.7:1
Stone:										
Crushed and broken	do	721,555	647,500	1.1:1	32,755	32,912	1.0:1	754,310	680,412	1.1:1
Dimension	do	8,399	2,503	3.4:1	130	41	3.2:1	8,529	2,544	3.4:1
Sulfur:										
Frasch-process mines	Thousand long tons	5,508	4,917	1.1:1	--------	--------	--------	5,508	4,917	1.1:1
Other mines	do	2	2	1.2:1	--------	--------	--------	2	2	1.2:1
Talc, soapstone, and pyrophyllite.	Thousand short tons	857	320	2.7:1	577	487	1.2:1	1,434	807	1.8:1
Tripoli	do	49	28	1.7:1	38	38	1.0:1	87	66	1.3:1
Vermiculite	do	3,953	226	17.5:1	--------	--------	--------	3,953	226	17.5:1

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Magnitude of the Mining Industry.—Crude ore production was reported from 7,093 mines (6,903 in 1962)—1,449 metal (1,362) and 5,644 (5,541) nonmetal—exclusive of sand and gravel operations, which are reported in the Sand and Gravel Chapter. Output from individual mines ranged from 1 to almost 100 million tons. The increased number of metal mines that produced less than 100 tons more than offset the decrease in nonmetal mines in the same class. The number of metal mines that produced more than 10 million tons of crude ore remained unchanged, but the nonmetal mines in this class decreased by 1. A total of 7,696 mines (7,680) reported production of ore and waste—1,890 metal (1,864) and 5,806 (5,816) nonmetal. Of these, 406 metal and 120 nonmetal mines produced less than 100 tons during the year; 22 (20) metal and 7 (9) nonmetal mines produced more than 10 million tons.

TABLE 9.—Number of domestic metal and nonmetal mines in 1963, classified by commodity and magnitude of crude ore production

Commodity	Total number of mines	Less than 100 short tons	100 to 1,000 short tons	1,000 to 10,000 short tons	10,000 to 100,000 short tons	100,000 to 1,000,000 short tons	1,000,000 to 10,000,000 short tons	More than 10,000,000 short tons
Metals:								
Antimony	2	--------	2	--------	--------	--------	--------	--------
Bauxite	14	--------	--------	8	3	3	--------	--------
Beryllium	15	10	4	1	--------	--------	--------	--------
Copper	115	37	13	6	23	17	16	3
Gold:								
Lode	124	86	22	12	2	1	1	--------
Placer	216	48	54	61	35	13	4	1
Iron ore	172	2	9	19	30	78	32	2
Lead	76	38	17	13	2	5	1	--------
Manganese ore	2	--------	--------	2	--------	--------	--------	--------
Manganiferous ore	3	--------	--------	--------	1	2	--------	--------
Mercury	39	20	10	5	4	--------	--------	--------
Molybdenum	3	1	--------	1	--------	--------	--------	1
Nickel	1	--------	--------	--------	--------	--------	1	--------
Platinum-group metals	1	--------	--------	--------	--------	--------	1	--------
Silver	117	68	28	13	5	3	--------	--------
Titanium minerals	9	--------	1	--------	1	2	5	--------
Tungsten	4	2	--------	--------	1	1	--------	--------
Uranium	461	96	140	154	52	19	--------	--------
Zinc	73	1	6	14	25	25	2	--------
Other [1]	2	--------	1	--------	1	--------	--------	--------
Total metals	1,449	409	307	309	185	169	63	7
Nonmetals:								
Abrasives [2]	21	5	8	4	4	--------	--------	--------
Aplite	2	--------	--------	--------	1	1	--------	--------
Asbestos	11	--------	3	3	3	2	--------	--------
Barite	46	1	5	4	19	17	--------	--------
Boron minerals	5	2	2	--------	--------	--------	1	--------
Clays	1,270	8	82	361	680	139	--------	--------
Diatomite	14	--------	5	1	4	4	--------	--------
Feldspar	66	14	13	23	12	4	--------	--------
Fluorspar	16	6	--------	5	2	3	--------	--------
Gypsum	71	--------	--------	9	27	35	--------	--------
Marl, greensand	2	--------	1	1	--------	--------	--------	--------
Mica: Scrap	27	--------	6	4	15	2	--------	--------
Olivine	8	--------	3	4	1	--------	--------	--------
Perlite	17	2	2	6	5	2	--------	--------
Phosphate rock	44	--------	1	6	6	17	13	1
Potassium salts	7	--------	--------	--------	--------	3	4	--------
Pumice	95	4	7	39	42	3	--------	--------
Pyrites	2	--------	--------	--------	2	--------	--------	--------
Salt	23	--------	--------	3	4	15	1	--------
Sodium carbonate (natural)	2	--------	--------	--------	--------	1	1	--------
Stone:								
Crushed and broken	3,174	24	100	395	1,147	1,414	93	1
Dimension	612	45	201	261	93	12	--------	--------
Sulfur:								
Frasch-process mines	10	--------	--------	--------	--------	8	2	--------
Other mines	2	--------	2	--------	--------	--------	--------	--------
Talc, soapstone, and pyrophyllite	76	4	14	38	19	1	--------	--------
Vermiculite	7	1	1	3	2	--------	--------	--------
Wollastonite	4	--------	2	1	1	--------	--------	--------
Other [3]	10	--------	1	2	2	5	--------	--------
Total nonmetals	5,644	116	459	1,173	2,091	1,688	115	2
Grand total	7,093	525	766	1,482	2,276	1,857	178	9

[1] Rare-earth metals and thorium and tin.
[2] Emery, garnet, grinding pebbles, and tripoli.
[3] Epsomite, graphite, kyanite, lithium minerals, magnesite, and sodium sulfate (natural).

TABLE 10.—Number of domestic metal and nonmetal mines in 1963, classified by commodity and magnitude of material (ore and waste) handled

Commodity	Total number of mines	Less than 100 short tons	100 to 1,000 short tons	1,000 to 10,000 short tons	10,000 to 100,000 short tons	100,000 to 1,000,000 short tons	1,000,000 to 10,000,000 short tons	More than 10,000,000 short tons
Metals:								
Antimony	4		4					
Bauxite	14			7	4	2	1	
Beryllium	21	9	4	7	1			
Copper	159	36	39	20	23	20	6	15
Gold:								
Lode	248	108	93	42	1	2	2	
Placer	267	52	74	79	41	14	6	1
Iron ore	211	2	13	25	43	76	48	4
Lead	106	35	37	21	6	6	1	
Manganese ore	2			2				
Manganiferous ore	6			1		5		
Mercury	47	23	13	6	2	3		
Molybdenum	7		1	3	2			1
Nickel	1						1	
Platinum-group metals	1						1	
Rare-earth metals and thorium	5		3	1	1			
Silver	174	62	60	35	14	3		
Titanium minerals	9		1			3	5	
Tungsten	5	2	1		1	1		
Uranium	517	76	140	181	82	32	5	1
Zinc	84	1	9	16	30	26	2	
Other [1]	2		1	1				
Total metals	1,890	406	493	447	251	193	78	22
Nonmetals:								
Abrasives [2]	24	7	7	6	4			
Aplite	2				1	1		
Asbestos	12	1		5	2	2	2	
Barite	53	1	4	12	16	19	1	
Boron minerals	7	3	1	1	1		1	
Clays	1,293	11	84	355	661	173	9	
Diatomite	16	1	4	3	3	3	2	
Feldspar	70	14	16	22	14	4		
Fluorspar	28	2	11	9	3	3		
Gypsum	75		2	9	27	32	5	
Marl, greensand	3		1	2				
Mica	31	1	7	6	15	2		
Olivine	9		4	4	1			
Perlite	19	1	2	9	5	2		
Phosphate rock	47		2	6	6	16	11	6
Potassium salts	11			1	3	3	4	
Pumice	105	3	7	46	45	4		
Pyrites	2				2			
Salt	23			2	5	12	4	
Sodium carbonate (natural)	2					1	1	
Sodium sulfate (natural)	1			1				
Stone:								
Crushed and broken	3,231	26	114	366	1,161	1,440	123	1
Dimension	625	45	195	263	101	20	1	
Sulfur:								
Frasch-process mines	11			1		8	2	
Other mines	3		3					
Talc, soapstone, and pyrophyllite	81	3	12	38	25	3		
Vermiculite	9	1	1	5		1	1	
Wollastonite	4		2	1		1		
Others [3]	9			1	3	5		
Total nonmetals	5,806	120	479	1,174	2,104	1,755	167	7
Grand total	7,696	526	972	1,621	2,355	1,948	245	29

[1] Tin and vanadium.
[2] Emery, garnet, grinding pebbles, and tripoli.
[3] Epsomite, graphite, kyanite, lithium minerals, magnesite, and sodium sulfate (natural).

Underground Methods.—Open-stoping and caving methods continued to be used to mine almost all the ore produced underground in the United States. The percentage mined by open-stoping was almost 75 percent, 1 percent less than in 1962. Ore mined by caving was approximately 25 percent (24 percent in 1962) and that mined by other methods was less than 1 percent. All bauxite, asbestos, perlite, sodium carbonate, tripoli, and wollastonite that was mined underground came from naturally supported open stopes; all molybdenum ore was produced by a caving method of mining. Some mineral product was mined by underground methods in the same 41 States reporting production by similar methods in 1962.

TABLE 11.—Mining methods used in underground operations, by commodities

(Percent)

Commodity	Open stoping				Caving		Other and unspecified	
	Natural support		Artificial support					
	1962	1963	1962	1963	1962	1963	1962	1963
Metals:								
Bauxite	100.0	100.0	-------	-------	-------	-------	-------	-------
Copper	35.4	37.6	10.4	10.7	54.1	51.7	0.1	-------
Gold: Lode	3.0	4.7	96.3	94.6	-------	-------	.7	0.7
Iron ore	45.7	47.9	3.6	2.4	47.1	49.2	3.6	.5
Lead	78.3	81.8	20.0	17.0	-------	-------	1.7	1.2
Manganese ore	7.7	-------	92.3	100.0	-------	-------	-------	-------
Mercury	1.8	1.6	78.4	80.7	19.8	17.7	-------	-------
Molybdenum	-------	-------	-------	-------	100.0	100.0	-------	-------
Silver	1.6	1.6	98.4	96.7	-------	1.2	-------	.5
Uranium	58.1	67.1	38.5	31.2	3.4	1.7	-------	-------
Zinc	73.9	69.7	25.9	30.2	.2	-------	-------	.1
Nonmetals:								
Asbestos	100.0	100.0	-------	-------	-------	-------	-------	-------
Barite	-------	-------	98.4	81.6	-------	18.4	1.6	-------
Boron minerals	85.7	100.0	14.3	-------	-------	-------	-------	-------
Clays	96.0	91.9	3.5	7.4	.5	.3	-------	.4
Feldspar	31.1	28.2	68.9	71.8	-------	-------	-------	-------
Fluorspar	45.1	39.8	48.6	54.5	4.7	5.7	1.6	-------
Gypsum	99.3	99.5	.7	.5	-------	-------	-------	-------
Perlite	100.0	100.0	-------	-------	-------	-------	-------	-------
Phosphate rock	25.7	28.0	71.3	69.1	3.0	2.9	-------	-------
Potassium salts	96.3	94.0	-------	-------	3.7	6.0	-------	-------
Pyrites	93.7	70.8	6.3	29.2	-------	-------	-------	-------
Salt	93.6	93.9	-------	-------	-------	-------	6.4	6.1
Sodium carbonate (natural)	100.0	100.0	-------	-------	-------	-------	-------	-------
Stone:								
Crushed and broken	99.0	98.2	.3	.8	[1]	.3	.7	.7
Dimension	95.9	94.6	-------	-------	4.1	5.4	-------	-------
Talc, soapstone, and pyrophyllite	79.2	57.8	17.6	16.6	-------	3.6	3.2	22.0
Tripoli	100.0	100.0	-------	-------	-------	-------	-------	-------
Wollastonite	100.0	100.0	-------	-------	-------	-------	-------	-------
Total	65.8	65.9	9.6	8.7	23.5	24.7	1.1	.7

[1] Less than 0.05 percent.

TABLE 12.—Mining methods used in underground operations, by States

(Percent)

State	Open stoping				Caving		Other and unspecified	
	Natural support		Artificial support					
	1962	1963	1962	1963	1962	1963	1962	1963
Alabama	99.6	95.4			0.4	4.6		
Alaska	20.0	41.7	80.0	58.3				
Arizona	4.4	6.9	9.3	9.0	86.3	84.1		
Arkansas	80.6	85.9	19.1	11.3		2.8	0.3	
California	83.5	80.0	16.4	14.4	.1	.3		5.3
Colorado	9.1	4.7	8.9	7.1	82.0	88.2		
Connecticut	100.0	100.0						
Georgia	100.0	100.0						
Idaho	2.5	4.1	96.5	95.9	1.0			
Illinois	94.8	94.4	4.3	4.9	.7	.7	.2	
Indiana	100.0	100.0						
Iowa	100.0	100.0						
Kansas	100.0	100.0						
Kentucky	98.4	98.5	1.6	1.5				
Louisiana	100.0	100.0						
Maine	12.5				87.5	100.0		
Maryland	100.0	100.0						
Michigan	74.4	76.5	6.3	4.2	15.6	18.7	3.7	.6
Minnesota	12.9	9.4			81.0	90.6	6.1	
Missouri	100.0	100.0						
Montana	9.9	15.4	53.5	84.5	36.6			.1
Nevada	10.2	3.7	22.3	22.8	67.5	72.0		1.5
New Hampshire	100.0	100.0						
New Jersey	89.7	81.1	10.3	18.9				
New Mexico	85.1	88.7	11.6	6.0	3.3	5.3		
New York	89.9	89.1	.1	.2	.2	.2	9.8	10.5
North Carolina	11.2	12.6	88.8	87.4				
Ohio	99.7	99.7	.3	.3				
Oklahoma	100.0	100.0						
Oregon	100.0	100.0						
Pennsylvania	45.4	46.5	.7	.6	53.9	52.9		
South Dakota	.4	.2	99.4	99.7	.2	.1		
Tennessee	100.0	100.0						
Texas	100.0	100.0						
Utah	46.7	32.6	42.5	58.2	5.6	5.7	5.2	3.5
Vermont	89.3	82.7	5.8	9.4			4.9	7.9
Virginia	91.2	92.7	.7	.6			8.1	6.7
Washington	91.9	91.3	6.5	7.3			1.6	1.4
West Virginia	100.0	100.0						
Wisconsin	42.7	82.0			57.3	17.4		.6
Wyoming	74.8	70.3	1.9	8.2	23.3	21.5		
Total	65.8	65.9	9.6	8.7	23.5	24.7	1.1	.7

Surface Mining.—Practically all the material handled at surface mines was loaded mechanically. In metal mining, a large percentage of the ore—mercury, nickel, and uranium excepted—required drilling and blasting before loading. Most of the output came from multiple bench operations. Of the nonmetals—barite, phosphate rock, sand and gravel, dimension stone, and sulfur—were mined with little or no blasting. Barite, phosphate rock, and sand and gravel were produced predominantly from open-pit or single bench operations.

TABLE 13.—Mining methods used in open-pit mining, by commodities, in 1963

(Percent)

Commodity	Mechanical loading: Preceded by drilling and blasting	Mechanical loading: Not preceded by drilling and blasting	Other	Explanation of other
Metals:				
Bauxite	95	5		
Beryllium			100	Hand methods.
Copper	96	4		
Gold:				
Lode	50	49	1	Unspecified.
Placer		100		
Iron ore	89	11		
Manganese ore		100		
Manganiferous ore	83	17		
Mercury	35	64	1	Hand methods.
Molybdenum	100			
Nickel	10	90		
Platinum-group metals			100	
Rare-earth metals and thorium	100			
Silver	81	19		
Titanium:				
Ilmenite	89	11		
Rutile		100		
Uranium	25	74	1	
Zinc	100			
Nonmetals:				
Abrasive stone	67		33	Specified.
Aplite	34	66		
Asbestos	94	6		
Barite	9	91		
Boron minerals	97	3		
Clays	20	79	1	Hand methods.
Diatomite	7	93		
Emery	100			
Feldspar	73	21	6	Unspecified.
Fluorspar	100			
Graphite	100			
Gypsum	80	20		
Kyanite	96	4		
Lithium minerals	90	10		
Magnesite	100			
Marl, greensand		100		
Mica: Scrap	21	79		
Olivine	24	76		
Perlite	23	77		
Phosphate rock		100		
Pumice	1	99		
Sand and gravel		100		
Sodium carbonate (natural)			100	Evaporation process.
Sodium sulfate (natural)		100		
Stone:				
Crushed and broken	95	5		
Dimension	27	5	68	Hand methods, drilled or cut without blasting.
Sulfur:				
Frasch-process mines			100	
Other mines		100		
Talc, soapstone, and pyrophyllite.	65	29	6	
Vermiculite	62	38		
Total	48	51	1	

TABLE 14.—Kind of surface mining operation, by commodities, in 1963

(Percent of crude ore)

Commodity	Open pit	Single bench	Multiple bench
Metals:			
Bauxite	62	4	34
Copper	----------	----------	100
Gold: Lode	3	----------	97
Iron ore	7	2	91
Manganiferous ore	80	20	----------
Mercury	49	4	47
Nickel	----------	----------	100
Rare-earth metals and thorium	----------	100	----------
Tin	----------	----------	100
Titanium:			
Ilmenite	88	1	11
Rutile	97	----------	3
Uranium	30	14	56
Zinc	----------	----------	100
Nonmetals:			
Abrasives:			
Emery	100	----------	----------
Garnet	----------	----------	100
Tripoli	100	----------	----------
Aplite	----------	----------	100
Asbestos	2	----------	98
Barite	83	1	16
Boron	----------	----------	100
Clays	72	15	13
Diatomite	45	17	38
Epsomite	100	----------	----------
Feldspar	24	1	75
Fluorspar	2	----------	98
Gypsum	65	3	32
Kyanite	4	56	40
Lithium ores	----------	----------	100
Magnesite	----------	----------	100
Marl, greensand	23	77	----------
Mica: Scrap	97	----------	3
Olivine	71	28	1
Perlite	57	9	34
Phosphate rock	83	14	3
Pumice	59	31	10
Sand and gravel	100	----------	----------
Stone:			
Crushed and broken	55	9	36
Dimension	32	14	54
Sulfur, other than Frasch	----------	----------	100
Talc, soapstone, and pyrophyllite	31	19	50
Vermiculite	1	----------	99

TABLE 15.—Kind of surface mining operation, by States, in 1963
(Percent of crude ore)

State	Open pit	Single bench	Multiple bench
Alabama	86	3	11
Arizona	1	2	97
Arkansas	45	----------	55
California	12	9	79
Colorado	25	30	45
Connecticut	48	38	14
Delaware	----------	----------	100
District of Columbia	100	----------	----------
Florida	94	6	----------
Georgia	65	13	22
Hawaii	51	19	30
Idaho	16	1	83
Illinois	33	8	59
Indiana	36	14	50
Iowa	60	7	33
Kansas	90	3	7
Kentucky	71	10	19
Louisiana	100	----------	----------
Maine	93	4	3
Maryland	47	13	40
Massachusetts	44	13	43
Michigan	56	4	40
Minnesota	4	2	94
Mississippi	83	----------	17
Missouri	55	3	42
Montana	19	4	77
Nebraska	79	7	14
Nevada	4	2	94
New Hampshire	81	----------	19
New Jersey	48	7	45
New Mexico	12	1	87
New York	42	10	48
North Carolina	84	2	14
North Dakota	100	----------	----------
Ohio	72	9	19
Oklahoma	91	6	29
Oregon	16	35	49
Pennsylvania	52	10	38
Rhode Island	20	----------	80
South Carolina	77	1	22
South Dakota	79	2	19
Tennessee	57	14	9
Texas	71	8	21
Utah	3	----------	97
Vermont	32	3	65
Virginia	40	15	45
Washington	37	21	42
West Virginia	51	1	48
Wisconsin	58	9	33
Wyoming	27	4	69

TABLE 16.—Characteristics of certain surface mining operations in the United States for selected commodities in 1963

	Open pit depth, feet		Single bench				Multiple bench				
			Face height, feet		Bench width, feet		Average No. of faces	Face height, feet		Bench width, feet	
	Weighted average	Range	Weighted average	Range	Weighted average	Range		Weighted average	Range	Weighted average	Range
Metals:											
Copper	---	---	---	---	---	---	19	49	20–68	104	15–310
Gold: Lode	18	10–40	11	9–20	21	4–24	3	15	15	20	20
Ilmenite	37	24–52	6	6	400	400	6	37	37	150	150
Iron ore	53	3–425	31	4–75	33	10–300	6	35	15–80	558	20–1,350
Mercury	147	4–150	39	7–60	26	20–150	4	30	30	30	30
Uranium	171	6–300	5	5–10	200	200	4	31	2–50	76	12–600
Nonmetals:											
Barite	20	4–90	19	2–30	685	18–75	7	14	8–15	86	10–100
Clays	27	2–350	27	3–80	492	6–2,000	4	22	3–100	104	9–500
Feldspar	44	18–92	10	10–40	40	20–40	3	44	6–60	79	25–167
Gypsum	18	2–36	14	5–20	108	100–500	5	17	5–30	141	40–300
Mica	25	10–60	10	10	40	40	2	18	10–40	34	25–60
Perlite	8	2–75	12	12	150	150	3	19	15–20	148	35–200
Phosphate rock	32	2–50	15	4–20	139	30–200	4	37	30–40	47	15–100
Pumice	26	5–150	72	8–100	259	20–400	4	16	8–25	60	20–100
Stone:											
Crushed and broken	58	2–460	55	5–260	211	4–1,500	4	42	5–200	196	4–1,500
Dimension	56	1–200	50	3–180	361	3–1,000	5	14	3–90	101	2–450
Talc, soapstone, and pyrophyllite	31	10–50	30	8–60	63	20–200	3	14	8–35	46	10–80
Vermiculite	22	15–25	---	---	---	---	12	19	11–20	53	15–60

TABLE 17.—Exploration and development activity in the United States, by commodities

Commodity	1962		1963	
	Feet	Percent of total	Feet	Percent of total
Metals:				
Beryllium	63,214	0.4	54,316	0.4
Copper	1,235,938	7.4	1,322,502	9.7
Gold	852,673	5.0	1,007,883	7.4
Iron ore	1,182,954	7.1	866,529	6.3
Lead	1,892,547	11.3	1,203,968	8.8
Mercury	34,404	.2	34,971	.3
Molybdenum	72,212	.4	160,745	1.2
Nickel	12,875	.1	12,797	.1
Silver	748,843	4.4	102,204	.7
Titanium	16,500	.1	83,905	.6
Tungsten	950,269	5.6	69,589	.5
Uranium and vanadium	6,309,944	37.4	[1] 3,989,221	[1] 29.2
Zinc	438,857	2.6	1,562,983	11.4
Other [2]	15,120	.1	10,386	.1
Total	13,826,350	82.1	10,481,999	76,7
Nonmetals:				
Asbestos	64,711	.4	12,482	.1
Barite	39,489	.2	32,270	.2
Clays	661,805	4.0	696,346	5.1
Fluorspar	11,814	.1	13,626	.1
Gypsum	376,619	2.2	281,325	2.1
Phosphate rock	221,411	1.3	96,658	.7
Potassium salts	25,056	.1	34,396	.2
Sodium carbonate (natural)	10,810	.1	27,000	.2
Stone	1,375,626	8.1	1,812,643	13.3
Sulfur:				
Frasch-process mines	122,965	.7	115,956	.9
Talc, soapstone, and pyrophyllite	20,106	.1	14,202	.1
Other [3]	132,386	.6	40,499	.3
Total	3,062,798	17.9	3,177,403	23.3
Grand total	16,889,148	100.0	13,659,402	100.0

[1] Uranium only.
[2] Antimony, bauxite, chromite, columbium-tantalum (1962), manganese ore, manganiferous ore, platinum-group metals, and rare-earth metals and thorium.
[3] Abrasives (1963), boron minerals, diatomite, feldspar, magnesite, mica (scrap), mica (sheet) (1962), perlite, pumice, pyrites (1962), salt, tripoli (1963), vermiculite, and wollastonite.

Exploration and Development.—The downward trend in exploration and development continued in 1963 when less than 14 million feet, 81 percent of that in 1962, was reported. Footage for metals dropped from 13.8 million to 10.5 million and offset a slight rise in footage for nonmetals (3.1 million to 3.2 million). Changes in exploration and development footage in metal mining were mixed, with increases reported for copper, gold, molybdenum, titanium, and zinc; decreases were registered for iron and lead; and sharp drops were reported for silver, tungsten, and uranium. Changes in exploration for nonmetals were less pronounced with only asbestos and phosphate rock registering sharp drops. Increased exploration and development of clay, potassium salts, sodium carbonate (natural), and stone counterbalanced these decreases and smaller ones for gypsum and sulfur produced by the Frasch-process.

Five methods of drilling accounted for 11.7 million feet, which was more than 85 percent of the total footage. About three-fourths of the drilling was for metals. More than half the diamond drilling was for copper and uranium; more than a third of the churn drilling was for lead; rotary and long-hole drilling was predominantly for uranium; and percussion drilling was for zinc. Footage for drilling for stone was 57 percent of the total for nonmetals and, combined with footages for clay and gypsum, was 88 percent of the total. Exploration and development activities were reported from 44 States. States reporting the greatest footage fo exploration and development were New Mexico, Idaho, Arizona, and Colorado, in that order.

More than 98 percent of 458 million tons of ore and waste removed during exploration and development was by stripping. About 55 percent of the total material resulting from the operations was handled at metal mines; 67 percent was removed from iron ore, phosphate rock, and copper deposits. Noteworthy among new mines being developed were Mineral Park mine (copper-molybdenum) in Arizona, Palmico River mine (phosphate-rock) in North Carolina, Fletcher mine (lead) in Missouri, and New Market mine (zinc) in Tennessee.

TABLE 18.—Exploration and development activity in the United States, by methods

Method	1962					
	Metals		Nonmetals		Total	
	Feet	Percent of total	Feet	Percent of total	Feet	Percent of total
Shaft and winze sinking	21,182	0.2	4,789	0.1	25,971	0.1
Raising	268,447	1.9	15,393	.5	283,840	1.7
Tunneling	50,836	.4	11,254	.4	62,090	.4
Drifting	825,745	6.0	43,079	1.4	868,824	5.1
Crosscutting	255,243	1.8	9,827	.3	265,070	1.6
Diamond drilling	2,271,017	16.4	148,029	4.8	2,419,046	14.3
Churn drilling	316,309	2.3	87,415	2.9	403,724	2.4
Rotary drilling	2,449,140	17.7	1,741,662	56.8	4,190,802	24.8
Long-hole drilling	3,047,473	22.0	60,085	2.0	3,107,558	18.4
Percussion drilling	4,059,752	29.4	733,659	24.0	4,793,411	28.4
Trenching	32,458	.2	87,504	2.9	119,962	.7
Other	228,748	1.7	120,102	3.9	348,850	2.1
Total	13,826,350	100.0	3,062,798	100.0	16,889,148	100.0

Method	1963					
	Metals		Nonmetals		Total	
	Feet	Percent of total	Feet	Percent of total	Feet	Percent of total
Shaft and winze sinking	14,445	0.1	4,858	0.1	19,303	0.1
Raising	224,163	2.1	17,344	.5	241,507	1.8
Tunneling	38,202	.4	8,834	.2	47,036	.3
Drifting	759,508	7.2	82,879	2.6	842,387	6.2
Crosscutting	174,931	1.7	6,409	.2	181,340	1.3
Diamond drilling	1,960,927	18.7	110,385	3.4	2,071,312	15.2
Churn drilling	125,311	1.2	21,942	.6	147,253	1.1
Rotary drilling	1,640,919	15.7	1,848,944	58.8	3,489,863	25.5
Long-hole drilling	1,781,107	17.0	153,003	4.8	1,934,110	14.2
Percussion drilling	3,306,267	31.6	733,941	23.0	4,040,208	29.6
Trenching	77,999	.7	10,734	.3	88,733	.6
Other	378,220	3.6	178,130	5.5	556,350	4.1
Total	10,481,999	100.0	3,177,403	100.0	13,659,402	100.0

TABLE 19.—Exploration and development by methods and selected metals in 1963

(Feet)

Metal	Method					
	Shaft and winze sinking	Raising	Tunneling	Drifting	Crosscutting	Trenching
Beryllium	45	220	------	350	50	1,630
Copper	2,272	51,177	2,393	141,575	16,111	954
Gold	2,703	18,855	4,737	67,550	3,182	21,531
Iron ore	20	61,218	7,928	107,931	17,847	5,010
Lead	1,624	13,752	2,092	48,248	5,126	23,660
Mercury	250	688	1,350	2,483	456	444
Molybdenum	189	1,526	950	28,327	175	4,500
Nickel	------	------	------	------	------	------
Silver	1,705	8,735	3,487	19,210	4,861	15,213
Tungsten	------	4,778	1,346	5,165	857	100
Uranium	4,595	23,191	13,274	251,543	117,366	35
Zinc	1,005	39,951	530	86,651	8,900	4,252
Other [1]	37	72	115	475	------	670
Total	14,445	224,163	38,202	759,508	174,931	77,999

Metal	Method						
	Diamond drilling	Churn drilling	Rotary drilling	Long-hole drilling	Percussion drilling	Other	Total
Beryllium	10,776	------	41,095	150	------	------	54,316
Copper	620,470	20,710	445,766	9,726	11,291	57	1,322,502
Gold	97,876	8,954	38,232	68,670	673,969	1,624	1,007,883
Irone ore	223,844	11,594	42,868	25,750	75,298	287,221	866,529
Lead	208,722	45,357	22,877	14,168	755,969	62,373	1,203,968
Mercury	------	4,360	9,185	15,736	------	19	34,971
Molybdenum	105,600	------	17,340	2,138	------	------	160,745
Nickel	250	12,547	------	------	------	------	12,797
Silver	43,658	------	475	3,445	150	1,265	102,204
Tungsten	17,805	------	------	------	39,538	------	69,589
Uranium	445,671	528	1,013,580	1,559,881	559,557	------	3,989,221
Zinc	182,329	19,663	------	81,018	1,138,023	661	1,562,983
Other [1]	3,926	1,598	9,501	425	52,472	25,000	94,291
Total	1,960,927	125,311	1,640,919	1,781,107	3,306,267	378,220	10,481,999

[1] Antimony, bauxite, chromite, manganese ore, manganiferous ore, platinum-group metals, rare-earth metals and thorium, and titanium.

TABLE 20.—Exploration and development by methods and selected nonmetals in 1963

(Feet)

Nonmetal	Method					
	Shaft and winze sinking	Raising	Tunneling	Drifting	Cross-cutting	Trenching
Asbestos		350	320	1,950		236
Barite		1,322		2,904	485	100
Boron minerals		116		64		4,059
Clays		45	1,350	1,320	425	144
Fluorspar	234	1,411	25	1,500	168	
Gypsum	416	1,850		6,800		5,500
Phosphate rock		5,114		14,541	825	25
Potassium salts	3,018	200		6,700	940	
Pumice						260
Sodium carbonate (natural)				27,000		
Stone	236	4,156	4,118	16,521	2,444	290
Sulfur: Frasch-process mines						
Talc, soapstone, and pyrophyllite	954	2,650	1,250	3,399	1,122	
Other [1]		130	1,771	180		120
Total	4,858	17,344	8,834	82,879	6,409	10,734

Nonmetal	Method						
	Diamond drilling	Churn drilling	Rotary drilling	Long-hole drilling	Percussion drilling	Other	Total
Asbestos	7,096		280	2,250			12,482
Barite		5,000	8,300	5,000		9,159	32,270
Boron minerals			1,432				5,671
Clays	5,940		555,367	97,162	5,642	28,951	696,346
Fluorspar	10,100			188			13,626
Gypsum	15,844		172,376		78,529	10	281,325
Phosphate rock	1,800		66,908		5,000	2,445	96,658
Potassium salts	5,223		18,315				34,396
Pumice						3,500	3,760
Sodium carbonate (natural)							27,000
Stone	59,047	16,642	890,601	48,403	636,120	134,065	1,812,643
Sulfur: Frasch-process mines			115,956				115,956
Talc, soapstone, and pyrophyllite	3,227	300			1,300		14,202
Other [1]	2,108		19,409		7,350		31,068
Total	110,385	21,942	1,848,944	153,003	733,941	178,130	3,177,403

[1] Abrasives, diatomite, feldspar, scrap mica, perlite, salt, tripoli, vermiculite, and wollastonite.

TABLE 21.—Exploration and development by methods and States in 1963

(Feet)

State	Shaft and winze sinking	Raising	Tunneling	Drifting	Crosscutting	Trenching
Alabama						
Alaska	124	94		1,002		14,600
Arizona	1,052	47,574	2,953	95,591	17,842	3,105
Arkansas		1,322		2,904	485	30
California	1,798	7,782	4,264	17,959	4,658	5,185
Colorado	2,763	9,522	9,924	91,151	2,543	14,147
Connecticut						
Florida						
Georgia						
Idaho	1,099	15,079	685	35,636	10,350	8,416
Illinois		1,165	775	720	345	
Indiana						
Iowa						
Kansas						
Kentucky	214	246	2,000	780	48	
Louisiana			1,671			
Michigan	161	31,340		109,163	11,701	
Minnesota		2,163		5,825	1,645	
Missouri		4,878		29,339	9,475	
Montana	513	1,880	1,121	16,781	1,897	20,280
Nevada	712	690	2,980	3,141	721	19,034
New Jersey		3,490		3,789		
New Mexico	4,213	32,593	1,247	151,987	105,404	397
New York	127	17,845	4,484	23,466	951	
North Carolina	300			326		
North Dakota						
Ohio						14
Oklahoma						
Oregon	74	60	387	530		100
Pennsylvania	20	18,546	4,958	21,107	799	
South Carolina						60
South Dakota	333	13,192	100	45,042	610	80
Tennessee	1,173	4,971		31,488		
Texas						
Utah	2,998	13,485	5,132	60,644	3,761	210
Vermont	300	850	600	600	300	
Virginia	416	5,585		20,486		
Washington	50	4,043	660	16,491	2,733	3,050
Wisconsin		416		285		
Wyoming	843	2,696	3,075	56,154	5,072	25
Other States [1]	20		20			
Total	19,303	241,507	47,036	842,387	181,340	88,733

See footnote at end of table.

TABLE 21.—Exploration and development by methods and States in 1963—Continued

(Feet)

State	Diamond drilling	Churn drilling	Rotary drilling	Long-hole drilling	Percussion drilling	Other	Total
Alabama	10,355	3,365	35,080			34,934	83,734
Alaska	14,434	2,498				36	32,788
Arizona	421,564	16,803	421,082	23,051	12,534	57	1,063,208
Arkansas			3,049				7,790
California	44,264	6,240	53,325	15,036	164,990	9,717	335,218
Colorado	483,672	869	96,175	85,634	204,222	402	1,001,024
Connecticut	1,000	8,807					9,807
Florida	8,576		187,300			27,445	223,321
Georgia	1,376	5,000	198,009	105,162	220,000	7,020	536,567
Idaho	73,579		55,608	14,463	1,858,694	864	2,074,473
Illinois	12,906	9,273	79,222	2,945	23,000	1,500	131,851
Indiana	2,954	4,000	474		214,585		222,013
Iowa	5,812	480	97,644				103,936
Kansas		2,732	37,000				39,732
Kentucky			64,716		4,036		72,040
Louisiana			98,665				100,336
Michigan	93,222		234,874	26,156			506,617
Minnesota	102,521	10,520	77,976	900	75,035	252,286	528,871
Missouri	183,181	48,601	11,599			71,495	358,568
Montana	2,515		16,595	4,940			66,522
Nevada	13,273	3,970	56,561	4,661	72,307	261	178,311
New Jersey	3,819		1,500		49,435		62,033
New Mexico	115,535	607	269,640	1,294,879	334,642	440	2,311,584
New York	47,643				9,550		104,066
North Carolina	14,000		1,016				15,642
North Dakota			3,000				3,000
Ohio			32	40			86
Oklahoma	976		7,500				8,476
Oregon	800	13,307	15	36,500	36,000	23,527	111,300
Pennsylvania	43,280		3,050	24,000			115,760
South Carolina		2,025					2,085
South Dakota	82,665		9,407	51,682			203,111
Tennessee	42,514	1,000	204,859	15,222	32,166	72,454	405,847
Texas	11,000		412,914	5,000	9,529		438,443
Utah	92,679	498	162,327	47,496	46,842	37	436,109
Vermont	9,646						12,296
Virginia	49,334		58,950			53,638	188,409
Washington	24,683		4,050	49,122	633,391	207	738,480
Wisconsin	809	6,658	196,922	1,514	39,150		245,754
Wyoming	9,920		327,327	125,707	100	10	530,929
Other States [1]	46,805		2,400			20	49,265
Total	2,071,312	147,253	3,489,863	1,934,110	4,040,208	556,350	13,659,402

[1] Maine, Maryland, Massachusetts, and Mississippi.

TABLE 22.—Total material (ore and waste) produced by exploration and development in the United States, by commodities, in 1963

(Thousand short tons)

Commodity	Shaft and winze sinking	Raising	Tunneling	Drifting	Crosscutting	Trenching	Stripping	Other	Total
Metals:									
Bauxite	-------	-------	-------	-------	-------	-------	1,021	-------	1,021
Copper	11	156	10	1,327	57	3	78,199	1	79,764
Gold:									
Lode	14	75	20	220	13	31	3,692	-------	4,065
Placer	-------	-------	-------	29	1	38	3,397	3	3,468
Iron ore	1	143	29	669	149	11	116,348	-------	117,350
Lead	16	92	13	364	29	17	273	189	993
Mercury	7	3	4	23	1	1	832	-------	871
Molybdenum	4	11	3	311	1	22	-------	-------	352
Silver	10	54	16	75	19	29	100	2	305
Tungsten	-------	21	16	33	5	-------	-------	-------	75
Uranium	19	77	60	1,054	310	-------	36,103	-------	37,623
Zinc	31	106	1	404	58	8	2	10	620
Other [1]	3	2	1	2	1	35	5,564	-------	5,608
Total metals	116	740	173	4,511	644	195	245,531	205	252,115
Nonmetals:									
Asbestos	-------	1	1	8	-------	1	363	-------	374
Barite	-------	2	-------	7	29	-------	524	7	569
Clays	-------	-------	4	1	1	5	30,394	-------	30,405
Diatomite	-------	-------	-------	-------	-------	-------	2,195	-------	2,195
Feldspar	-------	-------	-------	-------	-------	-------	42	-------	42
Fluorspar	1	8	-------	6	1	6	6	-------	28
Gypsum	3	5	-------	34	-------	8	8,976	-------	9,026
Phosphate rock	-------	21	-------	76	3	-------	108,013	-------	108,113
Potassium salts	41	1	-------	68	8	-------	-------	-------	118
Pumice	-------	-------	-------	-------	-------	1	65	-------	66
Sodium carbonate (natural)	-------	-------	-------	256	-------	-------	-------	-------	256
Stone	1	15	106	379	19	1	51,902	347	52,770
Talc, soapstone, and pyrophyllite	3	7	6	16	5	-------	312	-------	349
Other [2]	-------	1	120	3	-------	12	1,584	-------	1,720
Total nonmetals	49	61	237	854	66	34	204,376	354	206,031
Grand total	165	801	410	5,365	710	229	449,907	559	458,146

[1] Beryllium, manganese ore, manganiferous ore, rare-earth metals and thorium, and titanium.
[2] Boron minerals, kyanite, magnesite, mica, olivine, perlite, salt, vermiculite, and wollastonite.

TABLE 23.—Total material (ore and waste) produced by exploration and development in the United States, by States, in 1963

(Thousand short tons)

State	Shaft and winze sinking	Raising	Tunneling	Drifting	Crosscutting	Trenching	Stripping	Other	Total
Alabama							30,582		30,582
Alaska				4		60	2,337		2,401
Arizona	8	141	12	461	61	25	78,324	1	79,033
Arkansas		2		7	29		1,211		1,249
California	12	31	25	121	19	10	33,808	2	34,028
Colorado	16	52	38	522	8	49	1,405	1	2,091
Connecticut							544		544
Florida							107,697		107,697
Georgia							21,641		21,641
Idaho	11	85	2	145	51	13	4,967	1	5,275
Illinois		8	2	2		5	6,271		6,288
Indiana							3,865		3,865
Iowa							9,840		9,840
Kansas							531		531
Kentucky	2	1	60	3			2,310		2,376
Louisiana			119						119
Maine							3		3
Maryland							360		360
Michigan	2	70		1,152	49		15,926		17,199
Minnesota		9		73	11		53,929		54,022
Mississippi							333		333
Missouri		29		286	103		2,484	194	3,096
Montana	2	12	9	61	7	14	12		117
Nebraska							1,174		1,174
Nevada	5	3	15	10	3	40	5,316		5,392
New Hampshire							1		1
New Jersey		4		17			1		22
New Mexico	41	89	6	675	259	1	2,144	1	3,216
New York	1	43	10	106	6		4,515		4,681
North Carolina	1			2			388		391
North Dakota							480		480
Ohio						3	6,394		6,397
Oklahoma							377		377
Oregon		1	1	2			141	347	492
Pennsylvania	1	34	61	164	16		3,133		3,409
South Carolina							3,420		3,420
South Dakota	2	47		137	3		3,651		3,840
Tennessee	31	12		220			3,851	7	4,121
Texas							3,782		3,782
Utah	24	73	23	341	19	2	710	2	1,194
Vermont	1	3	3	2	1		102		112
Virginia	3	18		377			1,277		1,675
Washington		24	6	84	37	7	531	3	692
West Virginia							182		182
Wisconsin		1		2			536		539
Wyoming	2	9	18	389	28		29,421		29,867
Total	165	801	410	5,365	710	229	449,907	559	458,146

TABLE 24.—Exploration and development of copper, by States

State	1962		1963	
	Feet	Percent of total	Feet	Percent of total
Arizona	891, 260	72. 1	981, 936	74. 3
Maine	7, 628	. 6	37, 225	2. 8
Michigan	83, 093	6. 7	94, 429	7. 1
Missouri	(1)	(1)	18, 720	1. 4
Montana	5, 002	. 4	165	(2)
Nevada	7, 777	. 6	30, 470	2. 3
New Mexico	61, 702	5. 0	45, 366	3. 4
North Carolina	10, 798	. 9	----------	----------
Tennessee	35, 601	2. 9	39, 466	3. 0
Texas	6, 468	. 5	----------	----------
Utah	114, 759	9. 3	64, 719	4. 9
Other States [3]	11, 850	1. 0	10, 006	. 8
Total	1, 235, 938	100. 0	1, 322, 502	100. 0

[1] Included with other.
[2] Less than 0.1 percent.
[3] Alabama (1963), Alaska (1963), California, Colorado, Idaho, Oklahoma (1963), Oregon (1963), Washington, and Wyoming (1963).

TABLE 25.—Exploration and development of iron ore, by States

State	1962		1963	
	Feet	Percent of total	Feet	Percent of total
Alabama	51, 987	4. 4	76, 819	8. 9
Alaska	4, 529	. 4	----------	----------
Arizona	22, 124	1. 9	1, 501	. 2
California	3, 819	. 3	13, 598	1. 6
Michigan	621, 286	52. 6	168, 451	19. 4
Minnesota	297, 904	25. 2	450, 522	52. 0
Missouri	40, 477	3. 4	31, 986	3. 7
Nevada	13, 319	1. 1	----------	----------
New York	17, 636	1. 5	20, 361	2. 4
Pennsylvania	80, 991	6. 8	74, 811	8. 6
Utah	4, 610	. 4	3, 472	. 4
Wisconsin	7, 159	. 6	1, 201	. 1
Wyoming	8, 690	. 7	16, 539	1. 9
Other States [1]	8, 423	. 7	7, 268	. 8
Total	1, 182, 954	100. 0	866, 529	100. 0

[1] Arkansas (1962), Idaho (1962), New Jersey, North Carolina, and Washington.

TABLE 26.—Exploration and development of lead and zinc, by States

State	1962		1963	
	Feet	Percent of total	Feet	Percent of total
Arizona	24, 171	1. 0	21, 403	0. 8
Colorado	40, 512	1. 7	34, 088	1. 2
Idaho	1, 199, 861	51. 6	1, 936, 038	70. 0
Illinois	15, 620	. 7	12, 184	. 4
Missouri	618, 918	26. 5	295, 653	10. 7
Montana	5, 107	. 2	30, 035	1. 1
Nevada	6, 345	. 3	3, 115	. 1
New Mexico	26, 659	1. 1	58, 781	2. 1
New York	50, 812	2. 2	66, 325	2. 4
Pennsylvania	25, 734	1. 1	26, 325	1. 0
Tennessee	70, 957	3. 0	89, 522	3. 2
Utah	52, 965	2. 3	60, 838	2. 2
Virginia	56, 759	2. 4	56, 824	2. 1
Washington	78, 917	3. 4	56, 378	2. 0
Wisconsin	37, 797	1. 6	8, 963	. 3
Other States [1]	20, 270	. 9	10, 479	. 4
Total	2, 331, 404	100. 0	2, 766, 951	100. 0

[1] California, Kansas, and New Jersey.

TABLE 27.—Exploration and development of crushed and broken stone in 1963, by States

State	Feet	Percent of total	State	Feet	Percent of total
California	114, 903	6. 5	North Carolina	14, 016	0. 8
Colorado	12, 190	. 7	Oregon	81, 742	4. 6
Florida	160, 576	9. 0	Pennsylvania	10, 774	. 6
Georgia	229, 376	12. 9	Tennessee	72, 000	4. 0
Illinois	90, 167	5. 1	Virginia	63, 569	3. 6
Indiana	219, 094	12. 3	Washington	10, 510	. 6
Iowa	100, 206	5. 6	Wisconsin	223, 590	12. 6
Kentucky	64, 093	3. 6	Other States [1]	20, 344	1. 1
Michigan	240, 793	13. 5			
Minnesota	33, 110	1. 9	Total	1, 799, 392	100. 0
New Mexico	18, 339	1. 0			

[1] Arizona, Connecticut, Maine, Maryland, New Jersey, New York, Nevada, Ohio, South Carolina, and Wyoming.

TABLE 28.—Exploration and development of uranium, by States

State	1962		1963	
	Feet	Percent of total	Feet	Percent of total
Arizona	104, 713	1. 7	46, 590	1. 2
Colorado	1, 236, 653	19. 6	846, 543	21. 2
New Mexico	3, 653, 236	57. 9	2, 085, 448	52. 3
South Dakota	79, 590	1. 3	11, 648	. 3
Texas	----------	----------	283, 374	7. 1
Utah	290, 631	4. 6	240, 335	6. 0
Wyoming	928, 920	14. 7	465, 075	11. 7
Other States [1]	16, 201	. 2	10, 208	. 2
Total	6, 309, 944	100. 0	3, 989, 221	100. 0

[1] Alaska, California, Nevada (1962), North Dakota, Oregon (1962), and Washington.

TABLE 29.—Exploration and development in Arizona, by methods in 1963

(Feet)

Method	Copper	Gold	Lead-zinc	Uranium	Other [1]	Total
Shaft and winze sinking	575	126	156	----------	195	1, 052
Raising	43, 320	115	1, 641	2, 013	485	47, 574
Tunneling	1, 293	250	940	----------	470	2, 953
Drifting	68, 987	150	6, 939	17, 265	2, 250	95, 591
Crosscutting	10, 551	140	2, 637	4, 514	----------	17, 842
Diamond drilling	406, 742	----------	8, 990	2, 550	3, 282	421, 564
Churn drilling	16, 503	----------	----------	300	----------	16, 803
Rotary drilling	417, 582	----------	----------	2, 500	1, 000	421, 082
Long-hole drilling	4, 431	170	----------	16, 100	2, 350	23, 051
Percussion drilling	11, 186	----------	----------	1, 348	----------	12, 534
Trenching	710	70	100	----------	2, 225	3, 105
Other	56	----------	----------	----------	1	57
Total	981, 936	1, 021	21, 403	46, 590	12, 258	1, 063, 208

[1] Asbestos, beryllium, iron ore, molybdenum, silver, tungsten, and stone.

TABLE 30.—Exploration and development in Colorado, by methods in 1963

(Feet)

Method	Beryllium	Copper	Gold, lode, and placer	Lead-zinc	Molybdenum	Silver	Stone, crushed and broken	Uranium	Other [1]	Total
Shaft and winze sinking		30	555		139	240		1,762	37	2,763
Raising	200	75	234	4,380	941	1,162		2,530		9,522
Tunneling		630	620	945	950	1,528		5,136	115	9,924
Drifting	350	110	1,807	8,807	26,427	1,904		51,746		91,151
Crosscutting			231	638				1,674		2,543
Diamond drilling	690		986	11,971	53,527	1,500		414,430	568	483,672
Churn drilling			824	45						869
Rotary drilling			2,030				12,000	82,095	50	96,175
Long-hole drilling	150	485				2,068		82,931		85,634
Percussion drilling			18					204,204		204,222
Trenching	730	100	755	7,302	4,500	15	190	35	520	14,147
Other		1	401							402
Total	2,120	1,431	8,461	34,088	86,484	8,417	12,190	846,543	1,290	1,001,024

[1] Manganese ore and rare earth-metals and thorium.

TABLE 31.—Exploration and development in Idaho, by methods in 1963

(Feet)

Method	Lead-zinc	Molybdenum	Phosphate rock	Silver	Other [1]	Total
Shaft and winze sinking	481			543	75	1,099
Raising	8,596			6,373	110	15,079
Tunneling	63			232	390	685
Drifting	19,720			15,646	270	35,636
Crosscutting	6,859			3,475	16	10,350
Diamond drilling	33,671	5,948		33,960		73,579
Rotary drilling			55,608			55,608
Long-hole drilling	13,434			969	60	14,463
Percussion drilling	1,853,184		5,000		510	1,858,694
Trenching	30			8,246	140	8,416
Other				824	40	864
Total	1,936,038	5,948	60,608	70,268	1,611	2,074,473

[1] Copper and gold.

TABLE 32.—Exploration and development in Michigan, by methods in 1963

(Feet)

Method	Copper	Gypsum	Iron ore	Stone	Total
Shaft sinking	161				161
Raising	3,190		28,150		31,340
Drifting	51,600		57,563		109,163
Crosscutting	5,273		6,428		11,701
Diamond drilling	33,799	2,944	50,560	5,919	93,222
Rotary drilling				234,874	234,874
Long-hole drilling	406		25,750		26,156
Total	94,429	2,944	168,451	240,793	506,617

TABLE 33.—Exploration and development in Minnesota, by methods in 1963

(Feet)

Method	Clays	Iron ore	Manganiferous ore	Stone	Total
Raising		2,163			2,163
Drifting		5,825			5,825
Crosscutting		1,645			1,645
Diamond drilling		100,989	532	1,000	102,521
Churn drilling		8,420	770	1,330	10,520
Rotary drilling	35,000	4,396		38,580	77,976
Long-hole drilling				900	900
Percussion drilling		74,798	237		75,035
Other		252,286			252,286
Total	35,000	450,522	1,539	41,810	528,871

TABLE 34.—Exploration and development in New Mexico, by methods in 1963

(Feet)

Method	Copper	Lead-zinc	Molybdenum	Potash	Silver	Stone	Uranium	Other[1]	Total
Shaft and winze sinking	843	15		2,894	33		355	73	4,213
Raising	461	13,985	585		135		17,411	16	32,593
Tunneling					339		758	150	1,247
Drifting	4,166	21,317	1,900		230		124,374		151,987
Crosscutting	207	20	175		188		104,814		105,404
Diamond drilling	36,739	23,204	46,125	4,000	3,700	1,767			115,535
Churn drilling	467							140	607
Rotary drilling			16,845	18,315		865	233,515	100	269,640
Long-hole drilling	2,483	240	2,138				1,290,018		1,294,879
Percussion drilling						18,339	314,203	2,100	334,642
Trenching								397	397
Other					440				440
Total	45,366	58,781	67,768	25,209	5,065	20,971	2,085,448	2,976	2,311,584

[1] Barite, gold, mica, and perlite.

TABLE 35.—Exploration and development in Tennessee, by methods in 1963

(Feet)

Method	Barite	Clays	Copper	Stone	Zinc	Total
Shaft and winze sinking			483		690	1,173
Raising			4,031		940	4,971
Drifting			15,632		15,856	31,488
Diamond drilling			19,320		23,194	42,514
Churn drilling					1,000	1,000
Rotary drilling	8,000	196,859				204,859
Long-hole drilling					15,222	15,222
Percussion drilling					32,166	32,166
Other				72,000	454	72,454
Total	8,000	196,859	39,466	72,000	89,522	405,847

TABLE 36.—Exploration and development in Wyoming, by methods in 1963

(Feet)

Method	Clays	Iron ore	Natural sodium carbonates	Phosphate rock	Uranium	Other [1]	Total
Shaft and winze sinking					843		843
Raising		2,217			479		2,696
Tunneling		584			2,491		3,075
Drifting		5,738	27,000		23,416		56,154
Crosscutting					4,554	518	5,072
Diamond drilling		8,000		1,800		120	9,920
Rotary drilling	19,842				307,485		327,327
Long-hole drilling					125,707		125,707
Percussion drilling					100		100
Trenching				25			25
Other						10	10
Total	19,842	16,539	27,000	1,825	465,075	648	530,929

[1] Copper, gypsum, and stone.

Statistical Summary

By Kathleen J. D'Amico[1]

Contents

THIS summary appears in Minerals Yearbook volumes I 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 several commodity and area chapters contain further details on production. A summary table comparing world and U.S mineral production also is included.

TABLE 1.—Value of mineral production in the United States,[1] 1925–63, by mineral groups [2]

(Millions)

Year	Mineral fuels	Nonmetals (except fuels)	Metals	Total	Year	Mineral fuels	Nonmetals (except fuels)	Metals	Total
1925	$2,910	$1,187	$715	$4,812	1945	$4,569	$888	$774	$6,231
1926	3,371	1,219	721	5,311	1946	5,090	1,243	729	7,062
1927	2,875	1,201	622	4,698	1947	7,188	1,338	1,084	9,610
1928	2,666	1,163	655	4,484	1948	9,502	1,552	1,219	12,273
1929	2,940	1,166	802	4,908	1949	7,920	1,559	1,101	10,580
1930	2,500	973	507	3,980	1950	8,689	1,822	1,351	11,862
1931	1,620	671	287	2,578	1951	9,779	2,079	1,671	13,529
1932	1,460	412	128	2,000	1952	9,616	2,163	1,617	13,396
1933	1,413	432	205	2,050	1953	10,257	2,350	1,811	14,418
1934	1,947	520	277	2,744	1954	9,919	2,733	1,518	14,170
1935	2,013	564	365	2,942	1955	10,780	3,076	2,055	15,911
1936	2,405	685	516	3,606	1956	11,741	3,391	2,358	17,490
1937	2,798	711	756	4,265	1957	12,709	3,387	2,137	18,233
1938	2,436	622	460	3,518	1958	11,589	3,466	1,594	16,649
1939	2,423	754	631	3,808	1959	11,950	3,861	1,570	17,381
1940	2,662	784	752	4,198	1960	12,142	3,868	2,022	18,032
1941	3,228	989	890	5,107	1961	12,357	3,946	1,927	18,230
1942	3,568	1,056	999	5,623	1962	[3] 12,784	[3] 4,117	1,937	[3] 18,838
1943	4,028	916	987	5,931	1963	13,296	4,318	2,006	19,620
1944	4,574	836	900	6,310					

[1] Excludes Alaska and Hawaii, 1925–53.
[2] Data for 1925–46 are not strictly comparable with those for subsequent years, since for earlier years value of heavy clay products has not been replaced by value of raw clays used for such products.
[3] Revised figure.

[1] Statistical officer, Division of Minerals.

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.

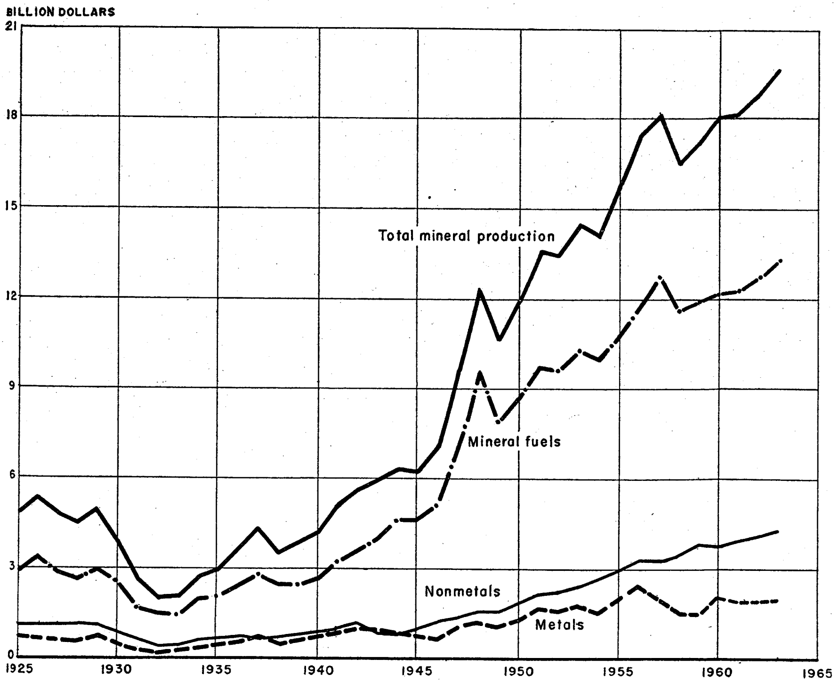

FIGURE 1.—Value of mineral production in the United States, 1925–63.

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

Mineral	1960		1961		1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Mineral fuels:								
Asphalt and related bitumens (native):								
Bituminous limestone and sandstone ... short tons	1,242,874	$3,070	} 1,558,792	$12,818	1,647,063	$14,601	1,632,645	$8,383
Gilsonite ... do	383,037	10,020						
Carbon dioxide, natural (estimate) ... thousand cubic feet	521,169	99	545,354	82	1,144,107	146	1,295,545	178
Coal:								
Bituminous and lignite [2] ... thousand short tons	415,512	1,950,425	402,977	1,844,563	422,149	1,891,553	458,928	2,013,309
Pennsylvania anthracite ... do	18,817	147,116	17,446	140,338	16,894	134,094	18,267	153,503
Helium ... thousand cubic feet	475,179	7,768	551,785	10,263	599,519	20,905	627,344	21,957
Natural gas ... million cubic feet	12,771,038	1,789,970	13,254,025	1,996,241	13,876,622	2,145,301	14,746,663	2,328,030
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	5,842,507	416,819	6,105,463	412,019	6,244,522	444,817	6,534,967	439,173
LP gases ... do	8,444,074	391,566	9,085,465	370,186	9,409,083	353,334	10,302,250	359,770
Peat ... short tons	470,889	5,138	531,067	5,036	[3] 566,441	5,186	546,621	5,423
Petroleum (crude) ... thousand 42-gallon barrels	2,574,933	7,420,181	2,621,758	7,565,582	2,676,189	7,774,051	[4] 2,752,723	[4] 7,966,651
Total mineral fuels	------------	12,142,000	------------	12,357,000	------------	[3] 12,784,000	------------	13,296,000
Nonmetals (except fuels):								
Abrasive stone [5] ... short tons	2,539	240	2,495	238	2,653	260	2,693	255
Aplite ... long tons	(6)	(6)	97,465	651	125,156	912	(6)	(6)
Asbestos ... short tons	45,223	4,231	52,814	4,347	53,190	4,677	66,606	5,425
Barite ... do	714,276	8,574	796,804	9,300	860,312	9,820	823,615	9,447
Boron minerals ... do	640,591	47,550	602,613	46,936	646,613	49,336	700,183	54,981
Bromine ... thousand pounds	175,010	44,637	180,798	44,517	190,747	46,617	203,333	48,558
Cement:								
Portland ... thousand 376-pound barrels	} 321,646	} 1,089,134	314,821	1,048,832	325,476	1,070,371	342,036	1,095,884
Masonry ... thousand 280-pound barrels			19,275	55,737	19,998	57,405	20,997	59,599
Natural and slag ... thousand 376-pound barrels			269	968	402	1,611	352	1,407
Clays ... thousand short tons	49,069	162,411	47,389	156,829	47,797	163,012	50,199	180,874
Emery ... short tons	8,169	142	6,180	106	4,316	71	6,732	119
Feldspar ... long tons	502,380	4,779	496,808	5,120	492,476	5,076	548,954	5,525
Fluorspar ... short tons	229,782	10,391	197,354	8,940	206,026	9,166	199,843	8,998
Garnet (abrasive) ... do	10,522	986	12,057	1,036	14,166	1,172	14,626	1,412
Gem stones (estimate)	(7)	1,188	(7)	1,309	(7)	1,296	(7)	1,421
Gypsum ... thousand short tons	9,825	35,690	9,500	34,996	9,969	36,343	10,388	38,138
Lime ... do	12,935	172,731	13,249	177,463	13,752	186,754	14,521	199,389
Magnesite ... short tons	498,528	2,051	603,656	3,129	492,471	[3] 1,621	527,655	1,779
Magnesium compounds from sea water and brine (except for metals) short tons, MgO equivalent	293,454	21,903	356,384	25,545	408,129	28,742	506,849	38,699

See footnotes at end of table.

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

Mineral	1960		1961		1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Nonmetals—Continued								
Mica:								
Scrap ... short tons	97,912	$2,698	99,044	$2,417	107,702	$2,639	109,323	$2,776
Sheet ... pounds	587,401	3,108	526,007	3,386	[3] 363,016	[3] 1,299	102,961	13
Perlite ... short tons	312,153	2,665	310,338	2,664	320,330	2,663	325,132	2,727
Phosphate rock ... thousand long tons	17,516	117,041	18,559	130,535	19,382	134,304	[12] 19,855	[12] 139,861
Potassium salts ... thousand short tons, K_2O equivalent	2,638	89,676	2,732	104,464	2,452	94,859	2,865	109,276
Pumice ... thousand short tons	2,210	5,569	2,463	6,799	[3] 2,271	[3] 6,301	2,618	6,578
Pyrites ... thousand long tons	1,016	7,936	988	7,418	916	6,809	825	5,698
Salt ... thousand short tons	25,479	161,140	25,707	160,223	28,807	174,841	30,644	184,635
Sand and gravel ... do	709,792	720,432	751,784	751,301	776,701	794,725	822,000	849,000
Sodium carbonate (natural) ... short tons	808,624	20,865	805,828	20,444	977,584	24,330	1,119,081	27,616
Sodium sulfate (natural) ... do	449,631	8,706	465,814	9,296	457,881	9,092	435,257	8,392
Stone [8] ... thousand short tons	616,784	952,555	611,938	947,359	656,954	1,025,697	688,366	1,068,108
Sulfur:								
Frasch process mines ... thousand long tons	5,003	115,494	5,082	117,884	4,917	107,069	4,995	99,014
Other mines ... long tons	181,422	1,732	177,549	1,694	150,550	1,439	1,371	15
Talc, soapstone, and pyrophyllite ... short tons	734,473	5,378	762,380	5,277	771,728	5,278	804,358	5,505
Tripoli ... do	57,713	247	54,641	225	61,732	244	66,635	266
Vermiculite ... thousand short tons	199	3,108	206	3,350	205	3,293	226	3,572
Value of items that cannot be disclosed: Calcium-magnesium chloride, diatomite, epsom salts from epsomite (1961-63), graphite, iodine, kyanite, lithium minerals, greensand marl, olivine, staurolite, wollastonite, and values indicated by footnote 6	-----	42,664	-----	44,863	-----	47,815	-----	53,026
Total nonmetals	-----	3,868,000	-----	3,946,000	-----	[3] 4,117,000	-----	4,318,000
Metals:								
Antimony ore and concentrate ... short tons, antimony content	635	(9)	689	(9)	631	(9)	645	(9)
Bauxite ... long tons, dried equivalent	1,997,827	21,107	1,228,032	13,937	1,369,007	15,609	1,524,700	17,234
Beryllium concentrate ... short tons, gross weight	509	162	[10] 1,122	(9)	[10] 978	(9)	[10] 751	(9)
Chromite ... do	[11] 107,000	[11] 3,813	[11] 82,000	[11] 2,939	-----	-----	-----	-----
Copper (recoverable content of ores, etc.) ... short tons	1,080,169	693,468	1,165,155	699,093	1,228,421	756,707	1,213,166	747,310
Gold (recoverable content of ores, etc.) ... troy ounces	1,666,772	58,336	1,548,270	54,189	1,542,511	53,990	1,454,010	50,889
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight	82,963	724,131	72,378	650,501	69,969	618,242	73,563	678,177
Lead (recoverable content of ores, etc.) ... short tons	246,669	57,722	261,921	53,956	236,956	43,602	253,369	54,727
Manganese ore (35 percent or more Mn) ... short tons, gross weight	80,021	5,352	46,088	3,224	24,758	(9)	10,622	(9)

Manganiferous ore (5 to 35 percent Mn) ... do	658,455	4,466	225,004	1,480	338,501	(9)	543,125	(9)
Mercury ... 76-pound flasks	33,223	7,002	31,662	6,257	26,277	5,024	19,100	3,618
Molybdenum (content of concentrate) ... thousand pounds	69,941	87,406	66,753	87,925	50,506	69,390	65,839	91,096
Nickel (content of ore and concentrate) ... short tons	14,079	(9)	13,133	(9)	13,110	(9)	13,394	(9)
Silver (recoverable content of ores, etc.) ... thousand troy ounces	30,766	27,846	34,794	32,166	36,798	39,929	35,243	45,076
Tin (content of ore and concentrate) ... long tons	10	12	(9)	(9)	(9)	(9)	(9)	(9)
Titanium concentrate:								
Ilmenite ... short tons, gross weight	789,237	14,655	782,629	13,320	809,037	13,974	890,071	16,529
Rutile ... do	9,226	957	7,664	778	8,033	933	11,311	1,262
Tungsten ore and concentrate ... short tons, 60-percent WO_3 basis	7,325	9,815	8,245	10,565	8,429	11,639	5,657	7,202
Uranium ore ... short tons	7,970,211	152,188	8,041,329	148,299	7,052,870	138,294	5,947,571	119,215
Vanadium (recoverable in ore and concentrate) ... do	4,971	17,749	5,343	19,076	5,211	18,605	3,853	13,756
Zinc (recoverable content of ores, etc.) ... do	435,427	112,365	464,390	106,848	505,491	116,413	529,254	122,533
Value of items that cannot be disclosed: Chromite,[11] cobalt, magnesium chloride for magnesium metal, manganiferous residuum, platinum-group metals (crude), rare-earth metal concentrates, zirconium concentrate, and values indicated by footnote 9	------	23,078	------	22,582	------	35,071	------	36,827
Total metals	------	2,022,000	------	1,927,000	------	1,937,000	------	2,006,000
Grand total mineral production	------	18,032,000	------	18,230,000	------	[3] 18,838,000	------	19,620,000

[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] Revised figure.
[4] Preliminary figure.
[5] Grindstones, pulpstones, millstones (weight not recorded), grinding pebbles, sharpening stones, and tube-mill liners.
[6] Figure withheld to avoid disclosing individual company confidential data; value included with "Nonmetal items that cannot be disclosed."
[7] Weight not recorded.
[8] Excludes abrasive stone, bituminous limestone, bituminous sandstone, and ground soapstone, all included elsewhere in table.
[9] Figure withheld to avoid disclosing individual company confidential data; value included with "Metal items that cannot be disclosed."
[10] Includes low-grade beryllium ore as follows: 805 tons in 1961, 760 tons in 1962, and 750 tons in 1963.
[11] Excludes quantity consumed by American Chrome Co.
[12] Final figure; superseded figure given in commodity chapter.

TABLE 3.—Minerals produced in the United States and principal producing States in 1963

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

TABLE 3.—Minerals produced in the United States and principal producing States in 1963—Continued

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

TABLE 4.—Value of mineral production in the United States, and principal minerals produced in 1963

(Thousands)

State	Value	Rank	Percent of U.S. total	Principal minerals in order of value
Alabama	$215,870	21	1.10	Coal, cement, stone, petroleum.
Alaska	67,840	38	.35	Petroleum, sand and gravel, coal, gold.
Arizona	481,392	12	2.45	Copper, sand and gravel, cement, molybdenum.
Arkansas	167,196	25	.85	Petroleum, stone, bauxite, sand and gravel.
California	1,525,359	3	7.77	Petroleum, natural gas, cement, sand and gravel.
Colorado	317,109	17	1.62	Petroleum, molybdenum, coal, sand and gravel.
Connecticut	20,614	45	.11	Stone, sand and gravel, lime, feldspar.
Delaware	1,341	50	.01	Sand and gravel, stone, clays, gem stones.
District of Columbia	78	51	(1)	Clays.
Florida	201,620	23	1.03	Phosphate rock, stone, cement, clays.
Georgia	119,476	28	.61	Clays, stone, cement, sand and gravel.
Hawaii	15,307	46	.08	Cement, stone, sand and gravel, pumice.
Idaho	82,755	33	.42	Silver, lead, zinc, sand and gravel.
Illinois	583,943	8	2.97	Petroleum, coal, stone, sand and gravel.
Indiana	202,530	22	1.03	Coal, cement, stone, petroleum.
Iowa	97,670	30	.50	Cement, stone, sand and gravel, gypsum.
Kansas	518,302	9	2.64	Petroleum, natural gas, cement, stone.
Kentucky	434,746	14	2.22	Coal, petroleum, stone, natural gas.
Louisiana	2,662,061	2	13.57	Petroleum, natural gas, natural gas liquids, sulfur.
Maine	14,104	47	.07	Cement, sand and gravel, stone, clays.
Maryland	70,250	36	.36	Stone, cement, sand and gravel, coal.
Massachusetts	32,661	43	.17	Sand and gravel, stone, lime, clays.
Michigan	492,032	11	2.51	Iron ore, cement, copper, petroleum.
Minnesota	453,543	13	2.31	Iron ore, sand and gravel, stone, cement.
Mississippi	219,938	20	1.12	Petroleum, natural gas, cement, sand and gravel.
Missouri	158,991	27	.81	Stone, cement, lead, lime.
Montana	182,027	24	.93	Petroleum, copper, sand and gravel, zinc.
Nebraska	98,706	29	.50	Petroleum, cement, sand and gravel, stone.
Nevada	85,440	32	.44	Copper, sand and gravel, lime, diatomite.
New Hampshire	6,154	48	.03	Sand and gravel, stone, clays, feldspar.
New Jersey	73,276	34	.37	Stone, sand and gravel, zinc, iron ore.
New Mexico	686,822	7	3.50	Petroleum, potassium salts, natural gas, copper.
New York	260,221	18	1.33	Cement, stone, sand and gravel, salt.
North Carolina	44,894	41	.23	Stone, sand and gravel, feldspar, clays.
North Dakota	94,504	31	.48	Petroleum, sand and gravel, natural gas, coal.
Ohio	419,396	15	2.14	Coal, stone, cement, lime.
Oklahoma	872,518	4	4.45	Petroleum, natural gas, natural gas liquids, cement.
Oregon	62,692	39	.32	Stone, sand and gravel, cement, nickel.
Pennsylvania	856,864	5	4.37	Coal, cement, stone, iron ore.
Rhode Island	2,807	49	.01	Sand and gravel, stone, gem stones.
South Carolina	36,479	42	.19	Stone, cement, clays, sand and gravel.
South Dakota	55,058	40	.28	Gold, sand and gravel, stone, cement.
Tennessee	160,723	26	.82	Stone, cement, coal, zinc.
Texas	4,413,034	1	22.49	Petroleum, natural gas, natural gas liquids, cement.
Utah	385,521	16	1.96	Copper, petroleum, uranium, coal.
Vermont	24,391	44	.12	Stone, asbestos, sand and gravel, talc.
Virginia	229,065	19	1.17	Coal, stone, cement, sand and gravel.
Washington	71,430	35	.36	Sand and gravel, cement, stone, zinc.
West Virginia	767,815	6	3.91	Coal, natural gas, natural gas liquids, stone.
Wisconsin	68,326	37	.35	Sand and gravel, stone, cement, iron ore.
Wyoming	504,633	10	2.57	Petroleum, natural gas, uranium, sodium carbonates and sulfates.
Total	19,620,000		100.00	Petroleum, natural gas, coal, cement.

[1] Less than 9.005 percent.

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

Mineral	1960		1961		1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ALABAMA								
Cement: [2]								
Portland ... thousand 376-pound barrels	12,931 (Portland and masonry combined)	$42,706 (Portland and masonry combined)	12,445	$39,027	12,482	$40,164	12,218	$38,417
Masonry ... thousand 280-pound barrels			2,006	6,156	2,187	6,521	2,386	7,242
Clays [3] ... thousand short tons	1,840	2,170	1,787	2,068	1,632	1,947	607	3,003
Coal (bituminous) ... do	13,011	92,439	12,915	90,903	12,880	95,149	12,359	91,243
Gem stones	------	------	------	------	------	------	(4)	2
Iron ore (usable) ... thousand long tons, gross weight	4,068	23,511	3,597	20,510	2,962	17,838	2,126	11,806
Lime ... thousand short tons	536	6,593	579	6,871	522	6,298	596	6,974
Natural gas ... million cubic feet	57	4	56	4	128	13	177	21
Petroleum (crude) ... thousand 42-gallon barrels	7,329	(5)	6,931	19,060	7,473	19,355	[6] 9,175	[6] 23,763
Sand and gravel ... thousand short tons	4,359	4,759	5,800	6,452	4,655	4,486	5,363	5,778
Stone [7] ... do	13,503	19,970	13,651	19,909	12,680	19,667	13,684	22,206
Value of items that cannot be disclosed: Native asphalt, bauxite, slag cement, clays (kaolin), scrap mica, sheet mica (1960–62), salt, stone (dimension limestone, dimension marble 1960–61, shell 1960–61, 1963, crushed sandstone 1960–61), talc, and values indicated by footnote 5	------	29,650	------	7,919	------	8,347	------	5,415
Total	------	221,802	------	218,879	------	[8] 219,785	------	215,870
ALASKA								
Clays ... thousand short tons	1	$10	------	------	------	------	------	------
Coal (bituminous) ... do	722	6,318	737	$5,868	871	$6,409	853	$5,910
Copper (recoverable content of ores, etc.) ... short tons	41	26	92	55	------	------	------	------
Gold (recoverable content of ores, etc.) ... troy ounces	168,197	5,887	114,216	3,998	165,259	5,784	99,573	3,485
Lead (recoverable content of ores, etc.) ... short tons	(5)	(5)	(5)	(5)	------	------	5	1
Mercury ... 76-pound flasks	4,459	940	4,129	816	3,719	711	400	76
Natural gas ... million cubic feet	246	30	631	129	2,184	467	4,498	1,111
Peat ... short tons	376	(5)	------	------	64	(5)	------	------
Petroleum (crude) ... thousand 42-gallon barrels	559	1,230	6,327	17,652	10,259	31,187	[6] 10,740	[6] 32,650
Sand and gravel ... thousand short tons	6,013	5,483	5,241	4,185	5,731	5,355	16,926	22,005
Silver (recoverable content of ores, etc.) ... thousand troy ounces	26	23	18	17	22	24	14	18
Stone ... thousand short tons	275	852	(5)	(5)	(5)	(5)	(5)	(5)
Value of items that cannot be disclosed: Gem stones, platinum-group metals, uranium ore, and values indicated by footnote 5	------	1,061	------	2,033	------	4,255	------	2,584
Total	------	21,860	------	34,753	------	[8] 54,192	------	67,840

See footnotes at end of table.

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

ARIZONA

Mineral	1960		1961		1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Beryllium concentrate ... short tons, gross weight	(9)	(10)	8	$4	1	(10)	------	------
Clays [3] ... thousand short tons	173	$260	165	240	139	$184	163	$203
Coal (bituminous) ... do	6	58	------	------	------	------	------	------
Copper (recoverable content of ores, etc.) ... short tons	538,605	345,784	587,053	352,232	644,242	396,853	660,977	407,162
Gem stones	(4)	120	(4)	119	(4)	120	(4)	120
Gold (recoverable content of ores, etc.) ... troy ounces	143,064	5,007	145,959	5,109	137,207	4,802	140,030	4,901
Lead (recoverable content of ores, etc.) ... short tons	8,495	1,988	5,937	1,223	6,966	1,282	5,815	1,256
Lime ... thousand short tons	148	2,430	167	2,686	174	2,914	181	3,048
Manganese ore (35 percent or more Mn) ... short tons, gross weight	1,626	40	------	------	------	------	------	------
Manganiferous ore (5 to 35 percent Mn) ... do	8,677	190	(5)	(5)	------	------	------	------
Mercury ... 76-pound flasks	(5)	(5)	148	29	(5)	(5)	(5)	(5)
Molybdenum (content of concentrate) ... thousand pounds	4,359	5,211	4,878	6,232	4,412	5,864	5,553	7,584
Natural gas ... million cubic feet	------	------	------	------	230	27	1,334	161
Petroleum (crude) ... thousand 42-gallon barrels	73	(5)	73	(5)	39	(5)	[6] 55	(5)
Pumice ... thousand short tons	703	1,164	745	1,893	756	1,640	800	1,877
Sand and gravel ... do	14,490	14,235	17,688	16,175	15,579	17,404	15,037	14,466
Silver (recoverable content of ores, etc.) ... thousand troy ounces	4,775	4,322	5,120	4,733	5,454	5,917	5,373	6,873
Stone ... thousand short tons	4,249	5,107	3,582	4,626	4,333	6,616	3,257	5,069
Tungsten ore and concentrate ... short tons, 60-percent WO_3 basis	(5)	(5)	------	------	15	14	------	------
Uranium ore ... short tons	283,684	6,219	228,225	4,965	143,196	3,047	150,584	4,844
Vanadium (recoverable in ore and concentrate) ... do	(5)	(5)	(5)	(5)	632	(5)	222	(5)
Zinc (recoverable content of ores, etc.) ... do	35,811	9,239	29,585	6,804	32,888	7,564	25,419	5,846
Value of items that cannot be disclosed: Asbestos, cement, clays (bentonite, fire clay 1961–63), diatomite (1961–63), feldspar, gypsum, helium (1961–62), iron ore (1961–63), scrap mica, perlite, pyrites, and values indicated by footnote 5	------	15,851	------	18,925	------	[8] 19,883	------	17,982
Total	------	417,225	------	425,995	------	[8] 474,131	------	481,392

ARKANSAS

Barite ... short tons	277,851	$2,578	277,855	$2,630	258,691	$2,232	236,077	$2,161
Bauxite ... long tons, dried equivalent	1,932,071	20,469	1,178,898	13,462	1,270,124	14,606	1,478,047	16,701
Clays ... thousand short tons	815	2,456	773	1,758	654	1,693	769	1,763
Coal (bituminous) ... do	409	3,116	395	2,888	256	1,809	221	1,505
Gem stones	(4)	38	(4)	19	(4)	15	(4)	42
Gypsum ... thousand short tons	67	208	167	531	83	261	(5)	(5)
Iron ore (usable) ... thousand long tons, gross weight	---	---	---	---	43	296	(5)	(5)
Lime ... thousand short tons	(5)	(5)	90	1,196	350	4,542	167	2,237
Natural gas ... million cubic feet	55,451	6,599	59,547	8,039	66,213	9,866	76,101	11,796
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	34,558	2,148	27,889	1,640	29,415	1,673	26,219	1,466
LP gases ... do	73,252	3,735	75,157	3,286	69,452	2,432	66,377	2,497
Petroleum (crude) ... thousand 42-gallon barrels	30,117	83,424	29,246	80,427	27,649	73,546	[6] 27,373	[6] 72,812
Sand and gravel ... thousand short tons	8,192	10,262	9,389	9,074	10,847	10,006	12,099	13,589
Stone ... do	10,939	13,555	12,029	12,402	20,611	19,866	18,913	22,727
Zinc (recoverable content of ores, etc.) ... short tons	50	13	37	9	211	49	---	---
Value of items that cannot be disclosed: Abrasive stones, bromine, cement, phosphate rock 1963, soapstone, and values indicated by footnote 5	---	10,918	---	10,906	---	11,063	---	17,900
Total	---	159,519	---	148,267	---	[8] 153,955	---	167,196

See footnotes at end of table.

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

Mineral	1960		1961		1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
CALIFORNIA								
Asbestos short tons	(5)	(5)	(5)	(5)	(5)	(5)	19,591	$1,547
Barite do	16,157	$181	21,203	$295	6,945	$133	5,082	76
Boron minerals do	640,591	47,550	602,613	46,936	646,613	49,336	700,183	54,981
Cement thousand 376-pound barrels	[2] 39,712	[2] 128,826	[2] 41,090	[2] 129,836	43,667	139,151	46,278	147,656
Clays thousand short tons	2,899	5,663	3,041	6,405	3,137	7,349	3,395	8,031
Copper (recoverable content of ores, etc.) short tons	1,087	698	1,382	829	1,162	716	916	564
Feldspar long tons	76,010	886	(5)	(5)	(5)	(5)	75,516	(5)
Gem stones	(4)	150	(4)	200	(4)	200	(4)	200
Gold (recoverable content of ores, etc.) troy ounces	123,713	4,330	97,644	3,418	106,272	3,720	86,867	3,040
Gypsum thousand short tons	1,616	3,687	1,574	3,733	1,747	4,113	1,756	4,222
Lead (recoverable content of ores, etc.) short tons	440	103	103	21	455	84	823	178
Lime thousand short tons	345	5,628	503	9,062	470	8,454	487	8,932
Magnesium compounds from sea water and bitterns (partly estimated) short tons, MgO equivalent	86,532	6,233	90,534	6,467	76,445	6,077	82,397	6,135
Manganiferous ore (5 to 35 percent Mn) short tons, gross weight	96	(5)			(5)	(5)		
Mercury 76-pound flasks	18,764	3,955	18,688	3,693	15,951	3,050	13,592	2,575
Mica, scrap short tons	(5)	(5)	950	12	(5)	(5)	977	14
Natural gas million cubic feet	517,535	138,182	556,241	157,416	564,220	163,624	646,486	189,420
Natural gas liquids:								
Natural gasoline and cycle products thousand gallons	794,657	62,496	762,878	57,645	716,904	54,460	715,303	54,188
LP gases do	408,378	21,482	424,767	21,805	407,378	19,294	393,503	17,329
Peat short tons	33,091	481	46,348	501	33,901	331	39,873	450
Petroleum (crude) thousand 42-gallon barrels	305,352	751,166	299,609	728,050	296,590	741,475	[6] 300,733	[6] 745,818
Pumice thousand short tons	427	1,895	610	2,202	573	2,615	460	2,017
Salt do	1,443	(5)	1,601	(5)	1,643	(5)	1,716	(5)
Sand and gravel do	87,679	107,503	110,181	124,111	107,660	124,922	112,185	128,178
Silver (recoverable content of ores, etc.) thousand troy ounces	180	163	93	86	133	144	157	200
Stone thousand short tons	33,075	49,842	33,850	50,327	34,776	54,722	37,977	58,253
Sulfur ore long tons	(5)	(5)	(5)	(5)	(5)	(5)	785	4
Talc, soapstone, and pyrophyllite short tons	130,539	1,396	161,068	1,524	117,912	1,339	120,452	1,427
Wollastonite do	(5)	(5)	4,075	42	(5)	(5)	3,000	28
Zinc (recoverable content of ores, etc.) do	465	120	304	70	322	74	101	23
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, carbon dioxide, masonry cement (1960–61), coal (lignite), diatomite, fluorspar (1960–61), iodine, iron ore, lithium minerals, magnesite (1960–61), molybdenum, perlite, platinum-group metals (crude), potassium salts, pyrites, (1960–62), rare-earth metal concentrates, sodium carbonates and sulfates, tin (1963), tungsten concentrate, uranium ore (1960, 1963), and values indicated by footnote 5		79,471		81,051		81,957		89,873
Total		1,422,087		1,435,737		[8] 1,467,340		1,525,359

COLORADO

Beryllium concentrate ... short tons, gross weight	304	$53	[11] 819	(5)	[11] 782	(5)	[11] 751	(5)
Carbon dioxide, natural ... thousand cubic feet	155,871	20	167,872	$19	148,940	$15	224,856	$38
Clays ... thousand short tons	490	1,424	556	1,241	802	1,573	686	1,334
Coal (bituminous) ... do	3,607	21,090	3,678	22,787	3,379	19,999	3,690	21,888
Copper (recoverable content of ores, etc.) ... short tons	3,247	2,085	4,141	2,485	4,534	2,793	4,169	2,568
Feldspar ... long tons	(5)	(5)	14,129	99	(5)	(5)	(5)	(5)
Gem stones	(4)	45	(4)	36	(4)	45	(4)	63
Gold (recoverable content of ores, etc.) ... troy ounces	61,269	2,144	67,515	2,363	48,882	1,711	33,605	1,176
Gypsum ... thousand short tons	82	296	85	320	108	383	99	346
Iron ore (usable) ... thousand long tons, gross weight	11	80	27	190	(5)	(5)	(5)	(5)
Lead (recoverable content of ores, etc.) ... short tons	18,080	4,231	17,755	3,658	17,411	3,204	19,918	4,302
Lime ... thousand short tons	(5)	(5)	75	1,319	93	1,518	128	2,104
Mica, scrap ... short tons	340	4	600	10	142	2	440	7
Molybdenum (content of concentrate) ... thousand pounds	51,615	65,448	47,485	63,582	32,412	45,376	47,977	67,168
Natural gas ... million cubic feet	107,404	12,781	108,142	12,544	101,826	11,812	105,705	12,367
Natural gas liquids:								
Natural gasoline ... thousand gallons	73,179	4,138	76,880	3,627	60,558	3,826	56,869	3,191
LP gases ... do	104,275	4,938	115,410	5,498	100,787	4,411	91,309	4,171
Peat ... short tons	9,384	37	9,894	44	12,351	68	13,774	98
Petroleum (crude) ... thousand 42-gallon barrels	47,469	137,660	46,759	134,666	42,477	122,334	[6] 38,271	[6] 110,220
Pumice ... thousand short tons	32	70	44	60	76	82	60	87
Sand and gravel ... do	19,053	16,882	18,360	16,946	19,313	18,926	20,385	20,929
Silver (recoverable content of ores, etc.) ... thousand troy ounces	1,659	1,502	1,965	1,817	2,088	2,265	2,307	2,951
Stone ... thousand short tons	2,442	4,651	2,451	5,301	2,353	5,597	2,510	5,693
Tin (content of ore and concentrate) ... long tons	10	12	(5)	(5)	(5)	(5)	(5)	(5)
Uranium ore ... short tons	1,149,583	23,462	1,282,462	21,509	1,135,440	18,044	1,014,206	15,864
Vanadium (recoverable in ore and concentrate) ... do	4,026	(5)	4,149	(5)	3,742	(5)	3,047	(5)
Vermiculite ... thousand short tons	-----	-----	-----	-----	(5)	(5)	(12)	1
Zinc (recoverable content of ores, etc.) ... short tons	31,278	8,070	42,647	9,809	43,351	9,971	48,109	11,065
Value of items that cannot be disclosed: Cement, fluorspar, perlite, pyrites, rare-earth and thorium concentrates (1960), salt, tungsten, and values indicated by footnote 5	-----	34,295	-----	36,278	-----	34,209	-----	29,478
Total	-----	345,418	-----	346,208	-----	[8] 308,164	-----	317,109

CONNECTICUT

Beryllium concentrate ... short tons, gross weight	16	$9	2	$1	7	$4	-----	-----
Clays ... thousand short tons	207	308	[3] 149	[3] 260	[3] 179	[3] 287	189	$339
Gem stones	(4)	7	(4)	9	(4)	8	(4)	8
Lime ... thousand short tons	35	616	33	589	35	635	35	666
Sand and gravel ... do	6,575	5,960	7,499	6,633	10,208	9,244	10,503	9,343
Stone ... do	5,057	8,313	5,206	8,616	5,090	8,816	5,318	9,612
Value of items that cannot be disclosed: Clays (kaolin 1961–62) feldspar, scrap mica (1961–63), sheet mica (1960–62), peat, and values indicated by footnote 5	-----	140	-----	491	-----	760	-----	646
Total	-----	15,353	-----	16,599	-----	19,754	-----	20,614

See footnotes at end of table.

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

Mineral	1960		1961		1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
DELAWARE								
Clays ... thousand short tons	(5)	(5)	(5)	(5)	(5)	(5)	13	$13
Sand and gravel ... do	1,084	$907	961	$970	1,755	$1,445	1,094	1,136
Value of items that cannot be disclosed: Nonmetals		82		83		86		192
Total		989		1,053		1,531		1,341
FLORIDA								
Clays ... thousand short tons	[3] 252	[3] $6,357	513	$7,202	487	$6,741	538	$7,777
Lime ... do	151	2,611	(5)	(5)	(5)	(5)	126	1,996
Natural gas ... million cubic feet	30	5	29	5	29	6	35	7
Peat ... short tons	39,275	162	26,673	157	[8] 20,595	[8] 139	21,049	129
Petroleum (crude) ... thousand 42-gallon barrels	369	(5)	374	(5)	419	(5)	[6] 464	(5)
Phosphate rock ... thousand long tons	12,321	82,530	13,789	95,590	13,949	94,595	14,592	101,050
Sand and gravel ... thousand short tons	6,757	5,559	6,530	5,577	5,924	5,179	7,542	5,823
Stone ... do	[7] 27,629	[7] 37,419	[7] 26,221	[7] 33,671	27,279	32,608	31,900	38,173
Titanium concentrate ... thousand short tons, gross weight	286	7,489	(5)	(5)	(5)	(5)	(5)	(5)
Value of items that cannot be disclosed: Cement, clays (kaolin and miscellaneous clay 1960), gem stones (1960-61, 1963), magnesium compounds, natural gas liquids (1962-63), rare-earth metals concentrates (1961-63), staurolite, stone (dimension limestone 1961, calcareous marl 1960), zirconium concentrate, and values indicated by footnote 5		38,154		45,919		[8] 46,432		46,665
Total		180,286		188,121		[8] 185,700		201,620

GEORGIA

Barite...short tons..	[5]	[5]	106,914	$2,046	108,829	$1,987	117,096	$2,013
Clays...thousand short tons..	3,519	$40,160	3,569	42,025	3,801	47,462	4,208	54,024
Coal (bituminous)...do....	4	21	4	22	8	28	5	16
Feldspar...long tons..	[5]	[5]	31,128	692	35,692	795	[5]	[5]
Gem stones...	[4]	[5]	[4]	[5]	[4]	[5]	[4]	1
Iron ore (usable)...thousand long tons, gross weight..	128	613	162	835	215	1,118	260	1,304
Mica (sheet)...pounds..	10,218	89	349	3	60	1	------	------
Peat...short tons..	6,904	73	1,914	[5]	[5]	[5]	[5]	[5]
Sand and gravel...thousand short tons..	3,338	3,047	3,150	3,049	3,429	3,365	3,817	3,922
Stone...do....	14,297	37,033	15,854	38,077	19,555	42,037	19,582	46,044
Talc...short tons..	40,200	88	47,950	98	45,940	96	42,000	93
Value of items that cannot be disclosed: Bauxite, cement, gem stones, iron ore (pigment material, 1960), kyanite (1963), manganiferous ore, (1960–62), scrap mica, and values indicated by footnote 5...	------	11,181	------	9,464	------	10,816	------	12,059
Total...	------	92,305	------	96,311	------	107,705	------	119,476

HAWAII

Cement...thousand 376-pound barrels..	113	$571	1,077	$5,574	1,128	$6,055	1,483	$7,125
Gem stones...	[4]	[5]	[4]	18	[4]	[5]	[4]	36
Lime...thousand short tons..	[5]	[5]	14	354	15	386	12	428
Pumice...do....	361	676	324	626	232	380	274	469
Salt...do....	------	------	[12]	4	[12]	[5]	[12]	[5]
Sand and gravel...do....	490	1,324	416	758	700	1,122	304	764
Stone...do....	3,535	6,443	4,429	7,656	4,071	6,883	3,844	6,480
Value of items that cannot be disclosed: Other nonmetals and values indicated by footnote 5...	------	353	------	------	------	18	------	5
Total...	------	9,367	------	14,990	------	14,844	------	15,307

See footnotes at end of table.

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

Mineral	1960 Quantity	1960 Value (thousands)	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)	1963 Quantity	1963 Value (thousands)
IDAHO								
Antimony ore and concentrate……short tons, antimony content	635	(5)	689	(5)	631	(5)	645	(5)
Clays……thousand short tons	[3] 36	[3] $29	[3] 27	[3] $20	35	$70	[3] 31	[3] $15
Copper (recoverable content of ores, etc.)……short tons	4,208	2,702	4,328	2,597	3,861	2,378	4,172	2,570
Gold (recoverable content of ores, etc.)……troy ounces	6,135	215	5,718	200	5,845	205	5,477	192
Iron ore (usable)……thousand long tons, gross weight	9	(5)	12	70	5	35	6	40
Lead (recoverable content of ores, etc.)……short tons	42,907	10,040	71,476	14,724	84,058	15,467	75,759	16,364
Lime……thousand short tons	----------	----------	47	658	68	801	60	874
Mercury……76-pound flasks	1,538	324	1,073	212	----------	----------	(5)	(5)
Phosphate rock……thousand long tons	2,177	11,044	1,440	7,984	1,912	10,635	1,700	10,589
Pumice……thousand short tons	56	88	60	95	[8] 67	[8] 103	161	275
Sand and gravel……do	7,088	6,594	7,305	6,793	14,321	13,029	12,433	10,615
Silver (recoverable content of ores, etc.)……thousand troy ounces	13,647	12,351	17,576	16,249	17,772	19,283	16,711	21,375
Stone……thousand short tons	1,318	2,141	1,873	3,111	1,381	2,698	1,168	2,217
Titanium concentrate……short tons, gross weight	2,014	30	1,873	28	(5)	(5)	(5)	(5)
Zinc (recoverable content of ores, etc.)……short tons	36,801	9,495	58,295	13,408	62,865	14,459	63,267	14,551
Value of items that cannot be disclosed: Barite, cement, clays (fire clay 1960–61, 1963, bentonite 1960–61, 1963, kaolin 1961, 1963), abrasive garnet, gem stones, scrap mica (1963), sheet mica (1960, 1962), peat, perlite (1961–63), tungsten concentrate (1961), uranium (1960–62), vanadium (1961–63), and values indicated by footnote 5	----------	2,553	----------	2,885	----------	3,451	----------	3,078
Total	----------	57,606	----------	69,034	----------	[8] 82,614	----------	82,755

ILLINOIS

Cement:								
Portland ... thousand 376-pound barrels } Masonry ... thousand 280-pound barrels }	9,139	$30,732	8,595	$28,301	9,145	$30,205	9,281	$30,577
Masonry ... thousand 280-pound barrels			461	1,420	440	1,320	472	1,440
Clays ... thousand short tons	2,357	5,479	1,982	4,166	1,929	4,151	1,949	4,368
Coal (bituminous) ... do	45,977	184,087	45,246	177,070	48,487	186,986	51,736	196,518
Fluorspar ... short tons	134,529	6,936	116,908	5,956	132,830	6,392	132,060	6,547
Lead (recoverable content of ores, etc.) ... do	3,000	702	3,430	707	3,610	664	2,901	627
Natural gas ... million cubic feet	11,666	1,458	9,970	1,276	10,650	1,523	9,459	1,220
Natural gas liquids:								
Natural gasoline and cycle products ... thousand gallons	16,496	1,313	16,956	1,311	13,315	1,023	14,939	1,077
LP gases ... do	358,366	19,941	340,284	16,495	327,616	13,812	337,278	14,714
Peat ... short tons	6,179	28	6,597	30	(5)	(5)	(5)	(5)
Petroleum (crude) ... thousand 42-gallon barrels	77,341	228,929	76,818	229,686	78,796	234,812	[6] 73,783	[6] 219,873
Sand and gravel ... thousand short tons	33,138	36,255	31,353	35,098	34,122	38,981	31,746	36,431
Stone ... do	41,721	55,593	36,361	47,939	41,293	54,411	40,293	52,217
Zinc (recoverable content of ores, etc.) ... short tons	29,550	7,624	26,795	6,163	27,413	6,305	20,337	4,678
Value of items that cannot be disclosed: Gem stones, lime, tripoli, and values indicated by footnote 5	------	10,797	------	11,775	------	12,133	------	13,656
Total	------	589,874	------	567,393	------	[8] 592,718	------	583,943

INDIANA

Abrasive stones ... short tons	(5)	(5)	5	$14	5	$15	5	$16
Cement [2] ... thousand 376-pound barrels	14,052	$48,310	13,780	47,024	12,878	42,572	(5)	(5)
Clays ... thousand short tons	1,822	3,396	1,362	2,446	1,450	2,255	1,546	2,347
Coal (bituminous) ... do	15,538	61,570	15,106	58,815	15,709	60,079	15,100	57,120
Natural gas ... million cubic feet	342	61	382	77	284	60	286	67
Peat ... short tons	27,486	290	57,146	502	47,430	272	47,695	412
Petroleum (crude) ... thousand 42-gallon barrels	12,054	35,439	11,500	34,270	12,077	35,989	[6] 11,417	[6] 33,794
Sand and gravel ... thousand short tons	20,752	18,377	19,577	16,898	21,261	18,692	22,840	20,683
Stone ... do	18,956	34,920	18,001	33,062	18,709	34,653	19,667	35,616
Value of items that cannot be disclosed: Cement (masonry 1960-61, 1963), gem stones (1961-63), gypsum, and values indicated by footnote 5	------	8,569	------	8,437	------	8,839	------	52,475
Total	------	210,932	------	201,545	------	[8] 203,426	------	202,530

See footnotes at end of table.

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

Mineral	1960 Quantity	1960 Value (thousands)	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)	1963 Quantity	1963 Value (thousands)
IOWA								
Cement:								
Portland ..... thousand 376-pound barrels	12,517	$44,204	12,108	$41,718	12,261	$42,417	12,495	$42,891
Masonry ..... thousand 280-pound barrels			557	1,843	568	1,786	551	1,754
Clays ..... thousand short tons	1,022	1,345	1,044	1,426	1,039	1,427	1,064	1,405
Coal (bituminous) ..... do	1,068	3,845	927	3,323	1,130	4,026	1,213	4,244
Gypsum ..... do	1,283	5,428	1,239	5,276	1,256	5,318	1,282	5,667
Sand and gravel ..... do	14,692	13,516	13,391	11,651	13,797	12,474	14,168	12,845
Stone ..... do	23,185	30,321	22,018	28,916	21,618	28,244	20,904	27,788
Value of items that cannot be disclosed: Gem stones (1960–62), lime, peat, and petroleum	-----	660	-----	845	-----	869	-----	1,076
Total	-----	99,319	-----	94,998	-----	96,561	-----	97,670
KANSAS								
Cement:								
Portland ..... thousand 376-pound barrels	8,162	$26,373	8,028	$25,605	8,058	$25,134	8,201	$25,372
Masonry ..... thousand 280-pound barrels			379	1,156	392	1,156	387	1,183
Clays ..... thousand short tons	894	1,224	954	1,225	895	1,091	893	1,104
Coal (bituminous) ..... do	888	4,197	664	3,102	915	4,249	1,169	5,311
Helium ..... thousand cubic feet	21,696	350	23,251	434	42,305	1,478	46,177	1,616
Lead (recoverable content of ores, etc.) ..... short tons	781	183	1,449	298	970	178	1,027	222
Lime ..... thousand short tons	-----	-----	15	193	5	59	-----	-----
Natural gas ..... million cubic feet	634,410	74,226	649,083	81,135	694,352	86,100	732,946	97,482
Natural gas liquids:								
Natural gasoline ..... thousand gallons	115,868	6,694	132,180	5,790	151,360	7,696	165,370	9,811
LP gases ..... do	127,270	6,343	135,643	5,916	166,769	6,295	395,877	15,481
Petroleum (crude) ..... thousand 42-gallon barrels	113,453	329,014	112,241	324,376	112,076	326,141	[6] 109,107	[6] 317,501
Salt ..... thousand short tons	1,213	14,109	[13] 913	[13] 11,409	[13] 944	[13] 11,654	[13] 924	[13] 11,993
Sand and gravel ..... do	9,710	6,808	11,366	7,781	11,552	8,039	12,062	8,676
Stone ..... do	[7] 11,814	[7] 15,031	[7] 12,328	[7] 16,411	[7] 13,527	[7] 17,274	13,558	18,483
Zinc (recoverable content of ores, etc.) ..... short tons	2,117	546	2,446	563	3,943	907	3,508	807
Value of items that cannot be disclosed: Natural cement, gem stones (1960), gypsum, pumice, salt (brine 1961–63), and stone (crushed sandstone 1960–62)	-----	1,436	-----	3,204	-----	3,625	-----	3,260
Total	-----	486,534	-----	488,598	-----	501,076	-----	518,302

KENTUCKY

Barite..........short tons..	(5)	(5)	3,304	$30	4,097	$36	5,812	$85
Clays [3]..........thousand short tons..	951	$2,646	906	2,406	936	2,158	984	2,397
Coal (bituminous)..........do....	66,846	282,395	63,032	256,158	69,212	270,875	77,350	295,743
Fluorspar..........short tons..	25,855	1,173	31,169	1,420	33,830	1,492	35,072	1,537
Lead (recoverable content of ores, etc.)..........do....	558	131	656	135	743	137	831	179
Natural gas..........million cubic feet..	75,329	18,380	70,937	17,592	70,241	17,419	74,634	17,838
Petroleum (crude)..........thousand 42-gallon barrels..	21,147	60,268	18,344	54,482	17,789	52,478	[6] 19,047	[6] 55,617
Sand and gravel..........thousand short tons..	5,113	5,763	5,582	5,540	6,137	5,378	6,480	6,071
Silver (recoverable content of ores, etc.)..........thousand troy ounces..	----------	----------	2	2	1	2	2	2
Stone..........thousand short tons..	[7] 15,810	[7] 21,493	17,085	23,309	19,472	27,682	24,689	34,571
Zinc (recoverable content of ores, etc.)..........short tons..	869	224	1,147	264	1,172	270	1,461	336
Value of items that cannot be disclosed: Cement, ball clay, gem stones, natural gas liquids, stone (crushed sandstone 1960), and values indicated by footnote 5..........	----------	22,080	----------	22,450	----------	20,609	----------	20,370
Total..........	----------	414,553	----------	383,788	----------	[8] 398,536	----------	434,746

LOUISIANA

Clays..........thousand short tons..	749	$749	645	$645	638	$641	655	$655
Lime..........do....	(5)	(5)	636	6,292	624	6,519	657	6,862
Natural gas..........million cubic feet..	2,988,414	511,019	3,271,857	611,837	3,525,456	694,515	3,928,427	777,829
Natural gas liquids:								
Natural gasoline and cycle products..........thousand gallons..	875,567	66,214	931,176	61,714	1,010,137	74,726	1,143,707	81,332
LP gases..........do....	606,023	28,147	806,559	33,214	862,772	29,037	1,113,670	41,043
Petroleum (crude)..........thousand 42-gallon barrels..	400,832	1,258,138	424,962	1,338,160	477,153	1,502,568	[6] 522,739	[6] 1,631,792
Salt..........thousand short tons..	4,792	21,959	4,722	23,357	5,248	27,407	6,199	30,450
Sand and gravel..........do....	14,319	19,106	12,042	14,833	12,040	14,817	12,500	14,701
Stone [7]..........do....	4,691	8,882	4,641	7,656	5,711	8,067	5,408	7,961
Sulfur (Frasch process)..........thousand long tons..	2,256	52,639	2,352	55,164	2,262	49,772	2,445	48,905
Value of items that cannot be disclosed: Cement, gypsum, stone (crushed miscellaneous), and values indicated by footnote 5..........	----------	24,042	----------	15,807	----------	18,554	----------	20,531
Total..........	----------	1,990,895	----------	2,168,679	----------	[8] 2,426,623	----------	2,662,061

See footnotes at end of table.

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

Mineral	1960		1961		1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
MAINE								
Beryllium concentrate short tons, gross weight	(5)	(5)	5	$3	(5)	(5)		
Clays thousand short tons	41	$50	43	51	48	$63	42	$55
Gem stones	(4)	15	(4)	20	(4)	25	(4)	25
Mica:								
Scrap short tons	171	6	80	2	15	(10)		
Sheet pounds	28,860	303	9,680	88	2,017	16		
Peat short tons					[8] 1,250	47	(5)	(5)
Sand and gravel thousand short tons	9,833	3,892	8,921	3,796	10,014	4,013	11,195	4,673
Stone do	1,012	3,851	998	4,694	1,127	4,249	947	3,581
Value of items that cannot be disclosed: Cement, feldspar, and values indicated by footnote 5		5,991		6,961		6,534		5,770
Total		14,108		15,615		14,947		14,104
MARYLAND								
Clays thousand short tons	[3] 612	[3] $853	581	$997	593	$899	580	$897
Coal (bituminous) do	748	2,799	757	2,868	821	3,168	1,162	4,330
Gem stones	(4)	2	(4)	3	(4)	3	(4)	3
Natural gas million cubic feet	4,065	1,081	3,578	973	2,472	667	1,633	439
Sand and gravel thousand short tons	10,076	13,221	12,404	16,894	12,762	16,816	13,310	16,063
Stone do	7,944	16,962	10,007	20,373	11,610	22,595	13,012	26,407
Value of items that cannot be disclosed: Cement, ball clay (1960), diatomite (1962–63), lime, greensand marl, peat (1961–63), potassium salts, and talc and soapstone		22,779		20,750		22,481		22,111
Total		57,697		62,858		66,629		70,250

MASSACHUSETTS

Clays ... thousand short tons	83	$71	104	$85	125	$96	157	$213
Gem stones	(4)	1	(4)	2	(4)	2	(4)	2
Lime ... thousand short tons	154	2,370	145	2,307	148	2,337	145	2,426
Sand and gravel ... do	14,789	13,013	18,061	14,958	17,566	15,026	19,905	15,592
Stone ... do	5,247	12,782	5,210	13,399	4,985	12,541	5,570	14,396
Value of items that cannot be disclosed: Nonmetals	------	8	------	38	------	33	------	32
Total	------	28,245	------	30,789	------	30,035	------	32,661

MICHIGAN

Cement:								
Portland ... thousand 376-pound barrels	22,361	$77,694	21,948	$75,172	22,682	$73,267	25,016	$76,944
Masonry ... thousand 280-pound barrels			1,515	4,467	1,517	4,335	1,684	4,519
Clays ... thousand short tons	1,738	1,904	1,817	1,975	1,751	1,917	1,958	2,149
Copper (recoverable content of ores, etc.) ... short tons	56,385	36,199	70,245	42,147	74,099	45,645	75,262	46,361
Gypsum ... thousand short tons	1,463	5,609	1,295	5,095	1,278	4,791	1,315	4,938
Iron ore (usable) ... thousand long tons, gross weight	10,792	95,791	9,384	87,604	9,422	85,597	10,789	107,201
Lime ... thousand short tons	1,177	15,730	1,190	15,665	1,153	15,371	1,371	18,431
Magnesium compounds from sea water and brine (except for metal) short tons, MgO equivalent	(5)	(5)	(5)	(5)	(5)	(5)	266,740	23,062
Manganiferous ore (5 to 35 percent Mn) ... short tons, gross weight	180,460	(5)	17,083	(5)	------	------	152,957	(5)
Natural gas ... million cubic feet	20,790	4,449	27,697	5,844	28,987	6,174	32,850	8,902
Peat ... short tons	214,402	2,755	210,376	2,009	257,693	2,277	251,809	2,413
Petroleum (crude) ... thousand 42-gallon barrels	15,899	46,266	18,901	55,191	17,114	48,775	[6] 15,973	[6] 45,523
Salt ... thousand short tons	4,088	33,759	3,885	31,284	4,274	33,343	4,244	33,656
Sand and gravel ... do	46,910	39,304	54,603	47,790	47,563	42,029	50,458	43,433
Silver (recoverable content of ores, etc.) ... thousand troy ounces	------	------	------	------	401	436	339	434
Stone ... thousand short tons	31,256	32,274	28,731	30,103	28,440	29,055	30,316	32,065
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, gem stones, iodine (1961–63), natural gas liquids, potassium salts, and values indicated by footnote 5	------	45,864	------	46,306	------	53,500	------	42,001
Total	------	437,598	------	450,652	------	[8] 446,512	------	492,032

MINNESOTA

Clays ... thousand short tons	[3] 125	[3] $163	[3] 176	[3] $241	203	$291	[3] 199	[3] $298
Iron ore (usable) ... thousand long tons, gross weight	54,723	470,874	44,699	407,152	44,295	385,997	45,435	408,486
Manganiferous ore (5 to 35 percent Mn) ... short tons, gross weight	441,028	(5)	181,835	(5)	292,779	(5)	347,336	(5)
Peat ... short tons	1,465	72	11,091	181	[8] 14,386	307	8,110	294
Sand and gravel ... thousand short tons	30,302	24,611	30,690	24,143	29,399	22,656	30,462	23,318
Stone ... do	4,234	10,034	3,957	9,975	3,803	10,360	3,898	11,027
Value of items that cannot be disclosed: Abrasive stones, cement, fire clay (1960–61, 1963), gem stones, lime, and values indicated by footnote 5	------	9,767	------	9,222	------	9,325	------	10,120
Total	------	515,521	------	450,914	------	428,936	------	453,543

See footnotes at end of table.

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

Mineral	1960 Quantity	1960 Value (thousands)	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)	1963 Quantity	1963 Value (thousands)
MISSISSIPPI								
Clays .... thousand short tons	1,017	$4,786	1,104	$5,034	1,129	$5,742	1,235	$5,968
Natural gas .... million cubic feet	172,478	32,426	172,543	32,093	170,271	32,351	176,807	31,825
Natural gas liquids:								
Natural gasoline and cycle products .... thousand gallons	23,648	1,552	25,135	1,625	25,891	1,616	28,757	1,755
LP gases .... do	10,151	564	15,510	700	20,401	732	24,541	956
Petroleum (crude) .... thousand 42-gallon barrels	51,673	146,235	54,688	154,220	55,713	154,882	[6] 58,752	[6] 162,156
Sand and gravel .... thousand short tons	6,181	5,568	5,920	5,903	7,001	7,262	6,825	7,056
Stone .... do	807	808	913	1,044	1,199	1,266	1,267	1,267
Value of items that cannot be disclosed: Certain nonmetals	....	7,271	....	7,961	....	9,030	....	8,955
Total	....	199,210	....	208,580	....	[8] 212,881	....	219,938
MISSOURI								
Barite .... short tons	180,702	$2,588	227,323	$3,052	303,945	$3,994	286,750	$3,680
Cement:								
Portland .... thousand 376-pound barrels	12,183 (Portland and Masonry)	42,330 (Portland and Masonry)	11,839	41,142	12,739	44,004	12,402	41,640
Masonry .... thousand 280-pound barrels			437	1,398	455	1,457	417	1,345
Clays .... thousand short tons	2,540	7,207	2,132	5,040	2,053	5,033	1,746	4,467
Coal (bituminous) .... do	2,890	12,450	2,938	12,567	2,896	12,057	3,174	13,196
Copper (recoverable content of ores, etc.) .... short tons	1,087	698	1,479	887	2,752	1,695	1,816	1,119
Iron ore (usable) .... thousand long tons, gross weight	365	3,760	341	3,633	346	3,188	345	3,085
Lead (recoverable content of ores, etc.) .... short tons	111,948	26,196	98,785	20,350	60,982	11,221	79,844	17,246
Lime .... thousand short tons	1,254	14,701	1,173	13,873	1,176	13,703	1,240	14,386
Natural gas .... million cubic feet	75	19	90	22	92	23	100	27
Petroleum (crude) .... thousand 42-gallon barrels	75	(5)	72	(5)	55	(5)	[6] 54	(5)
Sand and gravel .... thousand short tons	10,207	11,601	9,371	10,688	10,304	11,572	10,653	12,260
Silver (recoverable content of ores, etc.) .... thousand troy ounces	16	14	12	11	491	533	132	168
Stone .... thousand short tons	27,180	37,878	25,631	36,577	28,876	44,006	30,885	46,130
Zinc (recoverable content of ores, etc.) .... short tons	2,821	728	5,847	1,345	2,792	642	321	74
Value of items that cannot be disclosed: Native asphalt, cobalt (1960–61), gem stones, nickel (1960–61), and values indicated by footnote 5	....	2,074	....	703	....	179	....	168
Total	....	162,244	....	151,288	....	153,307	....	158,991

MONTANA

Chromite — short tons, gross weight	[14] 107,000	[14] $3,813	[14] 82,000	[14] $2,939	----------	----------	----------	----------
Clays [3] — thousand short tons	63	77	55	76	56	$77	38	$45
Coal (bituminous and lignite) — do	313	1,188	371	1,207	382	1,140	343	967
Copper (recoverable content of ores, etc.) — short tons	91,972	59,046	104,000	62,400	94,021	57,917	79,762	49,133
Fluorspar — do	31,273	(5)	14,905	(5)	(5)	(5)	(5)	(5)
Gold (recoverable content of ores, etc.) — troy ounces	45,922	1,607	35,377	1,238	24,387	854	18,520	648
Iron ore (usable) — thousand long tons, gross weight	55	293	34	209	9	62	13	89
Lead (recoverable content of ores, etc.) — short tons	4,879	1,142	2,643	544	6,121	1,126	5,000	1,080
Lime — thousand short tons	(5)	(5)	118	986	104	1,049	114	1,290
Manganese ore (35 percent or more Mn) — short tons, gross weight	29,036	1,996	17,515	1,372	24,758	(5)	5,260	(5)
Manganiferous ore (5 to 35 percent Mn) — do	676	11	2,236	33	2,264	29	1,688	(5)
Natural gas — million cubic feet	33,418	2,373	33,901	2,509	29,955	2,217	30,026	2,253
Peat — short tons	----------	----------	7,385	112	(5)	(5)	(5)	(5)
Petroleum (crude) — thousand 42-gallon barrels	30,240	72,878	30,906	74,793	31,648	76,690	[6] 30,875	[6] 75,335
Sand and gravel — thousand short tons	12,589	11,657	14,702	13,506	18,473	17,642	14,319	13,756
Silver (recoverable content of ores, etc.) — thousand troy ounces	3,607	3,265	3,490	3,227	4,561	4,948	4,242	5,426
Stone — thousand short tons	1,183	1,576	1,512	1,849	996	1,708	6,109	7,081
Uranium ore — short tons	1,726	29	729	10	(5)	(5)	(5)	(10)
Zinc (recoverable content of ores, etc.) — do	12,551	3,238	10,262	2,360	37,678	8,666	32,941	7,576
Value of items that cannot be disclosed: Barite, cement, chromite,[14] clays (fire clay), gem stones, gypsum, sheet mica (1960–62), natural gas liquids, phosphate rock, rare-earth metal concentrates (1962), talc, tungsten (1960–62), vermiculite, and values indicated by footnote 5	----------	15,217	----------	14,863	----------	16,531	----------	17,348
Total	----------	179,406	----------	184,233	----------	190,656	----------	182,027

NEBRASKA

Clays — thousand short tons	108	$109	146	$148	142	$142	148	$148
Gem stones	(4)	4	(4)	5	(4)	5	(4)	5
Natural gas — million cubic feet	15,258	2,670	15,743	2,629	14,880	2,708	13,051	2,454
Natural gas liquids:								
Natural gasoline — thousand gallons	(5)	(5)	(5)	(5)	12,239	809	10,119	687
LP gases — do	(5)	(5)	(5)	(5)	28,718	1,329	25,931	1,207
Petroleum (crude) — thousand 42-gallon barrels	23,825	68,378	24,369	69,452	24,894	70,450	[6] 21,775	[6] 61,623
Sand and gravel — thousand short tons	10,876	8,746	10,094	8,250	12,853	9,797	11,166	10,680
Stone — do	3,336	5,651	3,622	6,324	3,670	6,626	3,700	6,192
Value of items that cannot be disclosed: Cement, lime (1961–63), pumice, and values indicated by footnote 5	----------	18,384	----------	18,637	----------	16,507	----------	15,710
Total	----------	103,942	----------	105,445	----------	[8] 108,373	----------	98,706

See footnotes at end of table.

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

Mineral	1960 Quantity	1960 Value (thousands)	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)	1963 Quantity	1963 Value (thousands)
NEVADA								
Barite, short tons	86,061	$591	129,524	$863	137,727	$954	120,450	$760
Copper (recoverable content of ores, etc.), do	77,485	49,745	78,022	46,813	82,602	50,883	81,738	50,351
Fluorspar, do	18,505	388	18,129	357	(5)	(5)	(5)	(5)
Gem stones	(4)	100	(4)	100	(4)	100	(4)	100
Gold (recoverable content of ores, etc.), troy ounces	58,187	2,037	54,165	1,896	62,863	2,200	98,879	3,461
Gypsum, thousand short tons	802	2,721	729	2,625	817	2,952	890	3,216
Iron ore (usable), thousand long tons, gross weight	740	3,683	845	4,608	617	3,238	772	3,921
Lead (recoverable content of ores, etc.), short tons	987	231	1,791	369	771	142	1,126	243
Manganese ore (35 percent or more Mn), short tons, gross weight	49,076	3,301	28,573	1,852	-----	-----	-----	-----
Mercury, 76-pound flasks	7,821	1,648	7,486	1,480	6,573	1,257	4,944	937
Perlite, short tons	35,214	286	29,544	240	25,067	205	22,910	192
Petroleum (crude), thousand 42-gallon barrels	27	(5)	154	(5)	141	(5)	[6] 96	(5)
Sand and gravel, thousand short tons	4,085	5,224	7,095	7,443	7,850	9,655	9,688	10,513
Silver (recoverable content of ores, etc.), thousand troy ounces	707	640	388	359	245	266	215	275
Stone, thousand short tons	579	1,350	677	1,576	722	1,220	639	1,101
Sulfur ore, long tons	(5)	(5)	(5)	(5)	(5)	(5)	586	11
Talc and soapstone, short tons	4,882	30	3,090	33	6,157	55	4,243	50
Tungsten ore and concentrate, short tons, 60-percent WO_3 basis	(5)	(5)	(5)	(5)	156	234	(5)	(5)
Zinc (recoverable content of ores, etc.), short tons	420	108	453	104	281	65	571	131
Value of items that cannot be disclosed: Clays, diatomite, lime, magnesite, manganiferous ore (1960), molybdenum, pumice, salt, uranium ore (1960–61, 1963), and values indicated by footnote 5	-----	8,809	-----	10,815	-----	[8] 9,648	-----	10,178
Total	-----	80,892	-----	81,533	-----	[8] 83,074	-----	85,440
NEW HAMPSHIRE								
Beryllium concentrate, short tons, gross weight	14	$8	23	$14	7	$4	-----	-----
Clays, thousand short tons	27	27	30	30	37	37	110	$103
Feldspar, long tons	(5)	(5)	10,290	62	(5)	(5)	(5)	(5)
Gem stones	(4)	15	(4)	(5)	(4)	(5)	(4)	(5)
Mica:								
Sheet, pounds	80,077	1,026	105,943	1,009	[8] 37,508	[8] 396	-----	-----
Scrap, short tons	415	14	669	20	411	11	-----	-----
Peat, do	23	(5)	15	(5)	-----	-----	-----	-----
Sand and gravel, thousand short tons	6,621	3,687	7,701	3,627	8,260	4,119	7,581	4,376
Stone, do	104	594	117	684	154	1,368	137	1,566
Value of items that cannot be disclosed: Values indicated by footnote [5]	-----	68	-----	20	-----	97	-----	109
Total	-----	5,439	-----	5,466	-----	[8] 6,032	-----	6,154

NEW JERSEY

Clays .... thousand short tons	664	$1,597	657	$1,681	584	$1,476	498	$1,392
Gem stones	[4]	7	[4]	9	[4]	9	[4]	9
Peat .... short tons	25,100	192	21,257	212	[8] 29,099	247	23,685	241
Sand and gravel .... thousand short tons	11,594	19,511	12,257	20,895	13,728	21,230	16,672	25,245
Stone .... do	10,202	22,814	11,315	24,539	14,214	28,979	11,229	25,654
Zinc (recoverable content of ores, etc.) [15] .... short tons	------	------	112	26	15,309	3,559	32,738	7,855
Value of items that cannot be disclosed: Iron ore, lime, magnesium compounds, manganiferous residuum, greensand marl, titanium concentrate (ilmenite 1962-63) uranium ore (1960)	------	12,348	------	11,908	------	10,186	------	12,880
Total	------	56,469	------	59,270	------	65,686	------	73,276

NEW MEXICO

Barite .... short tons	492	$10	600	$10	252	$4	600	$6
Beryllium concentrate .... short tons, gross weight	------	------	24	12	34	19	------	------
Carbon dioxide, natural .... thousand cubic feet	230,115	[5]	242,903	24	826,810	74	854,339	63
Clays .... thousand short tons	[3] 56	[3] 132	[3] 67	[3] 165	52	156	[5]	140
Coal (bituminous) .... do	295	1,747	412	2,477	677	2,595	1,945	5,629
Copper (recoverable content of ores, etc.) .... short tons	67,288	43,199	79,606	47,764	82,683	50,933	83,037	51,151
Gem stones	[4]	40	[4]	46	[4]	45	[4]	45
Gold (recoverable content of ores, etc.) .... troy ounces	5,423	190	6,201	217	7,529	264	7,805	273
Gypsum .... thousand short tons	55	193	105	386	151	564	179	656
Helium .... thousand cubic feet	43,494	684	42,224	762	27,377	958	79,624	2,787
Iron ore (usable) .... thousand long tons, gross weight	1	27	[16]	[5]	9	121	[5]	[5]
Lead (recoverable content of ores, etc.) .... short tons	1,996	467	2,332	480	1,134	209	1,014	219
Lime .... thousand short tons	36	496	25	350	29	403	27	377
Manganiferous ore (5 to 35 percent Mn) .... short tons, gross weight	[5]	[5]	[5]	[5]	[5]	[5]	41,144	242
Mica: Scrap .... short tons	235	7	1,800	52	5,731	140	[5]	[5]
Natural gas .... million cubic feet	798,928	85,485	789,662	86,073	804,612	92,530	808,377	96,197
Natural gas liquids:								
Natural gasoline and cycle products .... thousand gallons	321,667	20,412	301,404	18,619	273,969	16,775	291,388	17,555
LP gases .... do	645,116	28,788	656,751	24,154	661,330	20,359	728,200	21,801
Perlite .... short tons	240,593	2,119	245,654	2,159	258,164	2,143	259,113	2,212
Petroleum (crude) .... thousand 42-gallon barrels	107,380	305,895	112,553	322,142	109,328	314,883	[6] 109,613	[6] 315,632
Potassium salts .... thousand short tons, K_2O equivalent	2,440	82,645	2,523	96,380	2,208	85,124	2,644	100,570
Pumice .... thousand short tons	365	827	339	879	308	741	322	850
Salt .... do	39	331	33	284	43	334	57	518
Sand and gravel .... do	7,419	7,459	12,523	10,049	6,889	8,021	8,402	12,843
Silver (recoverable content of ores, etc.) .... thousand troy ounces	304	275	283	261	302	327	256	328
Stone .... thousand short tons	1,277	1,692	1,853	2,206	2,004	2,782	2,509	4,236
Uranium ore .... short tons	3,793,494	61,827	3,631,036	62,482	3,478,238	63,504	2,304,577	41,372
Vanadium (recoverable in ore and concentrate) .... do	[5]	[5]	[5]	[5]	[5]	[5]	23	[5]
Zinc (recoverable content of ores, etc.) .... do	13,770	3,553	22,900	5,267	22,015	5,063	12,938	2,976
Value of items that cannot be disclosed: Cement, fire clay (1960-61), molybdenum, magnesium compounds (1960-61), manganese ore, (1962-63), sheet mica (1960, 1962), vanadium, and values indicated by footnote [5]	------	5,266	------	7,213	------	6,743	------	8,144
Total	------	653,766	------	690,913	------	[8] 675,814	------	686,822

See footnotes at end of table.

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

Mineral	1960		1961		1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
NEW YORK								
Clays thousand short tons	1,172	$1,717	1,037	$1,373	1,397	$1,618	1,598	$2,186
Emery short tons	8,169	142	6,180	106	4,316	71	6,732	119
Gem stones	(4)	9	(4)	10	(4)	10	(4)	10
Gypsum thousand short tons	755	3,928	663	3,441	601	3,122	647	3,339
Iron ore, (usable) thousand long tons, gross weight	2,484	32,977	1,973	25,548	2,099	24,953	(5)	(5)
Lead (recoverable content of ores, etc.) short tons	775	181	879	181	1,063	196	1,009	218
Natural gas million cubic feet	4,990	1,542	5,742	1,694	4,262	1,198	3,962	1,169
Peat short tons	10,042	146	11,209	123	[8] 14,400	113	21,358	178
Petroleum (crude) thousand 42-gallon barrels	1,813	8,412	1,658	7,892	1,589	7,309	[6] 1,929	[6] 8,854
Salt thousand short tons	4,008	30,763	4,149	30,761	4,456	32,236	4,782	34,228
Sand and gravel do	30,687	35,152	28,043	30,471	29,447	31,346	37,381	37,274
Silver (recoverable content of ores, etc.) thousand troy ounces	49	45	41	37	19	21	20	25
Stone thousand short tons	29,802	46,955	26,951	43,734	27,589	47,256	26,611	44,549
Zinc (recoverable content of ores, etc.) short tons	66,364	17,122	54,763	12,595	53,654	12,340	53,495	12,304
Value of items that cannot be disclosed: Beryllium concentrate (1960–61), cement, abrasive garnet, lime, talc, titanium concentrate, wollastonite, and values indicated by footnote 5		81,831		75,867		79,183		115,768
Total		260,922		233,833		[8] 240,972		260,221

NORTH CAROLINA

Abrasive stones (millstones)....short tons..	(4)	$2	(4)	$3	(4)	$2	(4)	$2
Clays [3]....thousand short tons..	2,476	1,548	2,603	1,669	2,731	1,782	2,735	1,761
Feldspar....long tons..	270,761	2,781	251,858	2,477	244,708	2,373	267,654	2,821
Gem stones....	(4)	4	(4)	6	(4)	2	(4)	14
Gold (recoverable content of ores, etc.)....troy ounces..	1,826	64	2,094	73	460	16	33	1
Iron ore (usable)....thousand long tons..	(5)	(5)	(5)	1	1	13	1	10
Lead (recoverable content of ores, etc.)....short tons..	424	99	318	66	219	40	62	13
Mica:								
Scrap....do....	47,281	1,100	53,615	1,010	61,983	1,384	61,598	1,497
Sheet....pounds...	436,579	1,539	390,870	2,237	320,305	867	92,961	13
Sand and gravel....thousand short tons..	8,801	7,453	9,779	8,467	12,516	11,457	11,028	10,132
Silver (recoverable content of ores, etc.)....thousand troy ounces..	212	192	170	157	100	109	27	34
Stone....thousand short tons..	14,721	23,296	15,921	25,262	19,308	29,533	15,701	25,683
Talc and pyrophyllite....short tons..	100,593	549	90,711	367	100,298	433	106,652	446
Zinc (recoverable content of ores, etc.)....do....	----	----	----	----	----	----	13	3
Value of items that cannot be disclosed: Asbestos, barite (1961), cement (1963), clay (kaolin), copper, lithium minerals, olivine, tungsten concentrate, and values indicated by footnote 5....	----	6,469	----	8,329	----	6,586	----	2,464
Total....	----	45,096	----	50,124	----	54,597	----	44,894

NORTH DAKOTA

Clays....thousand short tons..	[3] 102	[3] $129	(5)	(5)	98	$124	[3] 5	[3] $10
Coal (lignite)....do....	2,525	5,790	2,726	$6,141	2,733	6,135	2,399	5,250
Gem stones....	(4)	1	(4)	1	(4)	1	(4)	1
Natural gas....million cubic feet..	19,483	2,221	20,100	2,533	25,155	3,446	32,798	6,264
Natural gas liquids:								
Natural gasoline....thousand gallons..	(5)	(5)	(5)	(5)	16,872	1,085	20,511	1,339
LP gases....do....	(5)	(5)	(5)	(5)	68,881	2,665	79,653	3,166
Petroleum (crude)....thousand 42-gallon barrels..	21,992	59,598	23,652	64,333	25,181	69,248	[6] 24,957	[6] 68,133
Sand and gravel....thousand short tons..	8,648	6,904	9,395	7,507	9,615	7,122	9,529	9,193
Stone....do....	28	44	40	40	19	19	132	132
Uranium ore....short tons..	----	----	----	----	(5)	(5)	5,567	141
Value of items that cannot be disclosed: Clays (bentonite 1960, 1963, fire clay 1960, miscellaneous clay 1963), peat (1963), salt, and values indicated by footnote 5....	----	3,691	----	4,370	----	774	----	875
Total....	----	78,378	----	84,925	----	[8] 90,619	----	94,504

See footnotes at end of table.

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

Mineral	1960		1961		1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
OHIO								
Cement:								
Portland .... thousand 376-pound barrels..	17,480	$61,478	15,303	$53,251	15,353	$51,006	16,218	$53,244
Masonry .... thousand 280-pound barrels..			846	2,604	946	2,793	1,023	3,084
Clays .... thousand short tons..	5,165	14,325	4,923	13,790	4,751	12,979	4,841	13,959
Coal (bituminous) .... do....	33,957	130,877	32,226	121,343	34,125	127,051	36,790	136,113
Gem stones	([4])	3	([4])	4	([4])	3	([4])	3
Lime .... thousand short tons..	3,117	44,403	3,048	41,266	3,102	43,792	3,207	45,957
Natural gas .... million cubic feet..	36,074	8,477	36,423	9,069	36,747	9,407	36,817	8,909
Peat .... short tons..	6,755	93	9,113	123	7,383	106	6,910	109
Petroleum (crude) .... thousand 42-gallon barrels..	5,405	16,053	5,639	17,425	5,835	18,089	[6] 6,171	[6] 19,439
Salt .... thousand short tons..	3,108	24,149	3,465	25,037	4,187	28,706	4,245	29,682
Sand and gravel .... do....	37,943	44,979	33,688	41,272	35,204	43,333	37,790	44,368
Stone .... do....	[7] 35,856	[7] 59,479	33,652	55,701	34,470	57,202	37,537	62,787
Value of items that cannot be disclosed: Abrasive stones, gypsum, stone (dimension limestone 1960, calcareous marl 1960)	....	1,826	....	1,566	....	1,588	....	1,742
Total	....	406,142	....	382,451	....	[8] 396,055	....	419,396
OKLAHOMA								
Clays [3] .... thousand short tons..	734	$739	792	$801	737	$756	898	$911
Coal (bituminous) .... do....	1,342	9,113	1,032	6,784	1,048	6,978	1,008	5,667
Gypsum .... do....	([5])	([5])	([5])	([5])	509	1,668	531	1,462
Helium .... thousand cubic feet..	289,068	4,691	313,244	5,872	284,214	9,917	237,201	8,302
Lead (recoverable content of ores, etc.) .... short tons..	936	219	980	202	2,710	499	3,192	689
Natural gas .... million cubic feet..	824,266	98,088	892,697	108,016	1,060,717	135,772	1,233,883	160,405
Natural gas liquids:								
Natural gasoline and cycle products .... thousand gallons..	531,995	33,074	521,237	33,358	552,795	35,764	555,467	35,131
LP gases .... do....	762,258	32,409	817,082	30,141	838,903	25,223	810,894	28,981
Petroleum (crude) .... thousand 42-gallon barrels..	192,913	563,306	193,081	561,866	202,732	591,977	[6] 200,238	[6] 582,693
Salt .... thousand short tons..	3	16	3	19	5	25	4	26
Sand and gravel .... do....	6,424	7,468	5,310	5,513	4,436	4,736	5,420	6,116
Stone .... do....	[7] 14,054	[7] 16,098	14,981	16,561	14,666	18,819	13,817	16,160
Zinc (recoverable content of ores, etc.) .... short tons..	2,332	602	3,148	724	10,013	2,303	13,245	3,046
Value of items that cannot be disclosed: Native asphalt (1960), clay (bentonite), cement, gem stones (1960–62), lime, pumice, stone (crushed granite 1960), tripoli, and values indicated by footnote 5	....	16,756	....	21,920	....	20,853	....	22,929
Total	....	782,579	....	791,777	....	[8] 855,290	....	872,518

OREGON

Clays ---- thousand short tons	318	$370	294	$357	249	$305	279	$330
Copper (recoverable content of ores, etc.) ---- short tons	6	4	(5)	(5)	(5)	(5)	(5)	(5)
Diatomite ---- do	----	----	----	----	50	2	150	3
Gold (recoverable content of ores, etc.) ---- troy ounces	835	29	1,054	37	822	29	1,809	63
Lime ---- thousand short tons	(5)	(5)	82	1,702	78	1,514	87	1,835
Mercury ---- 76-pound flasks	513	108	138	27	(5)	(5)	(5)	(5)
Nickel (content of ore and concentrate) ---- short tons	13,115	5,246	12,860	(5)	13,110	(5)	13,394	(5)
Perlite ---- do	----	----	----	----	3	(10)	----	----
Pumice ---- thousand short tons	(5)	(5)	203	461	(5)	(5)	422	664
Sand and gravel ---- do	17,673	16,170	12,299	13,680	14,869	14,556	15,715	18,850
Silver (recoverable content of ores, etc.) ---- thousand troy ounces	(17)	(10)	2	2	6	7	58	74
Stone ---- thousand short tons	16,913	19,721	17,455	21,202	18,258	20,977	19,692	24,197
Uranium ore ---- short tons	(5)	(5)	2,160	66	2,722	112	1,763	45
Zinc (recoverable content of ores, etc.) ---- do	----	----	3	1	----	----	3	1
Value of items that cannot be disclosed: Asbestos (1960-61), carbon dioxide (1960), cement, gem stones, iron ore (pigment material 1961, 1963), lead (1961, 1963), and values indicated by footnote 5	----	14,124	----	15,557	----	14,956	----	16,630
Total	----	55,772	----	53,092	----	52,458	----	62,692

PENNSYLVANIA

Cement:								
Portland ---- thousand 376-pound barrels	38,320 (Portland and Masonry combined)	$131,763 (Portland and Masonry combined)	36,635	$124,506	38,463	$127,969	38,316	$118,203
Masonry ---- thousand 280-pound barrels			2,678	7,232	2,565	7,105	2,510	6,611
Clays [3] ---- thousand short tons	3,557	16,536	2,999	14,402	2,893	12,815	3,191	14,717
Coal:								
Anthracite ---- do	18,817	147,116	17,446	140,338	16,894	134,094	18,267	153,503
Bituminous ---- do	65,425	345,971	62,652	323,758	65,315	331,298	71,501	350,085
Copper (recoverable content of ores, etc.) ---- short tons	(5)	(5)	(5)	(5)	(5)	(5)	4,434	2,731
Gem stones	(4)	4	(4)	5	(4)	4	(4)	4
Lime ---- thousand short tons	1,120	16,277	1,093	16,428	1,104	16,647	1,188	17,548
Natural gas ---- million cubic feet	113,928	36,229	100,427	29,526	90,053	24,494	92,657	24,091
Natural gas liquids:								
Natural gasoline ---- thousand gallons	1,399	85	1,272	74	1,350	75	1,311	78
LP gases ---- do	1,580	138	1,453	115	1,521	112	1,721	118
Peat ---- short tons	30,837	325	27,993	291	32,936	369	33,952	339
Petroleum (crude) ---- thousand 42-gallon barrels	6,009	27,341	5,643	26,579	5,302	24,230	[6] 4,963	[6] 22,631
Sand and gravel ---- thousand short tons	13,011	21,204	12,594	19,766	14,419	23,587	14,066	23,539
Stone ---- do	42,136	74,168	41,834	71,344	48,144	82,087	49,536	83,450
Zinc (recoverable content of ores, etc.)[15] ---- short tons	13,746	3,559	23,428	5,408	24,308	5,652	27,389	6,572
Value of items that cannot be disclosed: Clays (kaolin), cobalt, gold, graphite (1960-61), iron ore, scrap mica, pyrites, pyrophyllite, silver, tripoli, and values indicated by footnote 5	----	17,430	----	25,355	----	32,966	----	32,644
Total	----	838,146	----	805,127	----	[8] 823,504	----	856,864

See footnotes at end of table.

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

Mineral	1960		1961		1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
RHODE ISLAND								
Gem stones			(4)	(5)	(4)	(5)	(4)	$1
Sand and gravel .... thousand short tons	1,535	$1,355	1,726	$1,666	2,346	$1,890	1,750	1,838
Stone .... do	1,810	4,372	(5)	(5)	[7] 304	[7] 483	442	968
Value of items that cannot be disclosed: Nonmetals and values indicated by footnote 5				1,413		621		
Total		5,727		3,079		2,994		2,807
SOUTH CAROLINA								
Clays .... thousand short tons	1,297	$6,201	1,346	$6,169	1,518	$7,165	1,491	$7,589
Mica (sheet) .... pounds	101	1	12	(10)				
Sand and gravel .... thousand short tons	3,029	3,048	2,904	3,067	3,318	3,670	4,051	4,750
Stone .... do	7,327	10,593	6,752	9,827	6,382	10,066	7,262	10,926
Value of items that cannot be disclosed: Barite, cement, feldspar, gem stones (1962–63), kyanite, scrap mica, peat, pyrites, and vermiculite		11,144		12,311		13,000		13,214
Total		30,987		31,374		33,901		36,479

Beryllium concentrate ... short tons, gross weight	167	$88	238	$130	144	$77	(9)	(10)
Cement:								
Portland ... thousand 376-pound barrels	(5)	(5)	(5)	(5)	2,316	7,369	(5)	(5)
Masonry ... thousand 280-pound barrels	(5)	(5)	(5)	(5)	60	197	(5)	(5)
Clays ... thousand short tons	[3] 202	[3] 202	[3] 249	[3] 249	249	690	315	$1,958
Coal (lignite) ... do	20	83	18	75	18	77	16	62
Copper (recoverable content of ores, etc.) ... short tons	1	1	------	------	------	------	1	(10)
Feldspar ... long tons	45,588	292	29,354	186	29,697	191	25,590	157
Gem stones ...	(4)	20	(4)	18	(4)	20	(4)	20
Gold (recoverable content of ores, etc.) ... troy ounces	554,771	19,417	557,855	19,525	577,232	20,203	576,726	20,185
Gypsum ... thousand short tons	22	89	22	89	23	93	24	97
Iron ore (usable) ... thousand long tons	(5)	(5)	22	100	34	113	------	------
Lead (recoverable content of ores, etc.) ... short tons	------	------	------	------	3	1	4	1
Mica:								
Scrap ... short tons	205	10	1,054	32	210	6	(5)	(5)
Sheet ... pounds	30,887	145	18,086	37	2,085	12	10,000	(10)
Petroleum (crude) ... thousand 42-gallon barrels	281	(5)	233	(5)	169	(5)	[6] 187	(5)
Sand and gravel ... thousand short tons	13,548	9,359	11,324	7,336	15,371	9,207	20,806	16,313
Silver (recoverable content of ores, etc.) ... thousand troy ounces	108	98	127	118	113	123	117	150
Stone ... thousand short tons	3,149	7,909	2,806	6,642	2,852	6,533	2,794	7,339
Uranium ore ... short tons	41,104	586	43,588	495	29,452	370	72,088	1,931
Value of items that cannot be disclosed: Clays (bentonite 1960–61), lime, lithium minerals (1960, 1962–63), vanadium, and values indicated by footnote 5 ...	------	9,376	------	8,975	------	[8] 505	------	6,845
Total ...	------	47,675	------	44,007	------	[8] 45,787	------	55,058

See footnotes at end of table.

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

Mineral	1960 Quantity	1960 Value (thousands)	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)	1963 Quantity	1963 Value (thousands)
TENNESSEE								
Barite ... short tons	(5)	(5)	(5)	(5)	13,797	$229	24,082	$404
Cement:								
Portland ... thousand 376-pound barrels }	8,246	$27,384	8,357	$26,964	8,509	27,741	8,283	26,760
Masonry ... thousand 280-pound barrels }			1,018	2,753	1,089	2,931	1,161	3,079
Clays ... thousand short tons	1,270	4,537	[3] 1,040	[3] 4,190	[3] 1,037	[3] 4,597	[3] 1,238	[3] 5,248
Coal (bituminous) ... do	5,930	21,154	5,860	20,681	6,214	22,555	6,121	22,689
Copper (recoverable content of ores, etc.) ... short tons	12,723	8,168	12,272	7,363	14,298	8,808	13,717	8,450
Gem stones	(4)	1	(4)	1	(4)	1	(4)	(10)
Gold (recoverable content of ores, etc.) ... troy ounces	123	4	152	5	158	6	137	5
Lead (recoverable content of ores, etc.) ... short tons	------	------	------	------	51	9	------	------
Manganese ore (35 percent or more Mn) ... short tons, gross weight	283	15	------	------	------	------	------	------
Natural gas ... million cubic feet	63	11	71	13	75	14	90	17
Petroleum (crude) ... thousand 42-gallon barrels	20	(5)	17	(5)	14	(5)	[6] 15	(5)
Phosphate rock ... thousand long tons	1,939	15,424	2,235	18,675	2,418	19,868	2,352	17,876
Sand and gravel ... thousand short tons	6,293	7,655	6,232	8,046	6,075	8,018	7,613	9,443
Silver (recoverable content of ores, etc.) ... thousand troy ounces	65	58	83	77	112	122	108	138
Stone ... thousand short tons	20,074	29,942	23,940	35,906	24,398	35,614	26,825	38,113
Zinc (recoverable content of ores, etc.) ... short tons	91,394	23,579	81,734	18,799	71,548	16,456	95,847	22,045
Value of items that cannot be disclosed: Clay (fuller's earth 1961–63), iron ore, lime, manganiferous ore (1960), scrap mica (1960), pyrites, and values indicated by footnote 5	------	7,606	------	7,238	------	[8] 7,050	------	6,456
Total	------	145,538	------	150,711	------	[8] 154,019	------	160,723

TEXAS

Cement:								
Portland thousand 376-pound barrels	23,365	$76,577	25,101	$80,808	26,204	$83,162	29,104	$92,734
Masonry thousand 280-pound barrels			851	2,529	926	2,774	930	2,858
Clays [3] thousand short tons	3,302	5,058	3,786	5,737	3,744	5,634	4,199	6,849
Gem stones	(4)	100	(4)	150	(4)	150	(4)	150
Gypsum thousand short tons	1,131	3,960	1,074	3,832	1,120	3,956	1,099	3,999
Helium thousand cubic feet	120,921	2,044	173,066	3,196	245,623	8,552	264,342	9,252
Lime thousand short tons	821	9,087	[5] 790	8,703	1,046	11,999	1,131	13,026
Natural gas million cubic feet	5,892,704	665,876	5,963,605	733,523	6,080,210	747,866	6,205,034	775,629
Natural gas liquids:								
Natural gasoline and cycle products thousand gallons	2,880,906	207,583	3,111,427	214,279	3,205,517	233,345	3,320,416	218,975
LP gases do	4,476,142	200,478	4,768,222	185,558	5,012,291	189,382	5,366,831	169,695
Petroleum (crude) thousand 42-gallon barrels	927,479	2,748,735	939,191	2,791,377	943,328	2,818,709	[6] 973,097	[6] 2,893,990
Salt thousand short tons	4,756	18,222	4,695	17,682	5,553	19,485	5,965	22,355
Sand and gravel do	29,844	30,754	27,398	30,691	30,076	33,097	33,256	36,311
Stone do	39,029	45,088	38,316	45,874	38,067	48,988	43,142	54,007
Sulfur (Frasch process) thousand long tons	2,747	62,855	2,730	62,720	2,655	57,297	2,550	50,109
Talc and soapstone short tons	67,031	336	78,214	376	73,635	387	72,658	368
Value of items that cannot be disclosed: Native asphalt, barite (1961–63), bromine, clay (fuller's earth), coal (lignite), feldspar (1960–61), graphite, iron ore, magnesium chloride (for metal), magnesium compounds (except for metal), mercury (1960), pumice (1961–63), sodium sulfate, and uranium ore		49,666		50,923		58,774		62,777
Total		4,126,419		4,237,958		[5] 4,323,557		4,413,084

See footnotes at end of table.

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

Mineral	1960		1961		1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
UTAH								
Asphalt and related bitumens, native: Gilsonite....short tons..	383,037	$10,020	(5)	(5)	(5)	(5)	(5)	(5)
Carbon dioxide, natural....thousand cubic feet..	60,425	4	78,136	$5	81,920	$6	100,895	$7
Clays....thousand short tons..	[3] 143	[3] 416	143	1,080	174	1,403	[3] 125	[3] 470
Coal (bituminous)....do....	4,955	31,458	5,159	31,126	4,297	23,209	4,360	22,755
Copper (recoverable content of ores, etc.)....short tons..	218,049	139,987	213,534	128,120	218,018	134,299	203,095	125,107
Fluorspar....do....	1,912	51	610	18	399	12	247	7
Gem stones....	(4)	72	(4)	73	(4)	75	(4)	75
Gold (recoverable content of ores, etc.)....troy ounces..	368,255	12,889	342,988	12,005	311,924	10,917	285,907	10,007
Iron ore (usable)....thousand long tons, gross weight..	3,334	23,862	3,533	25,493	2,630	18,242	1,881	12,900
Lead (recoverable content of ores, etc.)....short tons..	39,398	9,219	40,894	8,424	38,199	7,029	45,028	9,726
Lime....thousand short tons..	127	2,672	142	2,626	163	2,759	156	2,668
Natural gas....million cubic feet..	51,040	9,187	57,175	8,976	74,128	12,454	77,122	14,036
Perlite....short tons..	(5)	(5)	(5)	(5)	929	3	1,313	7
Petroleum (crude)....thousand 42-gallon barrels..	37,594	103,008	33,118	91,075	31,029	85,019	[6] 33,471	91,041
Pumice....thousand short tons..	60	134	60	95	28	46	28	46
Salt....do....	231	3,092	249	3,187	311	3,349	325	3,462
Sand and gravel....do....	6,848	6,182	18,325	16,979	19,941	20,954	11,709	10,408
Silver (recoverable content of ores, etc.)....thousand troy ounces..	4,783	4,329	4,798	4,435	4,628	5,022	4,791	6,128
Stone....thousand short tons..	1,837	3,087	1,808	3,219	2,118	3,865	2,346	4,040
Uranium ore....short tons..	1,089,757	27,843	1,098,783	25,734	781,955	23,653	743,792	23,852
Vanadium (recoverable in ore and concentrate)....do....	462	(5)	514	(5)	525	(5)	382	(5)
Zinc (recoverable content of ores, etc.)....do....	35,476	9,153	37,239	8,565	34,313	7,892	36,179	8,321
Value of items that cannot be disclosed: Barite (1960–62), cement, clay (kaolin 1960, 1963, fire clay 1963), gypsum, molybdenum, natural gas liquids, phosphate rock, potassium salts, pyrites (1960), and values indicated by footnote 5....	....	36,047	....	45,554	....	50,382	....	40,458
Total....	....	432,712	....	416,789	....	[8] 410,590	....	385,521
VERMONT								
Gem stones....	(4)	$1	(4)	$2	(4)	$2	(4)	(5)
Sand and gravel....thousand short tons..	1,809	1,218	2,232	1,567	1,430	1,076	2,375	$1,410
Stone....do....	2,114	17,444	2,731	18,715	1,715	19,815	2,159	19,193
Value of items that cannot be disclosed: Asbestos, clays, lime, talc, and values indicated by footnote 5....	....	4,240	....	4,012	....	4,237	....	3,788
Total....	....	22,903	....	24,296	....	25,130	....	24,391

VIRGINIA								
Aplite, long tons	(5)	(5)	97,465	$651	125,156	$912	(5)	(5)
Clays, thousand short tons	1,348	$1,395	1,406	1,332	1,464	1,444	1,410	$1,558
Coal (bituminous), do	27,838	122,723	30,332	126,121	29,474	117,560	30,531	120,972
Gem stones	(4)	5	(4)	6	(4)	6	(4)	6
Lead (recoverable content or ores, etc.), short tons	2,152	504	3,733	769	4,059	747	3,500	756
Lime, thousand short tons	711	8,028	657	7,375	615	7,668	639	8,058
Mica, sheet, pounds	103	1	(5)	(5)	-----	-----	-----	-----
Natural gas, million cubic feet	2,227	604	2,466	668	2,499	677	2,085	488
Petroleum (crude), thousand 42-gallon barrels	2	(5)	2	(5)	3	(5)	[6] 3	(5)
Sand and gravel, thousand short tons	7,666	11,432	9,839	14,697	9,745	16,375	10,400	17,752
Soapstone, short tons	(5)	(5)	(5)	(5)	(5)	(5)	3,696	9
Stone, thousand short tons	19,358	33,019	22,934	39,206	25,766	43,121	27,653	45,529
Zinc (recoverable content of ores, etc.)[15], short tons	19,885	5,142	29,163	6,726	26,479	6,141	23,988	5,725
Value of items that cannot be disclosed: Cement, feldspar, gypsum, iron ore (pigment materials), kyanite, pyrites (1960–62), salt, titanium concentrate, and values indicated by footnote 5	-----	26,027	-----	27,747	-----	27,843	-----	28,212
Total	-----	208,880	-----	225,298	-----	222,494	-----	229,065
WASHINGTON								
Abrasive stone (grinding pebbles), short tons	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(10)
Barite, do	(5)	(5)	5,100	$42	(5)	(5)	-----	-----
Clays[3], thousand short tons	169	$162	145	138	103	$100	134	$123
Coal (bituminous), do	228	1,721	191	1,381	235	1,630	190	1,380
Copper (recoverable content of ores, etc.), short tons	78	50	66	40	41	25	(5)	(5)
Lead (recoverable content or ores, etc.), do	7,725	1,808	8,053	1,659	6,033	1,110	5,374	1,161
Peat, do	27,770	121	57,393	363	[8] 41,962	288	37,248	188
Petroleum (crude), thousand 42-gallon barrels	1	(5)	(18)	(10)	-----	-----	-----	-----
Pumice, thousand short tons	(5)	(5)	(5)	(5)	10	130	(5)	(5)
Sand and gravel, do	25,594	19,459	18,994	16,145	19,580	18,145	22,760	20,490
Stone, do	13,897	15,796	11,464	14,758	12,749	18,180	12,934	16,346
Talc and soapstone, short tons	2,406	12	2,927	23	2,835	11	2,969	18
Uranium ore, do	171,255	3,223	175,327	3,582	110,948	2,050	117,286	2,545
Zinc (recoverable content of ores, etc.), do	21,317	5,500	20,217	4,650	21,644	4,978	22,270	5,122
Value of items that cannot be disclosed: Carbon dioxide, cement, clays (fire clay, bentonite 1961), diatomite, epsom salts, gem stones, gold, gypsum (1960–62), lime (1963), magnesite, olivine, silver, tungsten (1961), and values indicated by footnote 5	-----	24,552	-----	23,667	-----	21,827	-----	24,057
Total	-----	72,404	-----	66,448	-----	68,474	-----	71,430

See footnotes at end of table.

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

Mineral	1960		1961		1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
WEST VIRGINIA								
Clays ... thousand short tons	626	$2,639	475	$2,193	447	$2,086	414	$2,044
Coal (bituminous) ... do	118,944	597,222	113,070	558,525	118,499	578,293	132,568	634,794
Gem stones	(4)	1	(4)	(5)	(4)	(5)	(4)	(5)
Natural gas ... million cubic feet	208,757	54,694	210,556	57,692	210,698	57,942	210,223	55,919
Natural gas liquids:								
Natural gasoline ... thousand gallons	23,211	1,513	34,095	2,296	32,921	2,216	(5)	(5)
LP gases ... do	329,874	16,527	342,646	17,826	344,969	17,475	(5)	(5)
Petroleum (crude) ... thousand 42-gallon barrels	2,300	9,361	2,760	11,426	3,470	13,880	[6] 3,243	[6] 12,940
Salt ... thousand short tons	920	3,673	899	3,510	1,042	4,635	(5)	(5)
Sand and gravel ... do	4,506	9,802	4,882	10,152	5,202	10,942	4,808	10,578
Stone [7] ... do	8,001	14,001	7,628	13,244	7,506	13,242	9,452	14,489
Value of items that cannot be disclosed: Bromine, (1960), calcium-magnesium chloride, cement, lime, stone (dimension sandstone), and values indicated by footnote 5		13,195		13,385		14,753		37,051
Total		722,628		690,250		[8] 715,464		767,815
WISCONSIN								
Abrasive stones ... short tons	[19] 397	[19] $12	[19] 560	[19] $17	[19] 569	[19] $17	[20] 561	[20] $21
Clays ... thousand short tons	144	156	126	130	137	156	111	140
Iron ore (usable) ... thousand long tons, gross weight	1,502	(5)	1,122	(5)	1,045	(5)	938	(5)
Lead (recoverable content of ores, etc.) ... short tons	1,165	273	680	140	1,394	256	1,116	241
Peat ... do	8,500	(5)	(5)	(5)	(5)	(5)	2,667	136
Sand and gravel ... thousand short tons	35,681	25,648	39,978	28,457	33,649	24,408	35,633	26,348
Stone ... do	16,486	22,302	13,418	19,686	13,392	19,709	13,583	18,744
Zinc (recoverable content of ores, etc.) ... short tons	18,410	4,750	13,865	3,189	13,292	3,057	15,114	3,476
Value of items that cannot be disclosed: Abrasive stones (tube-mill liners, 1963), cement, gem stones, lime, and values indicated by footnote 5		25,619		21,892		20,686		19,220
Total		78,760		73,511		68,289		68,326

Beryllium concentrate ... short tons, gross weight	5	$2	2	$1	1	(10)	(9)	(10)
Clays ... thousand short tons	[3] 788	[3] 9,571	[3] 859	[3] 10,301	1,141	$11,138	1,113	$11,387
Coal (bituminous) ... do	2,024	6,992	2,529	8,573	2,569	8,198	3,124	9,922
Copper (recoverable content of ores, etc.) ... short tons	-----	-----	1	1	-----	-----	-----	-----
Gem stones	(4)	68	(4)	83	(4)	85	(4)	110
Gold (recoverable content of ores, etc.) ... troy ounces	40	1	1	(10)	-----	-----	4	(10)
Gypsum ... thousand short tons	13	46	(5)	(5)	(5)	(5)	(5)	(5)
Iron ore (usable) ... thousand long tons, gross weight	(5)	(5)	(5)	(5)	739	6,441	1,604	17,504
Natural gas ... million cubic feet	181,610	21,793	194,674	24,334	204,996	29,929	209,060	29,687
Natural gas liquids:								
Natural gasoline ... thousand gallons	72,195	4,535	76,349	4,705	78,780	4,935	86,014	5,523
LP gases ... do	120,693	5,279	132,831	5,451	149,438	5,762	150,437	6,203
Petroleum (crude) ... thousand 42-gallon barrels	133,910	336,114	141,937	354,843	135,847	338,259	[6] 144,407	[6] 361,018
Pumice ... thousand short tons	33	30	20	20	42	41	(5)	(5)
Sand and gravel ... do	5,928	5,356	6,669	5,356	7,769	8,104	7,901	7,874
Stone ... do	1,401	2,302	2,594	3,315	1,755	3,054	1,940	2,991
Uranium ore ... short tons	1,357,225	27,387	1,521,064	28,218	1,301,784	25,715	1,475,070	27,243
Vanadium (recoverable in ore and concentrate) ... do	(5)	(5)	(5)	(5)	(5)	442	(5)	435
Value of items that cannot be disclosed: Cement, clays (fire clay 1960–61, miscellaneous clay 1960–61), lime (1961–63), sheet mica (1960–61), phosphate rock, silver (1960–61), sodium carbonates and sulfates, vermiculite (1961–63), and values indicated by footnote 5	-----	19,780	-----	21,046	-----	20,467	-----	24,736
Total	-----	439,256	-----	466,247	-----	[8] 462,570	-----	504,633

[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] Weight not recorded.
[5] Figure withheld to avoid disclosing individual company confidential data.
[6] Preliminary figure.
[7] Excludes certain stone, included with "Value of items that cannot be disclosed."
[8] Revised figure.
[9] Less than 0.5 ton.
[10] Less than $500.
[11] Includes 805 tons of low-grade beryllium ore in 1961, 760 tons in 1962, and 750 tons in 1963.
[12] Less than 500 short tons.
[13] Excludes salt in brine, included with "Value of items that cannot be disclosed."
[14] Excludes quantity consumed by American Chrome Co.
[15] 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.
[16] Less than 500 long tons.
[17] Less than 500 troy ounces.
[18] Less than 500 barrels.
[19] Grinding pebbles and tube-mill liners.
[20] Grinding pebbles; tube-mill liners included with "Value of items that cannot be disclosed."

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

Area and mineral	1960		1961		1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
American Samoa:								
Pumice ... thousand short tons..					50	$108		
Sand and gravel ... do....					3	4	77	$193
Stone ... do....	523	$261	362	$286	1,103	1,788	944	2,351
Total		261		286		1,900		2,544
Canal Zone:								
Sand and gravel ... thousand short tons..	65	68	75	73	70	77	84	87
Stone (crushed) ... do....	203	306	163	271	207	359	162	281
Total		374		344		436		368
Canton: Stone (crushed) ... thousand short tons..					(3)	(4)	2	6
Guam:								
Sand and gravel ... do....	1	1	38	49				
Stone ... do....	962	2,194	292	591	82	123	307	439
Total		2,195		640		123		439
Johnston:								
Sand and gravel ... thousand short tons..	1	4	1	1				
Stone ... do....	2	5	1	2				
Total		9		3				
Midway: Stone (crushed) ... thousand short tons..			11	34				
Virgin Islands: Stone (crushed) ... do....	15	51	20	75	21	82	66	329
Wake: Stone (crushed) ... do....	36	49	24	62	5	41	9	51

[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 Commerce, Civil Aeronautics Administration; Midway and Johnston, by U.S. Depatrment of the Navy; Guam, by the Government of Guam; American Samoa, by the Government of American Samoa.
[3] Less than 500 short tons.
[4] Less than $500.

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

Mineral	1960 Quantity	1960 Value (thousands)	1961 Quantity	1961 Value (thousands)	1962 Quantity	1962 Value (thousands)	1963 Quantity	1963 Value (thousands)
Cement .... thousand 376-pound barrels	5,441	$14,546	5,931	$16,946	6,347	$20,018	7,217	$22,090
Clays .... thousand short tons	160	102	184	112	219	131	200	158
Lime .... do	1	15	1	15	1	14	4	103
Salt .... do	(2)	(2)	------	------	------	------	8	131
Sand and gravel .... do	8,996	8,669	11,370	10,385	7,378	9,793	7,616	10,407
Stone .... do	4,219	7,661	5,049	7,284	5,589	8,551	5,334	8,237
Value of items that cannot be disclosed: Other nonmetals and values indicated by footnote 2	------	74	------	------	------	------	------	------
Total	------	31,067	------	34,742	------	38,507	------	41,126

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Figure withheld to avoid disclosing individual company confidential data.

TABLE 8.—U.S. imports for consumption of principal minerals and products

Mineral	1962		1963	
	Quantity	Value	Quantity	Value
Metals:				
Aluminum:				
Metal ---------- short tons --	[1] 310,955	[1] $129,997	415,668	$163,524
Scrap ---------- do ----	6,496	1,864	9,306	2,307
Plates, sheets, bars, etc ---------- do ----	59,188	37,147	41,243	25,440
Antimony:				
Ore (antimony content) ---------- do ----	8,602	2,168	9,784	2,675
Needle or liquated ---------- do ----	17	8	22	11
Metal ---------- do ----	4,720	2,300	5,717	2,968
Oxide ---------- do ----	2,910	1,391	2,089	1,038
Arsenic: White (As_2O_3 content) ---------- do ----	15,758	1,077	14,559	1,058
Bauxite: Crude ---------- thousand long tons --	[1] 10,575	[1] 121,888	9,170	114,077
Beryllium ore ---------- short tons --	8,552	2,897	6,243	1,672
Bismuth (general imports) ---------- pounds --	816,190	1,478	1,123,466	2,082
Boron carbide ---------- do ----	9,124	34	13,468	39
Cadmium:				
Metal ---------- thousand pounds --	1,117	1,640	991	2,064
Flue dust (cadmium content) ---------- do ----	1,570	850	1,069	795
Calcium:				
Metal ---------- pounds --	43,962	52	26,343	32
Chloride ---------- short tons --	1,896	60	2,234	67
Chromate:				
Ore and concentrate (Cr_2O_3 content) ---------- do ----	613,572	23,700	605,349	20,135
Ferrochrome (chromium content) ---------- do ----	[1] 24,914	[1] 9,845	19,945	6,807
Metal ---------- do ----	648	993	860	1,308
Cobalt:				
Metal ---------- thousand pounds --	[1] 11,809	[1] 17,119	10,322	14,677
Oxide (gross weight) ---------- do ----	978	943	468	451
Salts and compounds (gross weight) ---------- do ----	120	47	94	45
Columbium ore ---------- pounds --	5,050,888	[1] 3,419	5,909,512	3,144
Copper: (copper content)				
Ore [2] ---------- short tons --	116	202	} 11,498	6,567
Concentrates [2] ---------- do ----	2,206	1,212		
Regulus, black, coarse ---------- do ----	22	12	2,800	1,674
Unrefined, black, blister ---------- do ----	1,119	669	119,231	72,502
Refined in ingots, etc ---------- do ----	[1] 130,197	[1] 76,995	123,149	71,342
Old and scrap ---------- do ----	3,846	2,242	2,195	1,259
Old brass and clippings ---------- do ----	1,289	738	945	558
Ferroalloys: Ferrosilicon (silicon content) ---------- do ----	2,573	976	2,376	744
Gold:				
Ore and base bullion ---------- troy ounces --	382,468	13,281	313,280	10,583
Bullion ---------- do ----	3,929,718	137,652	967,339	33,831
Iron ore:				
Ore ---------- thousand long tons --	[1] 33,409	[1] 324,573	33,263	323,158
Pyrites cinder ---------- long tons --	4,248	26	3,511	48
Iron and steel:				
Pig iron ---------- short tons --	[1] 500,074	24,684	645,334	28,937
Iron and steel products (major):				
Iron products ---------- do ----	54,132	10,634	64,408	13,347
Steel products ---------- do ----	[1] 4,243,340	[1] 513,978	5,517,364	646,747
Scrap ---------- do ----	189,035	5,726	195,383	5,701
Tinplate scrap ---------- do ----	21,092	341	21,824	403
Lead:				
Ore, flue dust, matte (lead content) ---------- do ----	[1] 133,080	[1] 21,003	134,445	21,436
Base bullion (lead content) ---------- do ----	2,083	710	3,758	1,792
Pigs and bars (lead content) ---------- do ----	257,866	41,570	220,398	40,226
Reclaimed, scrap, etc., (lead content) ---------- do ----	2,078	269	15,405	2,009
Sheets, pipe, and shot ---------- do ----	2,276	474	2,429	513
Babbitt metal and solder (lead content) ---------- do ----	1,030	3,443	1,246	3,207
Type metal and antimonial lead (lead content) short tons --	7,512	1,393	3,196	621
Manufactures ---------- do ----	2,021	978	2,295	792
Magnesium:				
Metallic and scrap ---------- do ----	2,359	1,080	1,982	825
Alloys (magnesium content) ---------- do ----	53	106	374	603
Sheets, tubing, ribbons, wire and other forms (magnesium content) ---------- short tons --	35	83	18	112
Manganese:				
Ore (35 percent or more manganese) (manganese content) ---------- short tons --	[1] 940,154	[1] 66,089	1,124,109	67,406
Ferromanganese (manganese content) ---------- do ----	[1] 97,870	[1] 16,757	115,377	16,974
Mercury:				
Compounds ---------- pounds --	46,368	105	14,899	37
Metal ---------- 76-pound flasks --	[1] 31,552	[1] 5,090	42,872	6,766
Minor metals: Selenium and salts ---------- pounds --	160,389	866	191,210	788

See footnotes at end of table.

TABLE 8.—U.S. imports for consumption of principal minerals and products—Continued

Mineral	1962 Quantity	1962 Value	1963 Quantity	1963 Value
Metals—Continued				
Nickel:				
Ore and matte .... short tons	14	5	34	3
Pigs, ingots, shot, cathodes .... do	[1] 115,972	[1] 175,425	108,127	161,804
Scrap .... do	601	545	703	520
Oxide .... do	8,661	9,086	12,887	13,753
Platinum group:				
Unrefined materials:				
Grains and nuggets, including crude, dust, and residues .... troy ounces	23,366	1,610	50,691	3,696
Sponge and scrap .... do	6,185	684	7,647	560
Osmiridium .... do	24	1	------	------
Refined metal:				
Platinum .... do	210,220	16,097	701,213	27,491
Palladium .... do	431,872	9,370	503,843	11,052
Iridium .... do	9,001	578	13,059	959
Osmium .... do	1,062	55	2,091	50
Rhodium .... do	30,123	3,965	36,500	4,801
Ruthenium .... do	8,499	339	3,917	166
Radium:				
Radium salts .... milligrams	46,962	700	44,660	304
Radioactive substitutes	(3)	1,732	(3)	1,081
Rare earths: Ferrocerium and other cerium alloys pounds	20,608	60	16,430	49
Silver:				
Ore and base bullion .... thousand troy ounces	37,168	35,814	41,660	47,708
Bullion .... do	39,191	36,907	17,402	19,573
Tantalum: Ore .... pounds	1,211,757	3,527	944,459	2,411
Tin:				
Ore (tin content) .... long tons	5,364	13,595	(4)	3,077
Blocks, pigs, grains, etc .... do	[1] 41,401	[1] 103,103	43,601	106,700
Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f .... long tons	[1] 2,185	[1] 913	2,816	2,067
Tinfoil, powder, flitters, etc	(3)	819	(3)	731
Titanium:				
Ilmenite .... short tons	166,434	4,470	200,880	5,088
Rutile .... do	35,966	2,646	71,990	4,921
Metals .... pounds	1,849,034	1,733	2,957,292	2,565
Ferrotitanium .... do	240,326	88	82,113	35
Compounds and mixtures .... do	[1] 33,152,354	[1] 6,311	51,093,307	9,468
Tungsten: (Tungsten content)				
Ore and concentrate .... thousand pounds	[1] 4,030	[1] 2,922	3,060	1,579
Metal .... pounds	497,054	938	147,811	274
Ferrotungsten .... thousand pounds	534	531	882	609
Other alloys .... pounds	41,807	47	41,556	40
Zinc:				
Ore (zinc content) .... short tons	387,321	31,817	371,919	30,757
Blocks, pigs, and slabs .... do	135,995	28,478	132,332	27,942
Sheets .... do	[1] 1,303	[1] 365	1,532	413
Old, dross, and skimmings .... do	2,768	406	2,876	446
Dust .... do	909	207	2,608	589
Manufactures	(3)	1,139	(3)	979
Zirconium: Ore, including zirconium sand .... short tons	30,872	845	52,543	1,716
Nonmetals:				
Abrasives: Diamonds (industrial) .... carats	12,281,143	51,040	11,847,028	49,871
Asbestos .... short tons	[1] 675,953	[1] 64,112	667,860	61,739
Barite:				
Crude and ground .... do	736,867	6,012	578,394	4,643
Witherite (crude) .... do	1,431	59	2,690	114
Chemicals .... do	5,319	595	4,646	543
Bromine .... pounds	461,108	245	374,012	168
Cement .... 376-pound barrels	[1] 5,632,699	[1] 12,855	4,030,046	10,202
Clays:				
Raw .... short tons	129,631	2,475	123,456	2,344
Manfactured .... do	2,598	66	2,029	61
Cryolite .... do	12,472	933	26,915	1,808
Feldspar: Crude .... long tons	33	1	68	2
Fluorspar .... short tons	595,695	15,596	555,123	14,104
Gem stones:				
Diamonds .... carats	[1] 2,403,421	[1] 191,736	2,767,261	223,847
Emeralds .... do	196,649	2,798	190,933	2,081
Other	(3)	[1] 30,068	(3)	29,864
Graphite .... short tons	39,528	1,783	52,184	2,000
Gypsum:				
Crude, ground, calcined .... do	5,422,656	10,545	5,490,524	10,949
Manufactures	(3)	1,367	(3)	1,408
Iodine, crude .... thousand pounds	3,026	2,841	3,336	2,958

See footnotes at end of table.

TABLE 8.—U.S. imports for consumption of principal minerals and products—Continued

Mineral	1962 Quantity	1962 Value	1963 Quantity	1963 Value
Nonmetals—Continued				
Kyanite ... short tons	5,281	234	2,624	119
Lime:				
Hydrated ... do	1,141	19	692	12
Other ... do	71,970	939	90,676	1,005
Dead-burned dolomite ... do	4,456	245	9,389	455
Magnesium:				
Magnesite ... do	107,169	5,939	96,562	5,093
Compounds ... do	14,860	589	13,552	496
Mica:				
Uncut sheet and punch ... pounds	[1] 1,110,739	[1] 1,796	1,133,521	1,615
Scrap ... short tons	4,458	55	8,150	132
Manufactures ... do	5,403	7,922	4,353	5,950
Mineral-earth pigments: Iron oxide pigments:				
Natural ... do	2,937	128	2,877	137
Synthetic ... do	6,206	960	7,215	1,150
Ocher, crude and refined ... do	146	9	144	8
Siennas, crude and refined ... do	879	84	610	62
Umber, crude and refined ... do	2,663	94	2,641	95
Vandyke brown ... do	256	21	217	18
Nitrogen compounds (major), including urea ... do	[1] 1,559,137	[1] 69,212	1,195,330	46,807
Phosphate, crude ... long tons	133,628	3,551	160,708	3,651
Phosphatic fertilizers ... do	83,894	4,630	94,331	5,044
Pigments and salts:				
Lead pigments and salts ... short tons	18,986	3,027	26,295	4,400
Zinc pigments and salts ... do	15,282	2,729	16,360	2,911
Potash ... do	[1] 616,684	[1] 21,764	1,041,376	31,137
Pumice:				
Crude or unmanufactured ... do	7,136	70	7,576	84
Wholly or partly manufactured ... do	3,184	89	3,555	119
Manufactures, n.s.p.f.	(3)	22	(3)	47
Quartz crystal (Brazilian pebble) ... pounds	935,927	843	712,897	547
Salt ... short tons	1,374,219	5,097	1,371,443	5,074
Sand and gravel:				
Glass sand ... do	31,416	64	22,724	69
Other sand [2] ... do	307,637	415	} 336,547	430
Gravel [2] ... do	29,198	32		
Sodium sulfate ... thousand short tons	188	3,768	159	3,081
Stone and whiting	(3)	17,204	(3)	18,978
Strontium: Mineral ... short tons	7,489	189	16,232	372
Sulfur and pyrites:				
Sulfur:				
Ores [2] ... long tons	[1] 442,943	[1] 8,433	} 1,351,216	23,942
Other forms, n.e.s.[2] ... do	[1] 597,530	[1] 11,877		
Pyrites ... do	301,899	747	194,171	488
Talc: Unmanufactured ... short tons	25,777	1,069	25,681	1,088
Fuels:				
Carbon black:				
Acetylene ... pounds	7,883,462	1,384	6,233,224	1,104
Gas black and carbon black ... do	284,296	49	1,261,215	216
Coal:				
Anthracite ... short tons	7,583	63	[2] 4,625	44
Bituminous, slack, culm, and lignite ... do	232,424	1,858	172,224	1,335
Briquets ... do	8,396	410	4,620	82
Coke ... do	141,883	1,855	152,595	2,047
Peat:				
Fertilizer grade ... do	261,347	12,448	255,709	12,040
Poultry and stable grade ... do	6,331	420	5,622	318
Petroleum:				
Crude [5] ... thousand barrels	450,157	1,011,914	454,620	1,024,973
Gasoline [6] ... do	[1] 34,166	[1] 104,404	49,093	135,487
Kerosine ... do	3	8	223	774
Fuel oil ... do	271,159	575,463	277,953	575,935
Unfinished oils ... do	21,527	57,224	15,936	33,919
Asphalt ... do	6,698	15,845	6,175	15,161
Miscellaneous ... do	30	421	30	462

[1] Revised figure.
[2] Effective Sept. 1, 1963—data no longer separately classified.
[3] Weight not recorded.
[4] January–August data reported as tin content, 793 long tons; September–December reported in gross weight, 2,140 long tons.
[5] Includes some quantities imported free for supplies of vessels and aircraft.
[6] Includes jet fuel, liquefied gases and naphtha, but excludes benzol (1962: 547,537 barrels, $4,927,771); 1963: 323,108 barrels ($3,719,309).

Source: Bureau of the Census.

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

Mineral	1962 Quantity	1962 Value (thousands)	1963 Quantity	1963 Value (thousands)
Metals:				
Aluminum:				
Ingots, slabs, crude ... short tons	[1] 151,197	[1] $66,596	165,340	$71,875
Scrap ... do	65,534	20,183	71,040	21,369
Plates, sheets, bars, etc ... do	[1] 40,128	[1] 32,970	53,363	39,276
Castings and forgings ... do	[1] 1,541	5,522	1,431	4,017
Antimony: Metals and alloys, crude ... do	35	15	14	12
Arsenic: Calcium arsenate ... pounds	942,399	104	186,577	18
Bauxite, including bauxite concentrates ... long tons	258,561	19,874	203,196	15,696
Aluminum sulfate ... short tons	17,776	608	17,576	559
Other aluminum compounds ... do	87,671	10,936	228,076	20,635
Beryllium ... pounds	63,975	352	100,323	457
Bismuth: Metals and alloys ... do	118,056	176	32,293	42
Cadmium ... thousand pounds	717	1,139	1,313	3,070
Calcium chloride ... short tons	43,830	1,687	36,984	1,527
Chrome:				
Ore and concentrate:				
Exports ... do	2,686	108	9,726	352
Reexports ... do	51,254	2,033	71,324	2,827
Chromic acid ... do	834	487	936	553
Ferrochrome ... do	3,075	1,182	2,354	773
Cobalt ... pounds	1,936,487	997	2,405,777	2,403
Columbium metals, alloys, and other forms ... do	38,157	277	61,163	531
Copper:				
Ore, concentrate, composition metal, and unrefined copper (copper content) ... short tons	1,916	1,045	1,210	638
Refined copper and semimanufactures ... do	366,585	234,605	344,960	225,649
Other copper manufactures ... do	6,768	5,107	5,811	4,273
Copper sulfate or blue vitriol ... do	1,916	456	851	228
Copper base alloys ... do	46,030	36,024	44,494	34,587
Ferroalloys:				
Ferrosilicon ... pounds	8,202,626	1,349	6,260,880	948
Ferrophosphorus ... do	28,260,782	595	82,722,701	1,302
Gold:				
Ore and base bullion ... troy ounces	22,724	809	30,107	1,140
Bullion, refined ... do	10,861,510	380,153	5,789,826	202,644
Iron ore ... thousand long tons	5,898	[1] 62,847	6,813	76,390
Iron and steel:				
Pig iron ... short tons	154,380	8,283	70,154	4,479
Iron and steel products (major):				
Semimanufactures ... do	[1] 1,506,071	[1] 282,563	1,609,332	301,003
Manufactured steel mill products ... do	[1] 759,527	[1] 261,047	1,054,374	309,554
Advanced products ... do	(2)	[1] 174,674	(2)	165,283
Iron and steel scrap: Ferrous scrap, including rerolling materials ... short tons	[1] 5,112,266	[1] 149,037	6,363,617	174,611
Lead:				
Ore, matte, base bullion (lead content) ... do	2,898	235	4	(3)
Pigs, bars, anodes ... do	2,108	528	1,088	313
Scrap ... do	2,461	457	2,421	1,034
Magnesium:				
Metal and alloys and semimanufactured forms, n.e.c ... short tons	7,020	4,659	3,958	3,018
Powder ... do	21	53	33	87
Manganese:				
Ore and concentrates ... do	8,643	1,012	8,296	926
Ferromanganese ... do	4,114	629	678	155
Mercury:				
Exports ... 76-pound flasks	224	64	187	46
Reexports ... do	257	43	------	------
Molybdenum:				
Ore and concentrate (molybdenum content) ... pounds	15,554,662	22,901	26,545,066	39,360
Metals and alloys, crude and scrap ... do	75,211	70	139,202	179
Wire ... do	12,088	374	30,892	631
Semifabricated forms, n.e.c ... do	8,961	135	9,109	110
Powder ... do	25,219	84	16,741	58
Ferromolybdenum ... do	189,823	305	239,034	379
Nickel:				
Ore ... short tons	45	16	12	5
Alloys and scrap (including monel metal), ingots, bars, sheets, etc ... short tons	25,510	20,796	59,107	27,279
Catalysts ... do	1,093	1,963	905	1,749
Nickel-chrome electric resistance wire ... do	190	965	189	953
Semifabricated forms, n.e.c ... do	803	3,463	714	3,199

See footnotes at end of table.

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

Mineral	1962 Quantity	1962 Value (thousands)	1963 Quantity	1963 Value (thousands)
Metals—Continued				
Platinum:				
Ore, concentrate, metal and alloys in ingots, bars, sheets, anodes, and other forms, including scrap troy ounces	49,651	1,514	51,236	3,650
Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap troy ounces	10,940	459	11,776	507
Platinum group manufactures, except jewelry	(2)	4,106	(2)	2,256
Radium metal (radium content) milligrams	328	4	311	7
Rare earths:				
Cerium ore, metal, and alloys pounds	3,708	16	128,612	41
Lighter flints do	38,501	173	40,100	182
Silver:				
Ore and base bullion thousand troy ounces	770	789	1,298	1,650
Bullion, refined do	12,287	12,586	30,187	38,372
Tantalum:				
Ore, metal, and other forms pounds	54,256	716	100,400	861
Powder do	7,445	353	14,146	425
Tin:				
Ingots, pigs, bars, etc.:				
Exports long tons	335	840	1,544	4,225
Reexports do	100	267	81	207
Tin scrap and other tin bearing material except tinplate scrap long tons	5,587	211	5,862	2,423
Tin cans finished or unfinished do	25,531	13,927	21,595	12,169
Titanium:				
Ore and concentrate short tons	1,224	167	1,212	176
Sponge (including iodide titanium) and scrap do	818	925	1,261	1,232
Intermediate mill shapes do	453	2,609	417	2,322
Mill products, n.e.c do	108	1,493	77	1,122
Ferrotitanium do	130	95	211	183
Dioxide and pigments do	29,095	8,636	26,702	8,051
Tungsten: Ore and concentrate:				
Exports do	40	80	50	66
Reexports do	159	132	----------	----------
Vanadium ore and concentrate, pentoxide, etc. (vanadium content) pounds	[1] 2,042,946	[1] 2,998	1,071,817	1,641
Zinc:				
Ore and concentrate (zinc content) short tons	136	46	17	6
Slabs, pigs, or blocks do	36,102	8,050	33,853	7,506
Sheets, plates, strips, or other forms, n.e.c. do	3,547	2,391	3,756	2,742
Scrap (zinc content) do	7,940	956	1,794	539
Dust do	676	240	759	261
Semifabricated forms, n.e.c do	1,613	1,254	1,532	1,163
Zirconium:				
Ore and concentrate do	1,666	365	1,418	305
Metals and alloys and other forms pounds	[1] 221,275	1,740	291,792	2,500
Nonmetals:				
Abrasives:				
Grindstones short tons	127	53	41	34
Diamond dust and powder carats	828,611	2,225	1,095,737	2,983
Diamond grinding wheels do	310,330	1,990	373,053	2,354
Other natural and artificial metallic abrasives and products	(2)	28,489	(2)	30,403
Asbestos: Unmanufactured:				
Exports short tons	2,824	578	9,978	1,289
Reexports do	125	20	66	15
Boron: Boric acid, borates, crude and refined pounds	584,528,807	24,736	677,823,693	27,519
Bromine, bromides, and bromates do	8,800,351	2,228	10,839,960	2,353
Cement 376-pound barrels	380,383	1,853	460,088	2,072
Clays:				
Kaolin or china clay short tons	118,890	2,939	111,717	3,314
Fire clay do	188,282	3,462	264,440	5,184
Other clays do	309,776	10,454	363,191	12,875
Cryolite do	1,109	196	3,719	689
Fluorspar do	1,308	119	1,202	157
Graphite:				
Amorphous do	746	110	533	89
Crystalline flake, lump or chip do	127	42	144	49
Natural, n.e.c do	286	71	222	51

See footnotes at end of table.

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

Mineral	1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Nonmetals—Continued				
Gypsum:				
Crude, crushed or calcined .... thousand short tons..	20	736	17	669
Manufactures, n.e.c	(2)	566	(2)	762
Iodine, iodide, iodates .... thousand pounds..	178	296	141	327
Kyanite and allied minerals .... short tons..	3,568	287	5,050	442
Lime .... do....	19,512	660	17,463	565
Mica:				
Unmanufactured .... pounds..	430,856	166	594,427	148
Manufactured:				
Ground or pulverized .... do....	7,427,420	432	7,244,428	413
Other .... do....	197,441	765	204,246	831
Mineral-earth pigments: Iron oxide, natural and manufactured .... short tons..	3,754	1,076	4,189	1,306
Nitrogen compounds (major) .... do....	[1] 906,924	[1] 43,538	824,295	41,357
Phosphate rock .... long tons..	[1] 4,242,057	[1] 38,886	4,612,299	40,726
Phosphatic fertilizers (superphosphates) .... do....	[1] 557,284	[1] 27,636	601,887	29,220
Pigments and salts (lead and zinc):				
Lead pigments .... short tons..	1,919	595	1,845	620
Zinc pigments .... do....	2,411	658	3,801	963
Lead salts .... do....	711	249	401	135
Potash:				
Fertilizer .... do....	[1] 845,744	[1] 28,296	707,039	22,202
Chemical .... do....	13,171	2,435	14,703	3,317
Quartz crystal (raw)	(2)	448	(2)	525
Radioactive isotopes, etc .... curie..	[1] 226,775	1,895	146,783	2,548
Salt:				
Crude and refined .... short tons..	[1] 670,532	[1] 3,638	781,135	4,140
Shipments to noncontiguous territories.. do....	11,347	823	10,021	881
Sodium and sodium compounds:				
Sodium sulfate .... do....	50,914	1,486	45,163	1,379
Sodium carbonate .... thousand short tons..	152	4,693	184	5,722
Stone:				
Limestone, crushed, ground, broken .... short tons..	621,177	1,547	762,658	1,753
Marble and other building and monumental cubic feet..	534,919	1,795	452,167	1,669
Stone, crushed, ground, broken .... short tons..	114,744	2,166	110,949	2,095
Manufactures of stone	(2)	501	(2)	585
Sulfur:				
Crude .... long tons..	1,537,419	35,496	1,603,438	33,531
Crushed, ground, flowers of .... do....	16,567	1,799	9,199	1,057
Talc:				
Crude and ground .... short tons..	46,939	2,133	56,483	2,690
Manufactures, n.e.c .... do....	122	97	107	88
Powders—talcum (face and compact)	(2)	1,286	(2)	1,140
Fuels:				
Carbon black .... thousand pounds..	442,437	[1] 41,036	370,928	35,447
Coal:				
Anthracite .... short tons..	[1] 1,801,724	[1] 24,675	3,353,192	43,669
Bituminous .... do....	[1] 38,413,371	351,319	47,078,435	429,864
Briquets .... do....	18,596	233	12,380	207
Coke .... do....	364,032	7,122	451,241	8,318
Petroleum:				
Crude .... thousand barrels..	[1] 1,790	[1] 5,086	1,697	4,616
Gasoline .... do....	5,987	41,339	6,418	44,720
Kerosine .... do....	312	1,817	513	3,405
Distillate oil .... do....	8,918	30,071	16,808	55,550
Residual oil .... do....	12,852	[1] 32,232	15,281	36,411
Lubricating oil .... do....	[1] 17,169	[1] 225,499	17,822	229,443
Asphalt .... do....	717	4,572	656	3,847
Liquefied petroleum gases .... do....	3,875	11,250	4,597	13,438
Wax .... do....	1,430	28,484	1,455	29,094
Coke .... do....	7,456	29,357	10,763	38,170
Petrolatum .... do....	238	6,151	240	6,202
Miscellaneous .... do....	476	15,423	566	15,496

[1] Revised figure.
[2] Weight not recorded.
[3] Less than $1,000.
[4] Includes naphtha, but excludes benzol: 1962—982,361 barrels ($12,027,669); 1963—1,541,316 barrels ($16,759,104).

Source: Bureau of the Census.

TABLE 10.—Comparison of world and U.S. production of principal metals and minerals

Mineral	1962			1963		
	World	United States		World	United States	
	Thousand short tons (unless otherwise stated)		Percent of world	Thousand short tons (unless otherwise stated)		Percent of world
Fuels:						
Coal:						
Bituminous	1,856,097	419,094	23	1,927,986	456,223	24
Lignite	755,318	3,055	(1)	796,046	2,705	(1)
Pennsylvania anthracite	198,100	16,894	9	202,000	18,267	9
Coke (excluding breeze):						
Gashouse [2]	50,380	164	(1)	50,120	160	(1)
Oven and beehive	301,020	51,910	17	313,236	54,278	17
Fuel briquets and packaged fuel	130,500	588	(1)	134,000	565	(1)
Natural gas (marketable)...million cubic feet	(3)	13,867,622	(3)	(3)	14,746,633	(3)
Peat	169,500	[4] 572	(1)	169,500	[4] 579	(1)
Petroleum (crude)....thousand barrels	8,882,218	2,676,189	30	9,535,434	2,752,723	29
Nonmetals:						
Asbestos	3,055	53	2	3,200	67	2
Barite	3,440	887	26	3,200	803	25
Cement [5]....thousand barrels	2,098,128	351,932	17	2,201,159	368,406	17
China clay	(3)	2,998	(3)	(3)	3,164	(3)
Corundum	9			11		
Diamonds....thousand carats	34,006			36,661		
Diatomite	1,630	482	30	1,610	482	30
Feldspar....thousand long tons	1,540	492	32	1,590	549	35
Fluorspar	2,410	206	9	2,340	200	9
Graphite	590	(6)	(6)	730	(6)	(6)
Gypsum	51,690	9,969	19	54,000	10,388	19
Lime (sold or used by producers)	(3)	13,753	(3)	(3)	14,521	(3)
Magnesite	8,600	492	6	9,050	528	6
Mica (including scrap)...thousand pounds	390,000	215,767	55	400,000	218,749	55
Nitrogen, agricultural [5,7]	12,900	3,353	26	13,800	3,778	27
Phosphate rock....thousand long tons	47,450	19,382	41	50,400	19,835	39
Potash (K_2O equivalent)	10,800	2,453	23	12,000	2,866	24
Pumice [8]	13,500	2,321	17	14,710	2,618	18
Pyrites....thousand long tons	19,800	916	5	19,700	825	4
Salt [5]	100,700	28,807	29	104,900	30,652	29
Strontium [8]	9			17		
Sulfur, elemental....thousand long tons	12,100	5,925	49	12,560	5,829	46
Talc, pyrophyllite, and soapstone	2,990	772	26	3,150	804	26
Vermiculite [8]	295	206	70	329	226	69
Metals, mine basis:						
Antimony (content of ore and concentrate)....short tons	58,700	631	1	61,100	645	1
Arsenic, white [8]	54	(6)	(6)	53	(6)	(6)
Bauxite....thousand long tons	30,535	1,369	4	29,835	1,525	5
Beryllium concentrate....short tons	10,900	978	9	7,400	751	10
Bismuth....thousand pounds	6,700	(6)	(6)	6,500	(6)	(6)
Cadmium....do	27,100	11,137	41	26,400	9,990	38
Chromite	4,840			4,475		
Cobalt (contained) [8]....short tons	15,900	(6)	(6)	12,700	(6)	(6)
Columbium-tantalum concentrate [8] thousand pounds	9,210			10,660		
Copper (content of ore and concentrate)	5,090	1,228	24	5,220	1,213	23
Gold....thousand troy ounces	49,800	1,556	3	51,700	1,469	3
Iron ore....thousand long tons	498,703	71,829	14	509,021	73,599	14
Lead (content of ore and concentrate)	2,760	237	9	2,800	253	9
Manganese ore (35 percent or more Mn)	15,782	25	(1)	16,090	11	(1)
Mercury....thousand 76-pound flasks	245	26	11	236	19	8
Molybdenum (content of ore and concentrate)....thousand pounds	75,100	51,244	68	91,600	65,011	71
Nickel (content of ore and concentrate)	401	11	3	384	11	3
Platinum groups (Pt, Pd, etc.) thousand troy ounces	1,630	29	2	1,530	50	3
Silver....do	241,800	36,345	15	249,500	35,000	14
Tin (content of ore and concentrate) long tons	187,000	(6)	(6)	191,000	(6)	(6)
Titanium concentrates:						
Ilmenite [8]	2,168	808	37	2,222	888	40
Rutile [8]	150	10	7	220	12	5
Tungsten concentrate (60 percent WO_3) short tons	73,300	8,429	11	64,700	5,657	9
Vanadium (content of ore and concentrate) [8]....short tons	8,286	5,233	63	7,004	3,862	55
Zinc (content of ore and concentrate)	3,890	505	13	3,970	529	13

See footnotes at end of table.

TABLE 10.—Comparison of world and U.S. production of principal metals and minerals—Continued

Mineral	1962 World	1962 United States		1963 World	1963 United States	
	Thousand short tons (unless otherwise stated)		Percent of world	Thousand short tons (unless otherwise stated)		Percent of world
Metals, smelter basis:						
Aluminum	5,595	2,118	38	6,095	2,313	38
Copper	5,360	1,323	25	5,500	1,297	24
Iron, pig (including ferroalloys)	291,820	67,636	23	308,970	73,853	24
Lead	2,655	376	14	2,795	395	14
Magnesium ... short tons	145,900	68,955	47	154,800	75,845	49
Selenium [8] ... thousand pounds	2,131	999	47	2,110	928	44
Steel ingots and castings	396,260	98,328	25	425,310	109,261	26
Tellurium [8] ... thousand pounds	396	264	67	316	201	64
Tin ... thousand long tons	190	[9] 5	3	192	[9] 2	1
Uranium oxide (U_3O_8) [8] ... short tons	34,600	17,010	49	30,200	14,218	47
Zinc	3,750	879	23	3,830	893	23

[1] Less than 1 percent.
[2] Includes low- and medium-temperature and gashouse coke.
[3] Data not available.
[4] Agricultural use only.
[5] Including Puerto Rico.
[6] Bureau of Mines not at liberty to publish U.S. figure separately.
[7] Year ended June 30 of year stated (United Nations).
[8] World total exclusive of U.S.S.R.
[9] U.S. imports of tin concentrates (tin content).

Employment and Injuries in the Metal and Nonmetal Industries

By Forrest T. Moyer [1]

INJURY experience and employment data are presented in this chapter for metal and nonmetal mines, stone quarries, sand and gravel pits, iron-blast-furnace slag plants, and metallurgical plants (including ore-dressing and nonferrous reduction plants and refineries) in the United States. Employment and injury experience data for all mineral industries are given in volume III. The 1963 figures are preliminary and are subject to revision.

METAL MINES

Preliminary estimates for the metal-mining industry of a combined fatal and nonfatal injury-frequency rate of 32.34 per million man-hours in 1963 indicate only a slight change from the rate of 32.00 in 1962. Metal operations had 41 fatal and 3,110 nonfatal injuries during 1963.

Employment at all metal mines was 8 percent lower than in 1962, owing principally to declines in the number of men working at copper, iron, and uranium mines. However, total man-hours worked was reduced only 6 percent since the mines and pits were active an average of 252 days in 1963, 5 days more than in 1962. The average employee worked an 8-hour shift for a total of 2,025 hours during the year, an increase of 2 percent over the 1962 figure.

Copper.—Injury experience at copper mines was an overall occurrence of 26.70 injuries (fatal and nonfatal) per million man-hours of worktime, 1 percent less than that of 1962. There were 14 fatal and 910 nonfatal injuries at these mines.

Copper mines averaged 299 days of activity in 1963. The average employee had an 8-hour daily shift and worked 2,387 hours during the year.

Gold Placer.—No fatalities were reported and 40 nonfatal injuries were estimated at gold placer operations. The overall injury-frequency rate was 34.19, 4 percent below the corresponding rate in 1962. The average employee worked 1,064 hours on an 8-hour daily shift in 1963.

Gold-Silver.—At gold-silver lode mining operations in 1963, the fatal and nonfatal combined injury-frequency rate of 33.71 declined 8 percent from that of 1962. The average employee worked an 8-hour daily shift for a total of 1,842 hours, a decrease of 1 percent from that of 1962. Mines were active an average of 230 days during the year.

[1] Chief, Branch of Accident Analysis, Division of Accident Prevention and Health.

TABLE 1.—Employment and injury experience at metal mines in the United States, by industry groups

Industry and year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
Copper:							
1954–58 (average)	16,772	292	4,893	39,074	25	1,249	32.60
1959	14,201	232	3,289	26,382	16	714	27.67
1960	16,077	275	4,421	35,388	17	828	23.88
1961	15,661	285	4,460	35,790	13	893	25.31
1962	15,629	280	4,377	35,017	15	908	26.36
1963 [1]	14,500	299	4,330	34,610	14	910	26.70
Gold placer:							
1954–58 (average)	1,647	198	327	2,703	1	123	45.88
1959	1,648	160	263	2,200	1	109	50.01
1960	1,224	165	202	1,688	2	68	41.47
1961	1,178	157	185	1,518	1	76	50.72
1962	854	145	124	1,035	----------	37	35.75
1963 [1]	1,100	127	140	1,170	----------	40	34.19
Gold-silver:							
1954–58 (average)	3,127	259	810	6,476	6	436	68.25
1959	3,592	246	885	7,076	8	339	49.04
1960	3,669	236	865	6,928	4	221	32.48
1961	3,833	230	883	7,058	3	289	41.38
1962	3,507	232	813	6,518	8	231	36.67
1963 [1]	3,800	230	875	7,000	6	230	33.71
Iron:							
1954–58 (average)	25,332	232	5,882	47,165	15	652	14.14
1959	22,099	179	3,966	31,823	14	482	15.59
1960	21,170	242	5,131	41,158	16	610	15.21
1961	17,251	224	3,868	31,027	10	449	14.79
1962	16,165	234	3,776	30,481	9	453	15.16
1963 [1]	13,400	251	3,357	27,100	10	405	15.31
Lead-zinc:							
1954–58 (average)	10,705	255	2,725	21,798	18	1,341	62.34
1959	7,665	253	1,939	15,515	10	869	56.65
1960	8,137	227	1,845	14,750	12	959	65.83
1961	7,510	243	1,829	14,628	7	1,167	80.26
1962	7,150	243	1,735	13,877	9	935	68.03
1963 [1]	7,600	233	1,772	14,180	6	980	69.53
Uranium: [2]							
1960	7,329	233	1,710	13,832	32	862	64.63
1961	5,965	245	1,461	11,811	11	525	45.38
1962	5,967	231	1,379	11,175	13	420	38.75
1963 [1]	5,100	198	1,011	8,160	4	350	43.38
Miscellaneous: [3]							
1954–58 (average)	8,035	240	1,931	15,493	14	1,070	69.97
1959	9,352	231	2,161	17,580	24	768	45.05
1960	2,989	246	736	5,908	1	246	41.81
1961	2,853	256	730	5,846	5	270	47.04
1962	3,015	239	720	5,764	7	279	49.62
1963 [1]	2,600	250	650	5,200	1	195	37.69
Total: [4]							
1954–58 (average)	65,618	252	16,568	132,710	79	4,872	37.31
1959	58,557	214	12,503	100,576	73	3,281	33.35
1960	60,595	246	14,910	119,653	84	3,794	32.41
1961	54,251	247	13,416	107,678	50	3,669	34.54
1962	52,287	247	12,924	103,867	61	3,263	32.00
1963 [1]	48,100	252	12,135	97,420	41	3,110	32.34

[1] Preliminary figures.
[2] Uranium included with miscellaneous metals before 1960. Formerly classed as uranium-vanadium and included with miscellaneous metals. These plants are now classed as uranium.
[3] Includes antimony, bauxite, beryl, manganese, mercury, nickel, rare earths, and titanium; before 1960 includes uranium.
[4] 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	Men working daily	Average active mill days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
Copper:							
1954–58 (average)	6,710	311	2,086	16,733	2	217	13.09
1959	5,588	250	1,394	11,156	---	82	7.35
1960	5,255	314	1,648	13,188	3	111	8.64
1961	5,688	317	1,804	14,434	---	106	7.34
1962	5,947	325	1,935	15,482	7	127	8.66
1963 [1]	4,800	323	1,550	12,400	1	90	7.34
Gold-silver:							
1954–58 (average)	405	283	115	915	---	29	31.68
1959	410	270	111	888	---	18	20.26
1960	253	286	72	580	---	2	3.45
1961	343	241	83	659	---	12	18.22
1962	347	251	87	702	---	30	42.74
1963 [1]	300	293	88	710	---	25	35.21
Iron:							
1954–58 (average)	4,879	247	1,204	9,687	2	77	8.16
1959	6,324	196	1,240	10,035	1	56	5.68
1960	6,413	258	1,653	13,320	---	79	5.93
1961	5,515	266	1,468	11,777	3	65	5.77
1962	4,868	283	1,376	11,130	3	91	8.45
1963 [1]	4,900	284	1,392	11,190	---	65	5.81
Lead-zinc:							
1954–58 (average)	3,171	249	791	6,345	---	105	16.55
1959	1,659	259	430	3,435	1	51	15.14
1960	1,614	258	416	3,336	---	70	20.98
1961	1,322	241	319	2,554	---	76	29.76
1962	1,743	254	442	3,539	---	55	15.54
1963 [1]	1,400	226	316	2,530	2	65	26.48
Uranium: [2]							
1960	2,578	321	826	6,610	1	138	21.03
1961	2,481	312	775	6,222	---	95	15.27
1962	2,219	302	670	5,406	2	87	16.46
1963 [1]	1,800	274	494	3,990	---	75	18.80
Alumina (includes bauxite):							
1960	5,104	332	1,697	13,574	---	43	3.17
1961	3,749	353	1,322	10,583	---	54	5.10
1962	4,004	344	1,376	11,006	1	67	6.18
1963 [1]	3,800	353	1,340	10,720	2	75	7.18
Miscellaneous metals: [3]							
1954–58 (average)	4,280	295	1,264	10,118	2	274	27.28
1959	5,442	300	1,632	13,107	3	146	11.37
1960	1,312	287	377	3,031	1	45	15.18
1961	1,420	292	415	3,324	---	50	15.04
1962	855	277	237	1,898	1	25	13.70
1963 [1]	1,000	298	298	2,390	---	15	6.28
Total: [4]							
1954–58 (average)	19,446	281	5,460	43,798	7	703	16.21
1959	19,423	248	4,808	38,621	5	353	9.27
1960	22,529	297	6,689	53,638	5	488	9.19
1961	20,518	301	6,186	49,552	3	458	9.30
1962	19,983	306	6,123	49,163	14	482	10.09
1963 [1]	18,000	304	5,478	43,920	5	410	9.45

[1] Preliminary figures.
[2] Uranium included with miscellaneous metals before 1960. Formerly classed as uranium-vanadium and included with miscellaneous metals. These plants are now classed as uranium.
[3] Includes antimony, bauxite, beryl, manganese, mercury, nickel, rare-earths, and anium; before 1960 includes uranium.
[4] Data may not add to totals shown because of rounding.

Iron.—The fatal and nonfatal combined injury-frequency rate was 15.31, a 1-percent increase over that of 1962. The average shift was 8 hours, and the average employee worked 2,022 hours, an increase of 136 hours over the 1962 figure. The mines were active an average of 251 days in 1963.

Lead-zinc.—The overall (fatal and nonfatal) injury-frequency rate at lead-zinc mines was 69.53, a 2-percent increase over that of 1962. The mines were active an average of 233 days, and the average employee worked 1,866 hours on an 8-hour daily shift.

Uranium.—The combined fatal and nonfatal injury-frequency rate of 43.38 was a 12-percent increase over the 1962 rate. Employees averaged 198 workdays and worked 1,600 hours on 8-hour shifts during the year.

Miscellaneous Metals.—These mines produce antimony, bauxite, beryl, manganese, mercury, nickel, rare-earths, titanium, and other ores not elsewhere classified. The combined fatal and nonfatal injury-frequency rate was 37.69, a 24-percent decrease from the 1962 rate. The average employee worked 2,000 hours on an 8-hour daily shift. Active mine days averaged 250, 11 days more than in 1962.

ORE-DRESSING PLANTS

Ore-dressing plants process metal-bearing ores by various methods including crushing, screening, washing, jigging, magnetic separation, flotation, and other milling operations. A 6-percent decrease was reported in the combined fatal and nonfatal injury-frequency rate. Gold lode, iron, uranium, and miscellaneous metal plants reported no fatalities. Employment at all ore-processing mills was 10 percent lower than in 1962. Likewise, total worktime declined 11 percent to a total of nearly 44 million man-hours. The average employee worked a total of 2,440 hours on a daily 8-hour shift.

NONFERROUS REDUCTION PLANTS AND REFINERIES

Nonferrous reduction plants and refineries are engaged in the primary extraction of nonferrous metals from ores and concentrates and the refining of crude primary nonferrous metals. The combined fatal and nonfatal injury-frequency rate was 10.35, 8 percent less than the combined rate for 1962. Although total employment of 33,100 was 5 percent lower than in 1962, the total worktime declined only 1 percent in 1963, owing to the greater number of active days at smelters. Workers averaged 2,720 hours of annual employment on 8-hour shifts.

TABLE 3.—Employment and injury experience at primary nonferrous reduction and refinery plants in the United States, by industry groups

Industry and year	Men working daily	Average active smelter days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rate per million man-hours
Copper:							
1954–58 (average)	11,551	315	3,638	29,205	4	399	13.80
1959	11,204	262	2,939	23,516	4	230	9.95
1960	11,805	313	3,693	29,445	3	370	12.67
1961	11,414	329	3,750	29,999	3	420	14.10
1962	10,954	328	3,590	28,697	5	360	12.72
1963 [1]	10,300	334	3,440	27,580	2	340	12.40
Lead:							
1954–58 (average)	3,392	305	1,034	8,270	2	125	15.36
1959	3,090	226	698	5,585	1	129	23.28
1960	2,782	267	742	5,939	1	103	17.51
1961	2,493	300	747	5,975	----------	116	19.41
1962	2,493	289	720	5,760	2	82	14.58
1963 [1]	2,600	277	720	5,720	1	60	10.66
Zinc:							
1954–58 (average)	8,831	330	2,912	23,201	2	609	26.33
1959	7,243	327	2,370	18,951	----------	361	19.05
1960	7,392	293	2,169	17,354	2	279	16.19
1961	6,518	328	2,138	17,107	2	360	21.16
1962	6,588	328	2,158	17,246	----------	277	16.06
1963 [1]	6,100	347	2,100	16,910	3	260	15.55
Aluminum: [2]							
1960	12,630	346	4,365	34,920	1	214	6.16
1961	13,408	326	4,371	34,966	1	331	9.50
1962	13,184	336	4,433	35,453	3	269	7.67
1963 [1]	12,700	356	4,520	36,180	----------	240	6.63
Miscellaneous metals:							
1954–58 (average)	15,808	352	5,570	44,397	1	524	11.83
1959	14,695	359	5,280	42,239	1	232	5.52
1960	1,551	315	489	3,913	----------	28	7.16
1961	1,714	278	477	3,816	----------	20	5.24
1962	1,605	297	477	3,819	----------	22	5.76
1963 [1]	1,400	321	450	3,630	1	25	7.16
Total: [4]							
1954–58 (average)	39,582	332	13,154	105,073	9	1,656	15.85
1959	36,232	312	11,287	90,291	6	952	10.61
1960	36,160	317	11,459	91,572	7	994	10.93
1961	35,547	323	11,483	91,862	6	1,247	13.64
1962	34,824	327	11,378	90,975	10	1,010	11.21
1963 [1]	33,100	340	11,240	90,020	7	925	10.35

[1] Preliminary figures.
[2] Aluminum included with miscellaneous metals group before 1960.
[3] Includes antimony, magnesium, tin, and titanium; before 1960 includes aluminum.
[4] Data may not add to total shown because of rounding.

NONMETAL MINES (EXCEPT STONE QUARRIES)

Nonmetal mines include those producing abrasives, asbestos, barite, boron minerals, clays, feldspar, fluorspar, gypsum, magnesite, mica, phosphate rock, potash, pumice, salt, sodium, sulfur, talc, soapstone, pyrophyllite, and other miscellaneous nonmetals. Injury experience was improved by the 7-percent reduction in the injury-frequency rate to 27.40 per million man-hours. The average number of men working declined 8 percent to 15,600 in 1963. However, total worktime was increased 1 percent because the number of active mine days advanced to 257. The average employee worked 2,096 hours in 1963.

Nonmetal Mills.—Injury experience in mills processing nonmetallic minerals was not as good as in 1962; this experience ended an annual improvement over a 3-year period. The combined fatal and nonfatal injury-frequency rate was 19.12, compared with the 1962 rate of 18.65. Employment declined 3 percent in 1963, but the total man-hours worked increased 3 percent. The average mill had an 8-hour shift and was active 279 days, 18 more than in 1962.

Clay Mines and Mills.—The principal clays are brick clay or shale, kaolin, bentonite, fuller's earth, ball clay, and fire clay. Table 6 shows an improved safety record at clay mines. Frequency of injuries was 26.06 per million man-hours, a 9-percent decrease from that of 1962. However, at clay mills the safety record was worse; the rate of occurrence of all injuries increased 12 percent.

TABLE 4.—Employment and injury experience at nonmetal mines (except stone quarries) in the United States [1]

Year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1954-58 (average)	15,730	262	4,120	33,429	14	1,043	31.62
1959	18,765	239	4,488	36,334	11	1,072	29.81
1960	18,653	242	4,515	36,805	19	1,056	29.21
1961	18,281	238	4,347	35,517	15	861	24.66
1962	16,917	235	3,979	32,484	14	944	29.49
1963 [2]	15,600	257	4,009	32,700	31	865	27.40

[1] Includes abrasives, asbestos, barite, boron minerals, clay, feldspar, fluorspar, gypsum, magnesite, mica, phosphate rock, potash, pumice, salt, sodium, sulfur, talc, soapstone, pyrophyllite, and other miscellaneous nonmetals.
[2] Preliminary figures.

TABLE 5.—Employment and injury experience at nonmetal mills (except stone quarries) in the United States

Year	Men working daily	Average active mill days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1958	32,401	272	8,809	71,161	9	1,490	21.06
1959	40,800	274	11,195	90,706	11	2,156	23.89
1960	39,568	270	10,679	86,386	13	1,794	20.92
1961	39,031	268	10,471	83,925	6	1,680	20.09
1962	34,900	261	9,112	74,621	9	1,383	18.65
1963 [1]	34,000	279	9,498	77,200	1	1,475	19.12

[1] Preliminary figures.

TABLE 6.—Employment and injury experience at clay mines and mills in the United States

Year	Men working daily	Average active days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
Mine:							
1959	5,914	191	1,132	9,184	5	271	30.05
1960	6,209	192	1,193	9,638	5	272	28.73
1961	5,896	194	1,144	9,220	3	189	20.83
1962	5,383	185	995	8,031	1	230	28.76
1963 [1]	4,700	198	932	7,520	1	195	26.06
Mill:							
1959	20,142	252	5,084	41,170	7	1,267	30.94
1960	20,222	247	4,991	40,784	6	1,121	27.63
1961	20,532	247	5,068	40,593	2	1,107	27.32
1962	17,142	233	3,987	32,756	3	796	24.39
1963 [1]	16,000	249	3,989	33,020		900	27.26

[1] Preliminary figures.

STONE QUARRIES

For quarries, the overall injury-frequency rate (fatal and nonfatal combined) per million man-hours of worktime increased 8 percent, from 17.40 in 1962 to 18.79 in 1963. Both employment and total man-hours worked at all quarries and mills were only slightly lower in 1963 than in 1962. The average employee worked 2,105 hours during the year.

Cement.—The combined fatal and nonfatal injury-frequency rate in quarries and mills increased from 4.14 in 1962 to 5.15 in 1963. The average man worked 2,469 hours in 1963 and 2,447 hours in 1962.

Granite.—The overall injury-frequency rate (fatal and nonfatal) increased 8 percent over that of 1962; the average man worked 1,904 hours, 22 hours fewer than in 1962.

Lime.—The lime industry's injury-frequency rate (fatal and nonfatal) was 13.13 per million man-hours of worktime; the rate was 17.76 in 1962. The average employee worked 2,386 hours, 65 hours more than in 1962.

Limestone.—The limestone industry reported an 8-percent increase in the overall injury-frequency rate, from 22.43 in 1962 to 24.22 in 1963. The average number of man-hours per man was 1,955, a decrease of 6 hours.

Marble.—The combined injury-frequency rate in the marble industry was 29.69, 33 percent less than the rate of 44.29 in 1962. The average man worked 2,057 hours in 1963.

Sandstone.—The sandstone quarrying industry reported a 25-percent increase in the overall injury-frequency rate from 25.00 in 1962 to 31.26 in 1963. The average employee worked 1,850 hours, an increase of 9 hours over the 1962 figure.

Slate.—The injury-frequency rate (fatal and nonfatal combined) for the slate industry increased by 21 percent over the 1962 rate. The average number of hours worked per man was 2,092.

Traprock.—The combined injury-frequency rate (fatal and nonfatal) in the traprock industry was 32.47, a 45-percent increase over the 22.36 reported in 1962. The hours worked per man averaged 1,798.

Miscellaneous Stone.—The combined injury-frequency rate was 21.75 in 1962 and 29.18 in 1963, an increase of 34 percent. The average employee worked 1,525 hours in 1963.

TABLE 7.—Employment and injury experience at stone quarries and mills in the United States, by industry groups

Industry and year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries: Fatal	Number of injuries: Nonfatal	Injury rate per million man-hours
Cement: [1]							
1954–58 (average)	28,771	316	9,102	72,839	10	300	4.26
1959	28,253	(2)	(2)	71,261	7	339	4.86
1960	28,837	(2)	(2)	70,846	5	334	4.79
1961	27,028	308	8,336	66,732	2	259	3.91
1962	25,564	306	7,817	62,545	8	251	4.14
1963 [3]	25,000	307	7,676	61,730	8	310	5.15

See footnotes at end of table.

TABLE 7.—Employment and injury experience at stone quarries and mills in the United States, by industry groups—Continued

Industry and year	Men working daily	Average active mine days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
Granite:							
1954-58 (average)	6,656	239	1,592	13,095	6	546	42.15
1959	8,512	(2)	(2)	18,003	3	717	39.99
1960	8,532	(2)	(2)	16,563	2	551	33.39
1961	8,329	234	1,949	16,192	4	547	34.03
1962	8,239	229	1,886	15,870	7	425	27.22
1963 [3]	7,600	228	1,732	14,470	12	415	29.51
Lime: [1]							
1954-58 (average)	8,122	290	2,356	18,915	5	420	22.47
1959	7,800	(2)	(2)	18,686	7	354	19.32
1960	8,295	(2)	(2)	20,036	8	372	18.97
1961	8,485	291	2,466	19,775	3	348	17.75
1962	7,690	289	2,222	17,847	5	312	17.76
1963 [3]	7,600	284	2,162	18,130	3	235	13.13
Limestone:							
1954-58 (average)	27,091	236	6,391	53,129	20	1,810	34.44
1959	31,939	(2)	(2)	63,184	26	2,060	33.01
1960	33,453	(2)	(2)	66,250	13	2,072	31.47
1961	31,923	229	7,322	61,717	15	1,903	31.08
1962	32,931	229	7,538	64,570	33	1,415	22.43
1963 [3]	33,000	230	7,602	64,530	28	1,535	24.22
Marble:							
1954-58 (average)	2,718	252	685	5,643	1	193	34.38
1959	3,071	(2)	(2)	6,432	----------	269	41.82
1960	3,093	(2)	(2)	6,457	2	308	48.01
1961	3,119	245	765	6,257	2	289	46.51
1962	2,919	247	721	5,938	3	260	44.29
1963 [3]	2,800	254	710	5,760	1	170	29.69
Sandstone:							
1954-58 (average)	3,377	224	756	6,152	1	300	48.93
1959	3,788	(2)	(2)	6,692	2	286	43.04
1960	4,701	(2)	(2)	7,770	3	374	48.52
1961	4,370	206	900	7,404	2	327	44.44
1962	5,867	219	1,282	10,802	3	267	25.00
1963 [3]	6,000	222	1,329	11,100	2	345	31.26
Slate:							
1954-58 (average)	1,457	255	372	3,082	----------	153	49.64
1959	1,403	(2)	(2)	2,842	1	152	53.84
1960	1,273	(2)	(2)	2,451	----------	117	47.74
1961	1,160	251	292	2,359	----------	135	57.23
1962	1,224	243	298	2,510	3	77	31.87
1963 [3]	1,300	258	335	2,720	----------	105	38.60
Traprock:							
1954-58 (average)	3,193	222	710	6,045	4	261	43.84
1959	4,808	(2)	(2)	8,746	3	443	50.99
1960	5,207	(2)	(2)	8,835	4	411	46.97
1961	4,979	220	1,097	9,079	4	407	45.27
1962	5,734	215	1,235	10,197	4	224	22.36
1963 [3]	6,200	218	1,350	11,150	2	360	32.47
Miscellaneous stone: [4]							
1957-61 (average)	1,744	209	364	3,082	1	127	41.53
1962	2,071	190	393	3,173	1	68	21.75
1963 [3]	2,000	190	379	3,050	4	85	29.18
Total: [5]							
1954-58 (average)	81,963	270	22,103	180,018	47	4,036	22.68
1959	91,523	(2)	(2)	199,321	52	4,790	24.29
1960	95,304	(2)	(2)	202,366	39	4,668	23.26
1961	91,371	257	23,524	192,705	32	4,280	22.38
1962	92,241	254	23,393	193,453	67	3,299	17.40
1963 [3]	91,500	254	23,275	192,640	60	3,560	18.79

[1] Includes burning or calcining and other mill operations.
[2] Data not available.
[3] Preliminary figures.
[4] Not compiled before 1957.
[5] Data may not add to total shown because of rounding.

SAND AND GRAVEL PLANTS

The combined fatal and nonfatal injury-frequency rate for sand and gravel operations was 19.51. Compared with a rate of 21.97

for 1962, this is an 11-percent improvement. The average number of men working and the total worktime at all sand and gravel plants each decreased 2 percent in 1963. The plants were active an average of 216 days, and the average employee worked 1,814 hours in 1963.

TABLE 8.—Employment and injury experience at sand and gravel plants in the United States

Year	Men working daily	Average active plant days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1959	59,492	(1)	(1)	109,830	21	2,161	19.87
1960	52,352	(1)	(1)	95,749	25	1,919	20.30
1961	55,726	217	12,117	101,707	21	1,814	18.04
1962	53,599	218	11,690	97,589	51	2,093	21.97
1963 [2]	52,800	216	11,403	95,770	33	1,835	19.51

[1] Data not available.
[2] Preliminary figures.

SLAG (IRON-BLAST-FURNACE) PLANTS

Reports from slag plants showed decreases of 3 percent in number of men working and 2 percent in number of man-hours worked. A fatal injury occurred, the first in 4 years. Six more nonfatal injuries were reported than in 1962. The injury-frequency rate increased 27 percent to 12.56 from 9.91 in 1962. Employees worked an average of 2,018 hours, and plants were active 4 more days during the year.

TABLE 9.—Employment and injury experience at slag (iron-blast-furnace) plants in the United States

Year	Men working daily	Average active plant days	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rate per million man-hours
					Fatal	Nonfatal	
1959	1,789	254	455	3,681	1	43	11.95
1960	1,680	(1)	(1)	3,613		34	9.41
1961	1,682	246	415	3,361		30	8.93
1962	1,462	248	362	2,927		29	9.91
1963	1,421	252	358	2,867	1	35	12.56

[1] Data not available.

Abrasive Materials

By Paul M. Ambrose [1]

Contents

ADVANCES in mining and processing technology made it possible to reopen the De Beers diamond mine in South Africa, originally located in 1871 by Cecil Rhodes and closed in 1908. Radioactive material was used to indicate the efficiency of hydrocyclones used in diamond concentration. Added interest was shown in recovering diamond from the sea off the coast of South-West Africa. Production of crude artificial abrasives declined because demand was paritally met by withdrawals from stocks. The value of graded grain-coated abrasives and grinding wheels surpassed those of 1962.

TABLE 1.—Salient abrasive statistics in the United States

Kind	1954-58 (average)	1959	1960	1961	1962	1963
Natural abrasives (domestic) sold or used by producers:						
Tripoli short tons	[1] 48,108	52,968	57,713	54,641	61,732	66,635
Value thousands	[1] $198	$219	$247	$225	$244	$266
Special silica-stone products [2] short tons	5,710	3,672	2,539	2,495	2,653	2,693
Value thousands	$381	$315	$241	$238	$260	$255
Garnet short tons	11,582	14,568	10,522	12,057	14,166	14,626
Value thousands	$1,037	$1,211	$986	$1,036	$1,172	$1,412
Emery short tons	10,445	8,555	8,169	6,180	4,316	6,732
Value thousands	$154	$150	$142	$106	$71	$119
Artificial abrasives [3] short tons	416,653	417,569	441,508	372,192	423,412	402,823
Value thousands	$53,139	$62,928	$64,594	$54,937	$59,854	$56,523
Foreign trade (natural and artificial abrasives):						
Imports for consumption (value) thousands	$81,523	$91,560	$84,488	$96,219	$79,473	$77,517
Exports (value) do	$24,507	$23,100	$26,550	$29,209	$32,757	$35,774
Reexports (value) do	$8,426	$13,700	$10,409	$17,814	$11,454	$12,918

[1] Average for 1955-58.
[2] See table 6 for kind of products.
[3] Production of silicon carbide and aluminum oxide (United States and Canada); shipments of metallic abrasives (United States).

[1] Commodity specialist, Division of Minerals.

FOREIGN TRADE

The large decrease in value of imports of diamond dust and powder as well as aluminous abrasives was not entirely balanced by increased imports in other abrasive commodities. This resulted in a 2-percent decline of the value of imports of abrasive materials in 1963.

The value of exports of abrasive materials has increased at a fairly uniform rate equivalent to slightly more than $3 million per year for the past 4 years. The value, in million dollars, was: 1959—23.1; 1960—26.5; 1961—29.2; 1962—32.7; and 1963—35.7. The value of reexports was $1.5 million above those of 1962 but was $4.9 million less than in 1961.

TABLE 2.—U.S. imports for consumption of abrasive materials (natural and artificial), by kinds

Kind	1962		1963	
	Quantity	Value	Quantity	Value
Burrstones: Bound up into millstones......short tons..	7	$943	17	$2,795
Hones, oilstones, and whetstones.............number..	244,717	61,042	[1] 251,784	[1] 62,315
Corundum (including emery):				
Corundum ore.........................short tons..	2,430	57,326	2,035	51,334
Emery ore..................................do....	2,240	19,500	[2] 560	[2] 13,000
Grains, ground, pulverized, or refined.......do....	[3] 56	[3] 9,531	(4)	(4)
Paper and cloth coated with sand, emery, or corundum..........	(5)	1,576,429	(5)	[1] 1,526,201
Wheels, files, and other manufactures of emery or garnet, and wheels of corundum or silicon carbide short tons..	(5)	304,520	(5)	[1] 440,569
Tripoli, rottenstone, diatomaceous earth, and burrstones, in blocks, unmanufactured.......short tons..	8,145	10,025	[1] 5,785	[1] 142,228
Diamonds:				
Diamond dies, pierced or partially pierced, mounted or unmounted...............number..	21,111	161,452	9,305	169,415
Crushing bort (including all types of bort suitable for crushing..........................carats..	2,644,408	6,995,489	4,204,733	10,861,161
Other industrial diamonds (including glaziers' and engravers' diamonds, unset, and miners') carats..	5,068,185	31,898,675	5,181,570	32,168,418
Carbonado and ballas.......................do....	12,601	77,171	165,239	779,256
Dust and powder............................do....	4,555,949	12,069,050	2,295,486	6,061,975
Flint, flints, and flintstones, unground.....short tons..	12,619	271,403	(4)	(4)
Grit, shot, and sand, or iron and steel...........do....	1,579	730,691	1,614	669,597
Artificial abrasives:				
Crude, not separately provided for:				
Carbides of silicon (Carborundum, Crystalon, Carbolon, and Electrolon).......short tons..	57,766	7,761,545	68,214	8,424,001
Aluminous abrasives, Alundum, Aloxite, Exolon, and Lionite............short tons..	150,154	15,452,298	134,875	13,473,368
Other.....................................do....	16	173	1,148	165,255
Manufactures:				
Grains, ground, pulverized, refined, or manufactured.........................short tons..	[3] 8,624	[3] 1,924,707	[1] 11,229	[1] 2,356,030
Wheels, files, and other manufactures, not separately provided for..........short tons..	(5)	91,221	(5)	[1] 150,342
Total..	....	79,473,191	....	77,517,260

[1] Due to changes in classifications by the Bureau of the Census, data not strictly comparable to earlier years.
[2] Not separately classified beginning Sept. 1, 1963; included with tripoli, rottenstone, etc.
[3] Revised figure.
[4] January–August, none. Not separately classified beginning Sept. 1, 1963; included with tripoli, rottenstone, etc.
[5] Quantity not recorded.

Source: Bureau of the Census.

TABLE 3.—U.S. imports of abrasive materials, by kinds

Kind	1962		1963	
	Quantity	Value	Quantity	Value
Natural abrasives:				
Diamond grinding wheels, sticks, hones, and laps carats	310, 330	$1, 990, 352	373, 053	$2, 353, 883
Diamond dust and powder do	828, 611	2, 225, 256	1, 095, 737	2, 982, 865
Diamond suitable only for industrial use do	715, 042	2, 268, 859	1, 068, 239	3, 302, 416
Grindstones and pulpstones short tons	127	53, 283	41	34, 210
Emery powder, grains, and grit (natural) pounds	1, 637, 188	178, 411	1, 251, 128	250, 812
Corundum grains and grits (natural) do	218, 792	55, 124	150, 622	47, 930
Whetstones, sticks, etc. (natural) do	171, 338	156, 102	138, 475	162, 257
Natural abrasives not elsewhere classified do	21, 421, 364	1, 177, 537	25, 450, 422	1, 397, 988
Manufactured abrasives:				
Aluminum oxide, fused, crude, and grains do	27, 053, 672	4, 419, 868	26, 273, 280	4, 075, 951
Silicon carbide, fused, crude, and grains do	20, 450, 190	3, 641, 249	19, 625, 889	3, 309, 004
Alumina, unfused do	297, 176	85, 815	375, 481	100, 486
Manufactured abrasives, not elsewhere classified do	357, 344	107, 565	207, 393	109, 847
Abrasive pastes, compounds, and cake (except chemical) pounds	872, 352	216, 282	830, 749	254, 710
Grinding wheels, except diamond wheels do	3, 324, 180	4, 379, 086	3, 050, 860	4, 342, 904
Pulpstones of manufactured abrasives do	2, 832, 176	789, 957	2, 842, 296	777, 755
Whetstones, etc., of manufactured abrasives do	384, 774	1, 041, 594	306, 112	1, 046, 569
Abrasive paper and cloth (natural abrasives) reams	29, 943	662, 730	30, 769	608, 495
Abrasive paper and cloth (artificial abrasives) do	231, 614	8, 048, 156	272, 690	9, 453, 860
Metallic abrasives (except steel wool) pounds	15, 823, 291	1, 260, 075	14, 537, 303	1, 161, 807
Total		32, 757, 301		35, 773, 749

Source: Bureau of the Census.

TABLE 4.—U.S. reexports of abrasive materials, by kinds

Kind	1962		1963	
	Quantity	Value	Quantity	Value
Natural abrasives:				
Diamond granding wheels, sticks, hones, and laps carats	658	$8, 429	303	$4, 814
Diamond dust and powder do	75, 426	216, 215	153, 853	350, 350
Diamond suitable only for industrial use do	1, 965, 021	11, 213, 091	2, 236, 222	12, 526, 158
Emery powder, grains, and grits (natural) pounds	8, 400	754	14, 560	1, 593
Natural abrasives not elsewhere classified do			145, 650	7, 371
Manufactured abrasives:				
Alumina, unfused do			129, 800	9, 305
Aluminum oxide, fused, crude, and grains do	5, 102	884	6, 073	1, 883
Grinding wheels, except diamond wheels do	3, 832	11, 923	7, 766	13, 223
Abrasive paper and cloth (artificial abrasives) reams	8	326		
Whetstones, etc., of manufactured abrasives pounds	139	1, 897	200	3, 030
Total		11, 453, 519		12, 917, 727

Source: Bureau of the Census.

TRIPOLI [2]

Tripoli is used as a general term to include tripoli from the Missouri-Oklahoma field, amorphous or soft silica from southern Illinois, and rottenstone from Pennsylvania. Although they differ in some respects, all are fine-grained, porous silica materials with many similar properties and end uses. Production of crude domestic tripoli increased 8 percent in quantity and 9 percent in value over that of 1962.

[2] Tripoli is the only natural silica abrasive included in the abrasive materials canvass. Information on sands used for abrasive purposes, formerly given in the Abrasive Materials chapter, can be found in the Sand and Gravel chapter. Information on abrasive quartz quarzite, and sandstone can be found in the Stone chapter.

Sales of processed tripoli increased 4 percent in quantity and value. Approximately 71 percent of the processed tripoli was sold for abrasive uses compared with 73 percent in 1962.

In 1963, five companies mined and processed tripoli, amorphous silica, and rottenstone: Ozark Minerals Co., Elco, Ill. (amorphous silica); Tamms Industries Co., Tamms, Ill. (amorphous silica); American Tripoli Division, The Carborundum Co., Seneca, Mo., and Ottawa County, Okla. (tripoli); Penn Paint & Filler Co., Antes Fort, Pa. (rottenstone); and Keystone Filler & Manufacturing Co., Muncy, Pa. (rottenstone).

Prices for processed tripoli remained unchanged from 1962 according to quotations in E&MJ Metal and Mineral Markets. They were as follows (per pound, paper bags, minimum carlot 30 tons, f.o.b. Missouri): Once-ground through 40 mesh, rose- and cream-colored, 2.5 and 2.75 cents; double-ground through 110 mesh, rose- and cream-colored, 2.6 to 2.75 cents; and air-floated through 200 mesh, 2.75 to 3 cents.

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

Year	Abrasives		Filler		Other, including foundry facings		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1954–58 (average)	31,654	$1,292	7,631	$179	[3] 4,390	[3] $156	43,675	$1,627
1959	34,389	1,527	8,199	192	5,061	169	47,649	1,888
1960	37,050	1,589	9,590	206	5,258	167	51,898	1,962
1961	34,581	1,472	9,409	231	4,605	149	48,595	1,852
1962	38,241	1,641	9,578	252	4,863	152	52,682	2,045
1963	38,979	1,645	10,145	276	5,619	197	54,743	2,118

[1] Includes amorphous silica and Pennsylvania rottenstone.
[2] Partly estimated.
[3] Includes some tripoli for filter block in 1955.

SPECIAL SILICA-STONE PRODUCTS

Grindstone sales were reported from Ohio; grinding pebbles, from Minnesota, Washington, and Wisconsin; tube-mill liners, from Minnesota and Wisconsin; natural silica abrasive material for oilstones and other sharpening stones, from Arkansas and Indiana; and millstones from North Carolina.

TABLE 6.—Special silica-stone products sold or used by producers in the United States

Year	Grindstones		Grinding pebbles		Other products[1]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1954–58 (average)	(2)	(2)	2,483	$84	3,227	$297	5,710	$381
1959	1,081	$101	1,695	82	896	132	3,672	315
1960	(2)	(2)	1,132	66	1,407	175	2,539	241
1961	(2)	(2)	(2)	(2)	2,495	238	2,495	238
1962	(2)	(2)	(2)	(2)	2,653	260	2,653	260
1963	(2)	(2)	(2)	(2)	2,693	255	2,693	255

[1] Includes products indicated by footnote 2, oilstones and other sharpening stones, value of millstones, and tube-mill liners.
[2] Included with "Other products" to avoid disclosing individual company confidential data.

NATURAL SILICATE ABRASIVES

Garnet.—Sales of domestic garnet, which has no value until crushed, concentrated, and ground to definite particle size specifications by the producer, increased 3 percent in quantity and 20 percent in value. The sharp change in value was largely due to increased production in New York. Material from New York was used principally in glass grinding, metal lapping, and wood, leather, and plastic sanding. Idaho garnet was used in sandblasting. Producers in 1963 were: Idaho Garnet Abrasive Co. and Emerald Creek Garnet Milling Co., Fernwood, Idaho; Porter Brothers Corp., Valley County, Idaho; Barton Mines Corp., North Creek, N.Y.; and Cabot Corp., Willsboro, N.Y.

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

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1954-58 (average)	11,582	$1,037	1961	12,057	$1,036
1959	14,568	1,211	1962	14,166	1,172
1960	10,522	986	1963	14,626	1,412

NATURAL ALUMINA ABRASIVES

Corundum.—There was no reported production of corundum in the United States or Canada in 1963. The American Abrasive Co., Westfield, Mass., was the sole importer and processor of corundum in 1963. That company reported receiving most of its corundum from Southern Rhodesia. Mining operations for this mineral in South Africa have been curtailed in favor of production from Southern Rhodesia since 1958. According to data of the Bureau of the Census, imports in 1963 decreased 16 percent in quantity and 10 percent in value below those of 1962.

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

(Short tons)

Country [1]	1954-58 (average)	1959	1960	1961	1962	1963
Argentina	6					
Australia	2					
India	424	236	276	363	332	[3] 330
Malaya, Federation of	[4] 21					
Mozambique	2					
Rhodesia and Nyasaland, Federation of:						
Nyasaland	8					
Southern Rhodesia	3,511	2,799	3,843	2,792	3,348	5,941
South Africa, Republic of	1,601	622	123	159	349	65
World total (estimate) [1] [2]	10,000	8,000	9,000	8,000	9,000	11,000

[1] Corundum is produced in U.S.S.R., data on production are not available, and estimate is included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Exports.

Emery.—Sales of emery mined in the United States increased 56 percent in quantity and 68 percent in value over sales in 1961. Domestic producers were De Luca Emery Mine at De Luca No. 1 and De Luca No. 2, Peekskill, N.Y., and Di Rubbo American Emery Ore, Kingston Emery Mine, Croton-on-Hudson, N.Y. As in recent years, the principal uses were in coated abrasives, grinding wheels, and in nonskid surfaces for floors, stairs, and pavements. Imports of emery were 560 short tons valued at $13,000 in the first 9 months of 1963; after September separate data were not available. In the previous 12-month period 2,240 short tons, valued at $19,500, was imported.

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

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1954-58 (average)	10,445	$154	1961	6,180	$106
1959	8,555	150	1962	4,316	71
1960	8,169	142	1963	6,732	119

INDUSTRIAL DIAMOND

Imports of crushing bort increased 59 percent in 1963. The Republic of the Congo became the principal supplier of crushing bort to the United States. Imports from that country increased more than 800 percent. Less than 200,000 carats of crushing bort was imported from the Congo in the first 6 months of 1963. This was less than for any month in the last half of the year. In December the United States received more than 400,000 carats of crushing bort from the Congo. Because crushing bort and dust and powder have similar end uses, a comparison of imports of the total of the two classes is important. The total crushing bort and dust and powder imports decreased from 7.2 million carats in 1962 to 6.5 million carats in 1963. The loss in imports may have been compensated for, at least partially, by increased production of manufactured diamond and an increase in the amount of recovered secondary diamond. There was only a small increase in imports of industrial stones.

Production of manufactured diamond suitable for use in grinding wheels and saws was estimated to be more than 5 million carats in 1963. Production continued at General Electric Co. at Detroit, Mich., and Ultra High Pressure Units, Ltd., at Springs near Johannesburg, Republic of South Africa. Early in the year production started at Shannon, Ireland, in units moved from the South African plant. There was also other production in the U.S.S.R. and reportedly in Japan.

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

(Thousand carats and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1954-58 (average)	13,635	$55,796	1961	14,210	$68,545
1959	13,094	62,626	1962	12,281	51,040
1960	13,146	51,836	1963	11,847	49,871

Source: Bureau of the Census.

TABLE 11.—U.S. imports for consumption of industrial diamond (including diamond dust), by countries

Year and country	Crushing bort (including all types of bort suitable for crushing)		Other industrial diamond (including glazers' and engravers' diamond, unset and miners') [1]		Carbonado and ballas		Dust and powder	
	Carat	Value	Carat	Value	Carat	Value	Carat	Value
1962:								
North America:								
Canada	56,813	$151,460	158,566	$761,090	----	----	4,753	$10,410
Mexico	----	----	5,917	474	----	----	----	----
Total	56,813	151,460	164,483	761,564	----	----	4,753	10,410
South America:								
Brazil	----	----	86,340	920,139	1,344	$14,656	----	----
British Guiana	----	----	1,640	35,544	----	----	----	----
Chile	----	----	500	2,000	----	----	----	----
Venezuela	2,571	7,099	38,630	341,123	----	----	----	----
Total	2,571	7,099	127,110	1,298,806	1,344	14,656	----	----
Europe:								
Belgium-Luxembourg	4,444	11,998	319,876	2,017,442	----	----	41,404	115,161
France	40,460	77,683	7,694	54,039	49	198	300	690
Germany, West	----	----	40,553	281,285	----	----	----	----
Ireland	----	----	309,739	1,584,323	----	----	400	1,031
Malta, Gozo	----	----	120	1,439	----	----	----	----
Netherlands	3,000	7,950	55,904	471,381	----	----	32,538	89,703
Switzerland	227	851	12,782	116,941	----	----	4,739	12,960
United Kingdom	1,520,126	3,927,954	625,235	4,892,428	570	12,013	646,245	1,732,927
Total	1,568,257	4,026,436	1,371,903	9,419,278	619	12,211	725,626	1,952,472
Asia:								
Israel	----	----	8,388	142,271	----	----	3,315	9,614
Japan	1,363	19,645	4,515	73,888	----	----	100	470
Total	1,363	19,645	12,903	216,159	----	----	3,415	10,084
Africa:								
British East Africa and Tanganyika	----	----	1,106	7,753	----	----	----	----
British West Africa and Sierra Leone	46,052	128,134	220,834	1,558,856	----	----	----	----
Congo, Republic of the, and Ruanda-Urundi	175,980	460,957	497,823	2,132,674	----	----	294,918	801,852
Ghana	10,059	27,571	830,323	4,228,881	----	----	17,449	49,949
Liberia	17,397	48,171	181,715	1,456,574	----	----	----	----
Nigeria, Federation of	834	3,000	1,044	31,000	----	----	----	----
Portuguese West Africa, n.e.c.	----	----	2,358	13,173	----	----	----	----
South Africa, Republic of	694,194	1,893,884	1,191,785	7,616,098	----	----	3,508,608	9,237,624
Western Africa, n.e.c.	59,190	183,955	387,201	2,343,729	2,905	13,245	55	490
Western Equatorial Africa, n.e.c.	11,698	45,177	77,597	814,130	7,733	37,059	553	5,069
Total	1,015,404	2,790,849	3,391,786	20,202,868	10,638	50,304	3,821,583	10,094,984
Oceania: Australia	----	----	----	----	----	----	572	1,100
Grand total	2,644,408	6,995,489	5,068,185	31,898,675	12,601	77,171	4,555,949	12,069,050

See footnote at end of table.

TABLE 11.—U.S. imports for consumption of industrial diamond (including diamond dust), by countries—Continued

Year and country	Crushing bort (including all types of bort suitable for crushing)		Other industrial diamond (including glazers' and engravers' diamond, unset and miners')[1]		Carbonado and ballas		Dust and powder	
	Carat	Value	Carat	Value	Carat	Value	Carat	Value
1963:								
North America:								
Canada	38,633	$99,658	121,790	$704,678			35,647	$105,001
Mexico	10,917	19,834			17,848	$929		
Total	49,550	119,492	121,790	704,678	17,848	929	35,647	105,001
South America:								
Brazil	6	219	8,249	116,591	787	12,435		
British Guiana			382	7,570				
Venezuela	1,261	4,522	16,471	290,261				
Total	1,267	4,741	25,102	414,422	787	12,435		
Europe:								
Azores	8,636	21,881						
Belgium-Luxembourg	432,780	1,024,919	400,836	2,465,139			58,452	164,708
France			17,874	264,589	676	3,380	100	295
Germany, West			16,561	349,798				
Ireland			558,681	2,672,882	80,219	417,513	91,216	291,407
Malta, Gozo			65	982				
Netherlands	7,853	17,782	112,318	1,378,250	846	5,938	37,794	104,325
Spain					64	1,277		
Sweden			980	4,303				
Switzerland	407	988	71,352	843,513			23,803	42,226
United Kingdom	641,770	1,755,256	643,333	6,271,933	669	4,684	741,649	1,914,277
Total	1,091,446	2,820,826	1,822,000	14,251,389	82,474	432,792	953,014	2,517,238
Asia:								
Israel	544	1,632	31,294	304,355	6,406	32,057		
Japan			32,924	514,533			2,550	7,400
Total	544	1,632	64,218	818,888	6,406	32,057	2,550	7,400
Africa:								
British West Africa, and Sierra Leone	66,979	176,386	44,524	250,359				
Congo, Republic of the, and Ruanda-Urundi	1,687,452	4,283,988	390,916	1,367,723	1,280	8,260	132,300	330,972
Ghana	1,397	2,096	775,493	3,941,928	28	956	2,500	6,000
Liberia			39,074	276,824				
Rhodesia and Nyasaland, Federation of			1,802	10,223				
South Africa, Republic of	1,216,124	3,217,146	1,428,771	7,530,472	26,816	139,505	1,150,880	3,059,116
Western Africa, n.e.c.	84,573	220,753	400,196	2,004,475	911	5,963	3,770	11,660
Western Equatorial Africa, n.e.c.	5,401	14,101	67,611	596,673	28,689	146,359	4,625	13,307
Total	3,061,926	7,914,470	3,148,387	15,978,677	57,724	301,043	1,294,075	3,421,055
Oceania: Australia			73	364			10,200	11,281
Grand total	4,204,733	10,861,161	5,181,570	32,168,418	165,239	779,256	2,295,486	6,061,975

[1] Beginning Sept. 1, 1963, changes in classifications by Bureau of the Census; data not strictly comparable to earlier years.

Source: Bureau of the Census.

World Review.—*Africa.*—A new company may be formed for diamond prospecting in an area in south Angola that was formerly reserved for the Government. Diamond production decreased from 1,147,539 carats in 1961 to 1,081,104 carats in 1962 but in the first 3 months of 1963 the Angolan Diamond Co. exported 377,362 carats of diamond which was 141,768 carats more than in the similar period of 1962.[3] Development of deposits in Angola led to a revised estimated reserve figure that was higher than the previous one although over 1 million carats of diamond had been mined.[4]

Because of diamond thieving and illicit operations, reported production from the Republic of the Congo represents only the diamond mined by Société Minière de Bakwanga. Illicit diamond operations were conducted on deposits adjacent to the concession operated by the Société Minière.[5]

TABLE 12.—World production of natural industrial diamond, by countries

(Thousand carats)

Country	1962	1963
Africa:		
Angola	[1] 319	325
Central African Republic	185	282
Congo, Republic of the	14,400	14,468
Congo, Republic of [2]	2,471	5,343
Ghana, Republic of	2,580	2,142
Guinea, Republic of	[3] 210	[4] 32
Ivory Coast, Republic of	182	117
Liberia [5]	680	508
Sierra Leone	[1] 1,200	833
South Africa, Republic of:		
"Pipe" mines:		
Premier	1,260	1,565
De Beers Group [6]	750	754
Others	84	86
"Alluvial" mines	190	196
South-West Africa	227	119
Tanganyika	324	313
Total Africa [7]	[1] 25,061	27,082
Other areas:		
Brazil [3]	175	175
British Guiana	40	40
Venezuela	83	31
U.S.S.R.[3]	[1] 2,300	2,760
World total	[1] 27,659	30,088

[1] Revised figure.
[2] Probable origin, Republic of the Congo.
[3] Estimate.
[4] Data known to be low, no sure basis for an upward revision.
[5] Exports, most production from adjacent nations.
[6] Includes some alluvial diamond from De Beers' properties.
[7] Data do not add to total because of rounding.

According to a decree of October 14, 1963, the Ministry of Commerce, Government of the Republic of Guinea would officially define an area estimated to contain 200,000 carats of diamond. This area was to be opened for private exploitation.[6] The area, bounded on the north by the parallel passing through Mazano, on the east by the meridian of Famarodou, on the south by the parallel passing through

[3] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, p. 12.
[4] Mining Journal (London). Angolian Diamond Exports. V. 261, No. 6690, Nov. 8, 1963, p. 448.
[5] Mining Journal (London). Sibeka. V. 260, No. 6668, June 7, 1963, p. 584.
[6] Bureau of Mines. Mineral Trade Notes. V. 58, No. 2, February 1964, p. 11.

Sommansenia, and on the west by the right bank of the Baule, was opened for private exploitation on November 15, 1963. Only residents of Guinea were eligible for mining permits which were good for 1 year and all diamond from the area was to be sold to the National Diamond Bourse. Mines were to be closed during the farming season and severe penalties were outlined for illicit operations.[7]

The closing of diamond fields in the Séguéla area, Republic of Ivory Coast, in April 1962 resulted in decreased production and export. The area was sealed by the Government because of alleged wasteful mining methods. Nine separate groups or companies were prospecting for diamond in the Ivory Coast.[8]

The mine operated by Liberian Swiss Mining Corp., Williamstown, was opened in February 1963. It was the first fully mechanized diamond mine in Liberia.[9]

Diamond mining, while not large compared with production from some other countries, was one of Sierra Leone's best sources of income. In 1962 diamond exports accounted for 44 percent of the total earnings. Diamond mining used more miners than any other mineral enterprise in the country. Between 17,000 and 40,000 miners were needed at any one time in hand mining gravels ranging from 6 inches to 48 inches in thickness and covered by overburden ranging from 0 to 40 feet.[10]

In the Republic of South Africa the De Beers mine which opened before 1880 and closed in 1908 and is the oldest mine in Africa was being reopened. The new operations will include removing crushed blueground from pillars left in early mining and exploiting a large section of the blueground on the west side of the old workings. The new blueground was said to have been left because of an arbitrary line drawn by Cecil Rhodes across the old mining plan. The arbitrary boundry, supposed to delineate the economic mining limit, lasted until the present time. The reopened mine was not expected to be a major producer but would furnish both industrial and gem diamond.[11]

A small recovery barge, operated by Marine Diamond Corp., Ltd., was damaged by a storm in June 1963 after operating for about 10 months in the Orange River mouth, South-West Africa. Marine diamond mining by that corporation was to be conducted from a larger vessel being outfitted in Cape Town. The 1962 output averaged 0.41 carat per stone with a recovery of 3.58 carats per cubic meter. Although Marine Diamond was the only producer of marine diamond in 1963, concessions within a 3-mile limit were held by Atlantic Diamond Mining Corp., Kahan-Tidewater, and Terra Marina. The Government was expected to extend its territorial waters to a 6-mile limit, and a new company, Coastal Diamonds, was reported to be interested in dredging rights in the 3- to 6-mile zone.[12] Marine Diamond Corp. was granted a concession to recover diamond to the

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[7] Bureau of Mines. Mineral Trade Notes. V. 58, No. 3, March 1964, pp. 9–10.
[8] Bureau of Mines. Mineral Trade Notes. V. 57, No. 2, August 1963, p. 19.
[9] Skillings' Mining Review. Liberia Diamond Mine. V. 52, No. 38, Sept. 21, 1963, p. 12.
[10] Bureau of Mines. Mineral Trade Notes. V. 57, No. 2, August 1963, p. 20.
Mining Journal (London). West African Diamonds. V. 260, No. 6648, Jan. 18, 1963, pp. 51, 53.
[11] Mining Engineering. Famous Diamond Mine Comes to Life Again. V. 15, No. 9, September 1963, pp. 44–45.
[12] Bureau of Mines. Mineral Trade Notes. V. 58, No. 3, March 1964, pp. 11–13.

end of the Continental Shelf or 6 miles from shore, whichever was greater.[13] It is expected that shares will be issued to the public if mining with the new barge, which was scheduled for February 1964, is successful. It was planned that De Beers would receive 29 percent, Sea Diamonds Corp. 29 percent, and General Mining and Anglo-Vaal 14.5 percent each.[14]

Other Areas.—*British Guiana.*—The percentage of industrial diamond in diamond being mined in British Guiana decreased from 60 percent in 1958 to 40 percent in 1961. This change occurred because of increased production from the Kurupung River where there is little industrial diamond.[15] Unconfirmed reports related the possibility of a rich deposit of diamonds in the Imbuidia District. Geologic investigations indicated the Roraima formation may be rich in diamond.[16]

Ireland.—Europe's first plant for manufacturing diamond was established at Shannon, by De Beers Consolidated Mines, Ltd. The plant was put at Shannon because of favorable financing and tax concessions. The high-value, light-weight diamond is suited for air transportation to markets principally in the United States and Europe. The plant was planned to have an annual production capacity of 750,000 carats per year.[17] The plant reportedly cost $5.6 million.[18]

Japan.—The history and use of industrial diamond in Japan from 1917, when one engineer returned from Antwerp and opened a shop for polishing precious stones and repairing and manufacturing diamond dressers and shaping tools until the present time, was published.[19] During World War II when importation of diamond was stopped, the Japanese people were asked to contribute gem diamonds for industrial use. It was reported that 100,000 carats of gem diamond is still deposited in the safe of the Bank of Japan. Diamond tool manufacturers increased from 15 in 1950 to 41 in 1963. The largest plant had 370 employees and used 400,000 to 450,000 carats of rough diamond and powder in producing 35 percent of the entire diamond tool output.

More than 1 million people viewed the exhibition of industrial diamond at the Fifth International Trade Fair in Tokyo. It was stated that, within 2 years, Japan would increase the use of industrial diamond from the present 1.4 million carats to 2.5 million carats.[20]

U.S.S.R.—It was reported that production from sources of natural diamond in Yakutia, Siberia, that are icebound most of the time could not keep up with demand.[21] There were no newly reported discoveries of diamond in Yakutia since the end of the 1962 season for prospecting. Serious attention was given to expanding the production of

[13] Mining Journal (London). V. 261, No. 6692, Nov. 22, 1963, p. 501.
[14] Bureau of Mines. Mineral Trade Notes. V. 58, No. 4, April 1964, pp. 11–12.
[15] Bureau of Mines. Mineral Trade Notes. V. 56, No. 3, March 1963, pp. 10–11.
[16] Mining Journal (London). V. 261, No. 6691, Nov. 15, 1963, p. 473.
[17] Chemical Engineering. Synthetic-Diamond Market Sparkles, Leads to New Setting in Eire. V. 70, No. 12, June 10, 1963, p. 86.
[18] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, p. 12.
[19] Kobayashi, Akira, and Saburo Joya. Diamond Industry in Japan. Ind. Diamond Rev., v. 23, No. 270, May 1963, pp. 118–122.
[20] South African Mining and Engineering Journal (Johannesburg). Tokyo Industrial Diamond Exhibit. V. 74, pt. 2, No. 3674, July 5, 1963, p. 270.
[21] Grinding and Finishing. V. 9, No. 8, August 1963, p. 11.

manufactured diamond to close the gap between production and consumption of industrial diamond.[22]

Venezuela.—The sharp decline in production was ascribed to exhaustion of the diamond deposits in the Caroni River near Caruachi and El Merey.[23]

TECHNOLOGY

A novel method of testing the efficiency of a hydrocyclone for the recovery of diamond was used by De Beers Consolidated Mines, Ltd. A radioactive zinc-aluminum alloy pellet (having the same specific gravity as diamond) was introduced with the feed and its path was followed by operators equipped with scintillation counters. Despite differences in the surface characterists of the alloy particle and those of diamond, the behavior in gravity-separation equipment corresponded closely to that of a diamond of equal size. The pellet normally emerged at the "sink" outlet with diamonds and other heavy material. Too frequent reporting with the float material indicated inefficient operation of the hydrocyclone.[24]

The First International Congress on Diamonds in Industry was held in Paris in May 1962.[25]

Rod mills were used for the first time in a diamond treatment plant at the Premier diamond mine to break up blue ground from an old tailings pile. After removing mud by scrubbing, the blue ground was broken down to fine grit in rod mills, deslimed by hydroclassifiers, screened into three separate sizes, fed to pulsating jigs then to a hydrocyclone concentrating section with a ferrosilicon medium ahead of the vibrating grease tables. It was reported that rod mills were selected because they produced grit without a high proportion of slimes. Complete recoveries were not obtained but the diamond content of retreated tailings, from a mill processing 500,000 tons per month from old dumps and current tailings from the heavy media plant, was of negligible value.[26]

Since directional hardness or abrasion resistance of diamond is dependent on its crystallography, new information on the importance of orienting diamonds was presented. Properly oriented diamond wheel dressers outperformed randomly oriented ones by as much as 250 percent and a diamond pointed phonograph needle with a hard cube direction normal to the axis gave excellent performance after being used more than 2,500 hours. This was four times as long as a diamond needle polished at random. It was found that correct orientation of the diamond for an intended purpose increased its effective lifetime 200 percent to 1,000 percent. More consistent performance was obtained.[27]

The physical properties of diamond, the preparation of diamond

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[22] Mining Journal (London). Synthetic Minerals. V. 260, No. 6651, Feb. 8, 1963, p. 123.

[23] Mining Journal (London). V. 261, No. 6691, Nov. 15, 1963, p. 473.

[24] South African Mining and Engineering Journal (Johannesburg). Radioisotopes Check Efficiency of Separation Process. V. 74, No. 3687, October 1963, pp. 981–982.

[25] Greene, Patrick (ed.). Proceedings, First International Congress on Diamonds in Industry (Paris). Industrial Diamond Information Bureau, London, 1963, 400 pp.

[26] Adamson, R. J., and H. F. Hodgson. The Re-Treatment Plant at Premier Diamond Mine. J. South African Inst. Min. and Met. (Johannesburg), v. 64, No. 2, September 1963, pp. 44–67.

[27] Raal, F. A. Orientation of Diamonds for Tools. Ind. Diamond Rev., v. 23, No. 269, April 1963, pp. 87–91.

for abrasives, and the behavior and use of natural and synthetic diamond in abrasives were discussed in considerable detail at the annual meeting of the American Society for Abrasives in New York City, April 4 and 5, 1963.[28]

The history of diamond synthesis and certain investigations and comparisons of the efficiency of natural and manufactured diamonds used in grinding tungsten carbide were presented.[29]

The commercial availability of synthetic diamond of six or seven specialist grits made the selection of the proper grit a complex matter. A research program on grit sizes from 60 mesh to 200 mesh led to the conclusion that the 60- to 80-mesh fraction was most suitable for use in resinoid grinding wheels. The influence of strength, surface, and shape of particles were studied, and an empirical prescription for a coarse grit was given.[30]

According to reports, a new type of manufactured diamond was superior to natural diamond of the same size—U.S. mesh sizes 35 to 80. When used in saws for cutting glazed vitreous tile, marble, granite, and slate, the saws cut faster and had a longer life. When used for cutting concrete, the saws cut faster but had the same life as those made from natural diamond. The manufactured diamond was described as a tough single crystal material with discrete symmetry and a high degree of uniformity.[31]

The results of comprehensive research on electrolytic grinding of sintered carbide were described. The effects of a number of variables including current density, size of diamond grit, and size of grinding area were determined. It was stated that with electrolytic grinding the wear of diamond was no less than with mechanical grinding; however, the surface quality of the carbide workpiece was considerably improved by using electrolytic grinding.[32]

Results of diamond carbide grinding research at General Electric Co. were released. Reports were concerned with wet and dry grinding and included both technical and cost information. All tests were with wheels made with manufactured diamond.[33] According to one manufacturer, diamond grinding wheels, used in grinding carbide cutting tools, outlasted others 25 to 1.[34]

Some ideas on the differences in the grinding behavior of different types of diamond grit and on the wear of diamond abrasive wheels were advanced as a working hypothesis following an extensive series of grinding tests.[35]

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[28] Baumgold, Charles. Diamond Abrasives. Ind. Diamond Rev., v. 23, No. 276, November 1963, pp. 272–276.

[29] Industrial Diamond Abstracts (London). Natural and Synthetic Diamonds. V. 23, No. 275, October 1963, p. B233.

[30] Dyer, P. H., and A. R. Roy. A New Synthetic Diamond Grit. Ind. Diamond Rev., v. 23, No. 277, December 1963, pp. 284–290.

[31] Industrial Diamond Abstracts (London). New Man-Made Diamond. V. 23, No. 272, July 1963, p. B154.
Industrial Diamond Abstracts (London). Synthetic Diamond for Stonecutting. V. 23, No. 275, October 1963, p. B234.

[32] Reinhart, Hans, and Walter Grunwald. Electrolytic Stock Removal of Sintered Carbide With Diamond Grinding Wheels. Ind. Diamond Rev., pt. 1, v. 23, No. 266, January 1963, pp. 19–25; pt. 2, v. 23, No. 267, February 1963, pp. 45–49.

[33] Kapernaros, E. L., and Ernest Ratterman. High Efficiency Approach to Diamond Carbide Grinding: Part 1—Wet Surface Grinding. Grinding and Finishing, v. 9, No. 8, August 1963, pp. 26–30; Part 2—Dry Tool and Cutter Grinding, No. 9, September 1963, pp. 36–40; Part 3—Cost Analysis of Wet Surface and Dry Cutter Grinding, No. 10, October 1963, pp. 32–36.

[34] South African Mining and Engineering Journal (Johannesburg). Diamond Grinding of Carbide Tools. V. 74, pt. 2, No. 3688, Oct. 11, 1963, p. 1049.

[35] Seal, Michael. Effects of Shape and Structure of Diamond Particles on Efficiency. Grinding and Finishing, v. 9, No. 10, October 1963, pp. 23–25, 64–66, 68–69.

The increasing use of micron-size diamond powder for finishing, lapping, and honing was ascribed to sharpness, wearing qualities, cool cutting at low pressures, chemical inertness, and rapid abrading speed.[36]

Diamond-tipped tools were used in the lathe turning of some brass and aluminium parts for a "zoom" camera. The parts were turned at 2,700 revolutions per minute lathe speed, using a tool with a diamond tip shaped for the particular use. About 4,000 pieces could be machined with extreme accuracy before relapping of the diamond tips was required. Engraving of metal parts was eliminated by rolling the markings into the metal sling, anodizing the entire surface of the part with a black finish and using a diamond-tipped tool to remove the black surface, except for the indented design. Both concave and convex lenses were milled with special cup-metal bonded diamond grinding wheels. Each lens was ground to within 0.0005 inch of its specified dimension so they could be properly centered in the optical system.[37]

The first known successful commercial machining of grooves to tolerances of 0.0001 inch on hardened steel rolls used for processing nickel-chromium resistance wire for computers was reported. The tool consisted of a 0.03 carat diamond in a sintered bond on a steel shank. The depth of grooves on the rolls ranged from 0.0015 to 0.038 inch.[38]

The development and perfection of diamond coated cutting tools gave ceramic manufacturers and investigators an important research tool. Diamond coated tools which could be used to advantage in hogging operations or fast or intricate sawing without generating excessive heat would not replace diamond impregnated tools or lapping machines for fine finishing operations.[39]

Diamond grinding wheels and diamond saws were used by paleontologists in preparing micro- and macro-fossils for studies of importance in connection with the search for oil[40] and in removing dinosaur tracks, undamaged, from a limestone quarry in England.[41]

The use of diamond impregnated concrete cutting saws for making joints in the highway linking Paris to Lyons and at Orly Airport outside Paris was publicized.[42] Information on scarifying pavement surfaces to affect stopping distances was also given.[43]

The role of diamond in machining sapphire and magnesia single crystals and in producing ultra-thin ceramic petrological sections of

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[36] Diamond Data (Engelhard Hanovia, Inc., Industrial Diamond Div.). SND—Micron Powders. V. 4, No. 4, May 1963, 4 pp.

[37] Industrial Diamond Review. New "Zoom" Camera Mechanism. V. 23, No. 266, January 1963, pp. 14–17.

[38] South African Mining and Engineering Journal (Johannesburg). Natural Diamonds Turn Hardened Steel. V. 74, No. 3688, Oct. 11, 1963, p. 1041.

[39] Ceramic Age. Diamond-Coated Tools Speed Cutting of Hard Ceramics. V. 79, No. 11, November 1963, pp. 72–73.

[40] Rixon, A. E. The Use of Industrial Diamonds in Palaeontology. Ind. Diamond Rev., v. 23, No. 270, May 1963, pp. 123–125.

[41] Burls, J. Diamonds Saw Dinosaurs' Footprints. Ind. Diamond Rev., v. 23, No. 272, July 1963, pp. 158–160.

[42] The Constructor. Diamond Saws. V. 45, No. 12, December 1963, p. 43.

[43] The Constructor. Concrete Saws. V. No. 12, December 1963, p. 43.

interest in basic research on the application of materials for atomic energy research was studied at Harwell, England.[44]

A similar use in machining a solid state laser rod from gem quality synthetic ruby was also discussed.[45]

A diamond knife was developed that did not require constant resharpening like glass and steel knives. This newly perfected knife was capable of cutting biological tissue for electron microscope examination and metals and other substances for atomic and molecular structure studies. Slices were prepared as thin as 50 to 100 Angstrom units which were thinner than any previously obtained.[46]

A 16-page publication on the use of diamond in the stone industry was compiled for distribution by The Industrial Diamond Information Bureau in London.[47]

The uses of diamond in the Soviet Union for grinding, drilling, and machining articles for industry, dressing and truing grinding wheels, making lathe tools and diamond dies, and for many other normal applications were described.[48]

Resinoid bonded grinding wheels were frequently specified for dry grinding operations because the resin broke down properly and continuously brought new cutting points to the surface. Resinoid bonded wheels were made more satisfactory for use in wet grinding by developing a silane coating for abrasive grain which gave a chemical as well as an adhesive bond between the resin and the grain. By controlling the compatibility of resin and grain, it was possible to make wheels of different controlled surface softening that provided the necessary surface breakdown.[49]

Molybdenum alloy honeycomb for structural and insulating panels and foamed ceramic shields capable of withstanding reentry temperatures in space exploration were sawed using a diamond-impregnated steel bandsaw. Use of diamond-edged bandsaws gave a straight cut and reduced burning of cell walls which made the finishing operation much easier.[50]

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[44] Davies, L. M., R. N. Simmonds, and Thorold Jones. Diamonds in Atomic Energy Research—1, Machining of Sapphire. Ind. Diamond Rev., v. 23, No. 269, April 1963, pp. 97–100.
Jones, Thorold, R. W. M. Hawes, and J. R. Dyson. Diamonds in Atomic Energy Research—3, Diamond Grinding of Ultra-Thin Ceramic Petrological Sections. Ind. Diamond Rev., v. 23, No. 271, June 1963, pp. 152–154.
Simmonds, R. N., R. A. J. Sambell, and A. Briggs. Diamonds in Atomic Energy Research—2, Diamond Grinding of Magnesium Oxide. Ind. Diamond Rev., v. 23, No. 270, May 1963, pp. 126–127.

[45] Industrial Diamond Review. Solid State, High Energy Lasers. V. 23, No. 273, August 1963, pp. 186–187.

[46] South African Mining and Engineering Journal (Johannesburg). Diamonds Make the Thinnest Cut. V. 74, pt. 2, No. 3676, July 19, 1963, p. 381.

[47] Mining Journal (London), v. 261, No. 6679, Aug. 23, 1963, p. 175.

[48] Petrosyan, Leon. The Use of Diamonds in Soviet Industry. Ind. Diamond Rev., v. 23, pt. 1, No. 271, June 1963, pp. 146–149; pt. 2, No. 272, July 1963, pp. 172–173; pt. 3, No. 275, October 1963, pp. 244–246.

[49] Shoemaker, Frank O. Controlled Coolant Resistance Widens Resinoid Use. Grinding and Finishing, v. 9, No. 1, January 1963, pp. 41–42.

[50] Thrash, C. O. New Cellular Materials at Space Systems Division. Ind. Diamond Rev., v. 23, No. 269, April 1963, pp. 92–95.

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ARTIFICIAL ABRASIVES

Since 1960 there has been a trend toward decreased production of silicon carbide in the United States and Canada and an increase in the production of metallic abrasives in the United States. There has not been a trend established for the production of abrasive grade aluminum oxide in the United States and Canada. Most nonmetallic artificial abrasives are manufactured in Canada and processed in the United States. Some abrasive grain is returned to Canada for use in grinding wheels and other manufactured abrasive products. Silicon carbide production was at 75 percent of capacity; aluminum oxide, at 53 percent; and metallic abrasives, at 35 percent. Nonabrasive uses accounted for 6 percent of the aluminum oxide and for 43 percent of the silicon carbide.

Sales to domestic users of graded abrasive grain of all types increased 5 percent above those of 1962, and sales to foreign users remained the same as in 1962. The value of grinding wheels sold by domestic producers was $174.8 million, an increase of 1 percent over 1962. Of the total sales, vitrified wheels accounted for 44 percent; resin- and shellac-bonded wheels, 39 percent; rubber-bonded wheels, 5 percent; and all others, including diamond grinding wheels, 12 percent. Sales of coated abrasives totaled 2,442,834 reams valued at $128,388,840, an increase of 1 percent in quantity and 2 percent in value compared with sales in 1961. Aluminum oxide accounted for 42 percent of the total reams sold; silicon carbide, 33 percent; garnet, 13 percent; flint, 9 percent; and emery and crocus, 3 percent. Glue bond was used on 55 percent of the coated abrasives; waterproof bonds, on 23 percent; and resin bonds, on 22 percent.

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

Year	Silicon carbide [1]		Aluminum oxide [1] (abrasive grade)		Metallic abrasives [2]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1954–58 (average)	94,540	$14,300	192,347	$22,438	129,766	$16,401	416,653	$53,139
1959	132,458	21,987	158,392	22,072	126,719	18,869	417,569	62,928
1960	133,219	20,636	195,906	27,111	112,383	16,847	441,508	64,594
1961	125,726	20,078	136,951	18,735	109,515	16,124	372,192	54,937
1962	115,716	17,728	181,924	23,458	125,772	18,668	423,412	59,854
1963	109,351	15,530	160,064	20,936	133,408	20,057	402,823	56,523

[1] Figures include material used for refractories and other nonabrasive purposes.
[2] Shipments from 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)		
1962:						
Chilled iron shot and grit	43,016	$4,764	41,771	$4,689	10,792	237,458
Annealed iron shot and grit	27,572	3,348	27,738	3,521	1,169	[1] 89,774
Other [2]	57,953	9,843	56,263	10,458	9,220	126,410
Total	128,541	17,955	125,772	18,668	[3] 21,181	363,868
1963:						
Chilled iron shot and grit	36,895	3,965	39,228	4,625	8,459	253,658
Annealed iron shot and grit	33,682	3,948	32,384	3,985	2,467	[1] 91,574
Steel shot and grit	58,675	9,628	60,105	10,834	} 7,771	126,860
Other [4]	1,672	607	1,691	613		
Total	130,924	18,148	133,408	20,057	18,697	380,518

[1] Included in capacity of chilled iron shot and grit.
[2] Mostly steel shot and grit. Includes figures for cut wire shot and some other types of metallic abrasives that cannot be shown separately.
[3] Includes revisions in product detail.
[4] Includes cut wire shot.

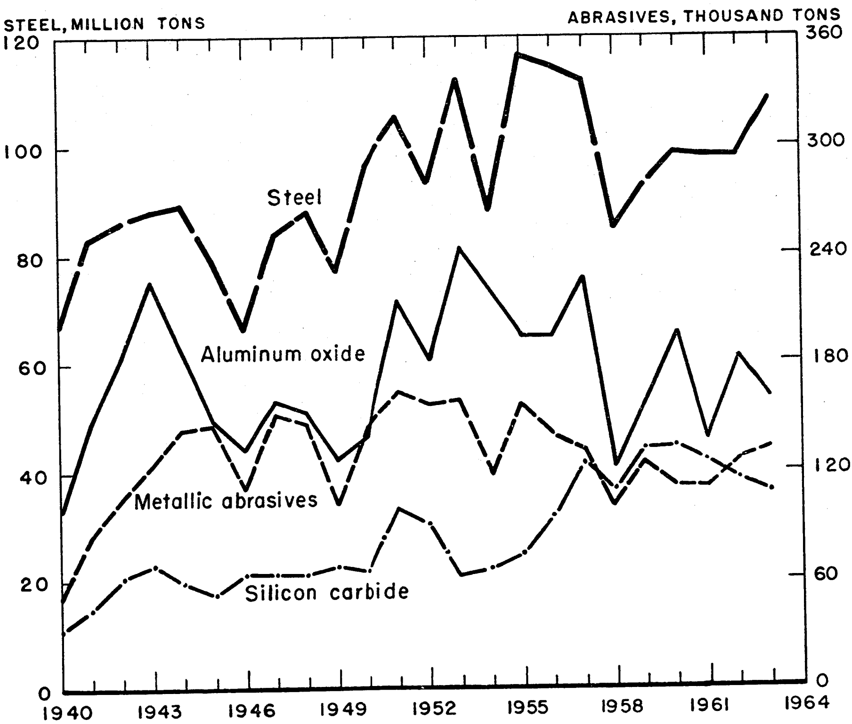

FIGURE 1.—Relationship between ingot steel and artificial abrasives production, 1940–63.

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
1954-58 (average)	14.7	126.3	36.3	288.8	16.0	254.1
1959	10.6	142.0	29.2	299.5	16.2	265.3
1960	16.0	145.6	25.1	299.5	15.6	263.1
1961	14.7	145.7	23.2	299.5	18.6	265.4
1962	19.2	144.9	33.8	299.5	[2] 21.2	363.9
1963	11.2	146.5	20.6	303.4	18.7	380.5

[1] United States only.
[2] Revised figure.

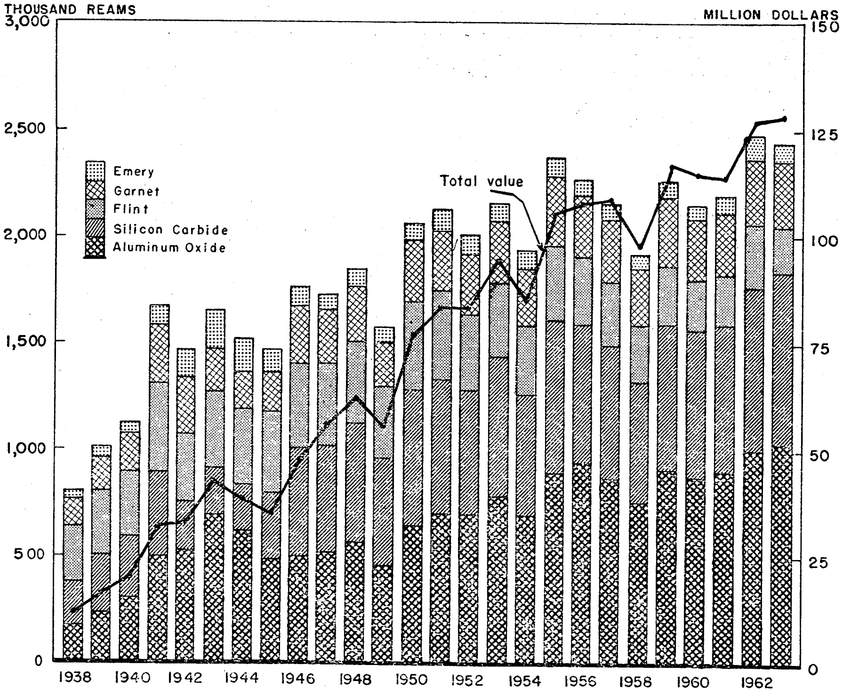

FIGURE 2.—Coated-abrasives industry in the United States, 1938–63.

TECHNOLOGY

The toughness of abrasive alumina grain as influenced by the size, shape, and composition of particles, crystal size, and heat treatment was reported and discussed. Roasting done under controlled time and temperature conditions was shown to have a significant influence on the toughness of the grain, especially when small quantities of impurities were present. The impurities migrated and helped to seal microcracks formed during the cooling or crushing of the crude fused alumina. Toughened grains usually reduced the rate and increased the heat generated by cutting but are desirable where strong bonding material and high contact pressures can be used.[51]

A brief discussion of manufacturing processes and properties of silicon carbide and abrasive-grade aluminum oxide was presented in two articles. The properties discussed included grain size, appearance and color, specific gravity, toughness, crystalline structure, shape, hardness, and electrical resistance and conductivity. Some information was given on chemical stability and composition.[52]

Information on kinds and types of alumina and silicon carbide, together with a discussion on composition, grain size, shape, and friability, as well as information on bonding material and processing for bonded abrasives was given in two parts,[53] followed by similar information on coated abrasive[54] and by a dissertation on general considerations in determining the suitability of one or the other group of abrasives for an intended use.[55]

The addition of potassium silicofluoride and potassium titanium fluoride to improve fillers used in synthetic resin bonded abrasives was proposed.[56] Potassium zirconium fluoride was proposed as an additive in making abrasive articles.[57]

Surface finish, time for cleaning, consumption of abrasive, and maintenance costs were considered in explaining the utilization of 10 different types of metallic abrasives. The desirability of various iron and steel abrasives ranging in Rockwell hardness from 20 to 68 was discussed.[58]

Part-to-part dimensional repeatability regardless of variations in starting stock size or hardness was expected from a controlled force concept in precision grinding. The process was said to have positive control of part geometry and surface finish. The percentage of good parts in tests was materially increased over conventional grinding methods. In constant force, grinding wheel force, surface finish, and part size become constants, and cycle time is the variable.[59]

Experimental results indicated that the efficiency and capacity of sedimentation tanks for sizing abrasive powders could be increased by performing a preliminary classification with a wet cyclone. One formula was proposed for calculating the size of separation, and another was advanced for calculating the cyclone capacity.[60]

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[51] Patch, J. B. Heat Treating Fused Alumina Abrasive Grain. Ceramic Age, v. 79, No. 11, November 1963, pp. 38–40.

[52] Grinding and Finishing. Physical and Chemical Properties of Abrasive Grain. Pt. 1, v. 9, No. 3, March 1963, pp. 34–36; pt. 2, No. 4, April 1963, pp. 34–38.

[53] Grinding and Finishing. Abrasive Grain in Bonded Abrasive Products. Pt. 1, v. 9, No. 5, May 1963, pp. 36–39; pt. 2, No. 6, June 1963, pp. 37–39.

[54] Grinding and Finishing. Use of Abrasive Grain in the Manufacture of Coated Abrasives. Pt. 1, v. 9, No. 7, July 1963, pp. 33–36; pt. 2, No. 8, August 1963, pp. 36–38.

[55] McKee, Richard L. Bonded or Coated Abrasives: A Comparative Tool Analysis. Grinding and Finishing, pt. 1, v. 9, No. 10, October 1963, pp. 28–30; pt. 2, No. 12, December 1963, pp. 30–31.

[56] Kibbey, Harry S. (assigned to The Cincinnati Milling Machine Co., Cincinnati, Ohio). Filler for Grinding Wheels. U.S. Pat. 3,113,006, Dec. 3, 1963.

[57] Cohen, John C., and Edward Roy B. Jackson (assigned to The Carborundum Co., Niagara Falls, N.Y.). Abrasive Articles. U.S. Pat. 3,111,401, Nov. 19, 1963.

[58] Borch, Einar A. Which Abrasive Is Best for You? Foundry, v. 91, No. 9, September 1963, pp. 139–140, 142, 144–146, 148, 150–151.

[59] Industrial Research Newsletter (IIT Research Institute, Chicago, Ill.). Metalworking. September 1963, p. 2.

[60] Papacharalambous, Harry G., and Shiou-Chuan Sun. Cyclone Classification of Artificial Abrasive Powders. Trans. Soc. Min. Engs., v. 226, No. 4, December 1963, pp. 461–467.

MISCELLANEOUS MINERAL-ABRASIVE MATERIALS

In addition to the natural and artificial abrasive materials for which data are available, many other minerals were used for abrasive purposes. Oxides of tin, magnesium, iron, and cerium were used for polishing. Boron carbide and tungsten carbide were used as abrasives where extreme hardness was required. Finely ground and calcined clays, lime, talc, ground feldspar, river silt, slate flour, whiting, and other materials also were used as abrasives.

Aluminum

By John W. Stamper[1]

WORLD output of primary aluminum reached a new record of 6.1 million short tons in 1963, 9 percent higher than the previous record set in 1962 and 90 percent of the world capacity. Production in the United States also increased 9 percent to 2.3 million tons.

The principal aluminum producers in North America and Europe continued to widen their participation in all aspects of the industry throughout the world.

Average prices obtained for aluminum in the United States were lower during 1963 than in 1962; however, in the last quarter an increase in the price of primary metal halted the declining trend in several preceding years.

TABLE 1.—Salient aluminum statistics

(Thousand short tons and thousand dollars)

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Primary production	1,584	1,954	2,014	1,904	2,118	2,313
Value	$738,642	$955,190	$1,030,007	$949,768	$998,559	$1,039,812
Price: Ingot, average...cents per pound	25.2	26.9	26.0	25.5	23.9	22.6
Secondary recovery [1]	324	360	329	340	[3] 462	506
Imports for consumption (crude and semicrude)	260	302	196	255	377	466
Exports (crude and semicrude)	59	164	384	238	259	292
Consumption, apparent [2]	2,087	2,488	2,016	2,320	[3] 2,763	3,033
World: Production	3,580	4,480	4,985	5,205	5,595	6,095

[1] Aluminum Content.
[2] Measured by quantity of primary sold or used plus secondary recovery and net imports.
[3] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

Delivery of 24,293 short tons of aluminum ingot to the Government Defense Production Administration (DPA) by Harvey Aluminum, Inc., completed shipments under a supply contract negotiated in 1950–52. Quantities of aluminum metal delivered to the Government in 1957–63 and in various Government stockpiles are given in table 7 and in the section on stocks.

[1] Commodity specialist, Division of Minerals.

The Government instituted a program to dispose of 135,000 short tons of aluminum metal by mid-1965. Under the program 51,189 tons was sold by the General Services Administration to domestic firms at 22.3 to 23 cents per pound.

On June 17, the Office of Emergency Planning (OEP) established a new stockpile objective for aluminum of 450,000 short tons.

DOMESTIC PRODUCTION

PRIMARY

Domestic production of primary aluminum ingot reached a new peak for the second successive year and exceeded the 1962 record output by nearly 200,000 short tons. Total output was 92 percent of the industry's rated capacity of 2,511,250 tons available at the end of 1963. The yearend capacity included 27,500 tons of new and expanded facilities brought in at various times and operated for only part of the year.

Northwest aluminum producers entered into agreements with the Bonneville Power Administration (BPA) for additional electric power. Kaiser Aluminum & Chemical Corp. at Spokane, Wash., will have 100,000 kw available starting September 1, 1966; The Anaconda Aluminum Co. at Columbia Falls, Mont., will have 64,000 kw starting on October 15, 1965; and Harvey Aluminum, Inc. at The Dalles, Oreg., will have 15,000 kw available starting in 1965 or 1966. BPA was considering a proposal to increase rates from the current $17.50 per kw year (2 mills per kwh) to $19.80 per kw year (2.26 mills per kwh).[2]

Consolidated Aluminum Corp. (Conalco), a fully owned subsidiary of Swiss Aluminum, Ltd., Zurich, Switzerland, began production of primary aluminum at its 20,000-ton-per-year plant at Jackson, Tenn. Conalco also was a major producer of superpure aluminum and had facilities for producing foil, sheet, and other rolled aluminum products. The company planned expansion of the reduction plant to 31,000 tons by mid-1964 and 62,000 tons by mid-1965. Future plans called for an annual capacity of 250,000 tons.

Aluminum Company of America (Alcoa) reactivated potlines at Wenatchee and Vancouver, Wash., and at Point Comfort and Rockdale, Tex., and nearly completed construction of the new 52,000-ton potline at Badin, N.C., to replace a 47,150-ton smelter at the same location. New equipment for producing light-gage aluminum sheet was installed at the company's plant in Alcoa, Tenn., and Davenport, Iowa, and work was continued on new facilities at Warrick, Ind., for producing mill products.

The Anaconda Aluminum Co. planned to start construction of a third potline at its Columbia Falls, Mont., aluminum smelter. The new facilities, which were expected to be completed by mid-1965, would add a capacity of 32,500 tons bringing the total to 100,000

[2] American Metal Market. Northwest Aluminum Firms Facing Boost in Electrical Power Rates. V. 70, No. 214, Nov. 6, 1963, p. 1, 19.

tons. Under a 2-year program for expanding the company's Terre Haute, Ind., rolling mills four new cold rolling mills were installed.

Harvey Aluminum, Inc., announced that as a result of various metallurgical improvements annual capacity of its 75,000-ton aluminum smelter at The Dalles, Oreg., was raised from 75,000 to 80,000 tons.

Kaiser Aluminum & Chemical Corp. operated all its reduction facilities except the 41,000-ton smelter at Tacoma, Wash. The company acquired or planned to build 5 new fabricating plants during the year which, when completed, will bring to 28 the number operated by the company in 14 States.

Phelps Dodge Corp., a major producer of copper and copper products, announced plans to begin producing aluminum items. The company reportedly planned to loan $31 million to N. V. Billiton Maatschappij, a Dutch concern with bauxite mines in Surinam, and Consolidated Aluminum Corp. the new primary aluminum producer in the United States. The loans would be used to help finance a plant in Surinam for producing alumina from bauxite and to expand Conalco's new primary aluminum plant. Phelps Dodge expected to eventually provide a full line of aluminum electrical conductors and other products.

Reynolds Metals Co. announced long-range plans for expanding capacity of its aluminum reduction plants from 701,000 short tons per year to 851,000 tons by the addition of new facilities and increasing efficiency of existing plants, when needed. The company also planned to double its research activity at Richmond, Va., and the capacity of its 205,000-ton aluminum sheet and plate mill in Chicago, Ill., and expand facilities to produce cans at Torrance, Calif., and Sheffield, Ala.

TABLE 2.—Production and shipments of primary aluminum in the United States [1]

(Short tons)

Quarter	1962		1963	
	Production	Shipments	Production	Shipments
First	505,266	541,585	528,725	549,279
Second	536,992	575,126	566,688	602,935
Third	528,377	512,711	601,807	591,335
Fourth	547,294	555,454	615,310	610,077
Total	2,117,929	2,184,876	2,312,530	2,353,626

1 Quarterly production and shipments adjusted to final annual totals.

U.S. Reduction Co., a major producer of aluminum foundry items, and Howe Sound Co. formed a jointly owned company to produce aluminum based master alloys at Russellville, Ala. Howe Sound Co., 40 percent of which is owned by Pechiney, Compagnie de Produits Chimiques et Electrometallurgiques, the largest primary aluminum producer in Western Europe, invested $5 million in new equipment and expansion of the Lancaster, Pa., light gage aluminum rolling mill operated by its subsidiary Howe Sound Aluminum Co.

TABLE 3.—Actual and planned primary aluminum production capacity in the United States, by companies

(Short tons per year)

Company and plant	Capacity: Actual, end of 1963	Capacity: Being built in 1963	Capacity: Total, actual and planned
Aluminum Company of America:			
Alcoa, Tenn	157,100		157,100
Badin, N.C	[1] 47,150	52,000	52,000
Evansville, Ind	35,000	140,000	175,000
Massena, N.Y	118,000	32,000	150,000
Point Comfort, Tex	140,000		140,000
Rockdale, Tex	150,000		150,000
Vancouver, Wash	97,500		97,500
Wenatchee, Wash	108,500		108,500
Total	853,250	224,000	1,030,100
Reynolds Metals Co.:			
Arkadelphia, Ark	55,000		55,000
Jones Mills, Ark	109,000		109,000
Listerhill, Ala	190,000		190,000
Longview, Wash	60,500		60,500
Massena, N.Y	100,000		100,000
San Patrico, Tex	95,000		95,000
Troutdale, Oreg	91,500		91,500
Total	701,000		701,000
Kaiser Aluminum & Chemical Corp.:			
Chalmette, La	247,500		247,500
Mead, Wash	176,000		176,000
Ravenswood, W. Va	145,000		145,000
Tacoma, Wash	41,000		41,000
Total	609,500		609,500
Anaconda Aluminum Co.: Columbia Falls, Mont	67,500	32,500	100,000
Consolidated Aluminum Corp.: New Johnsonville, Tenn	20,000	11,000	62,000
Harvey Aluminum, Inc.: The Dalles, Oreg	80,000		80,000
Ormet Corp.: Hannibal, Ohio	180,000		180,000
Grand total	2,511,250	267,500	2,762,600

[1] The 52,000-ton plant being built in 1963 will replace the existing 47,150 ton plant.

American Metal Climax, Inc. (AMAX), which in 1962 acquired Kawneer Co., a fabricator of aluminum architectural products in the United States, Canada, and other foreign countries, and its subsidiary, Apex Smelting Co., a major producer of secondary aluminum, continued expansion within the aluminum industry acquiring Hunter Engineering Co., a pioneer in development of the continuous casting of aluminum sheet.

Olin Mathieson Chemical Corp. completed a 2-year multimillion-dollar program to broaden its continuous sheet and plate casting and rolling mills at Hannibal, Ohio., raising capacity of the plant from 60,000 to 90,000 tons a year. Olin and Revere Copper & Brass Corp., Inc., owned Ormet Corp., a producer of primary aluminum.

SECONDARY

The secondary aluminum industry had its best year on record, recovering about 44,000 tons more aluminum metal than in 1962. According to reports received by the Bureau of Mines, domestic recovery of aluminum alloys (including all constituents) from 647,000 tons of aluminum-base scrap totaled 544,000 tons. Metallic recovery from new scrap was 413,000 tons, an increase of 10 percent. However, recovery from old scrap and sweated pig decreased to 131,000 tons, 8 percent less than in 1962. An additional 1,164 tons of aluminum was recovered from copper-base, zinc-base, and magnesium-base scrap. The value of 504,427 tons of aluminum recovered from processed aluminum scrap was $228 million, computed from the average price of primary aluminum ingot of 22.6 cents per pound.

Purchased aluminum-base scrap and sweated pig reported used by all consumers totaled 647,000 tons. Independent secondary smelters used 493,000 tons, or 76 percent. Primary producers used 45,000 tons, or 7 percent; fabricators used 78,000 tons, or 12 percent; and foundries and other consumers used 31,000 tons, or 5 percent.

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

(Short tons)

Kind of scrap	1962	1963
New scrap:		
Aluminum-base	[1,3] 332,734	[2] 389,263
Copper-base	42	56
Zinc-base	202	131
Magnesium-base	258	220
Total	[3] 333,236	389,670
Old scrap:		
Aluminum-base	[1,3] 127,756	115,164
Copper-base	89	76
Zinc-base	443	436
Magnesium-base	[3] 232	245
Total	[3] 128,520	115,921
Grand total	[3] 461,756	505,591

Form of recovery	1962	1963
As metal	[3] 35,269	25,114
Aluminum alloys	[3] 423,725	469,337
In brass and bronze	131	538
In zinc-base alloys	611	5,121
In magnesium alloys	292	1,636
In chemical compounds	1,728	3,845
Total	[3] 461,756	505,591

[1] Aluminum alloys recovered from aluminum-base scrap in 1962, including all constituents, was 353,578 tons from new scrap and 146,737 tons from old scrap and sweated pig; total 500,315 tons.
[2] Aluminum alloys recovered from aluminum-base scrap in 1963, including all constituents, was 413,174 tons from new scrap and 131,325 tons from old scrap and sweated pig; Total 544,499 tons.
[3] Revised figure.

The Bureau of Mines estimated that complete coverage of the industry would show a total scrap consumption of 780,000 tons and a secondary ingot production of 512,000 tons. Calculated aluminum recovery based on full coverage would total 608,000 tons, and the metallic aluminum-alloy recovery would total 654,000 tons.

Secondary aluminum-alloy ingot production, as reported to the Bureau of Mines, totaled 437,000 tons, 14 percent more than in 1962. Data on remelt ingots excluded alloys produced from purchased scrap by the primary producers. Shipments of most casting alloys increased in 1963.

Data obtained through a Bureau 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 & Chemicals Corp. acquired a 50-percent interest in Cuyahoga Smelting & Processing Co. of Cleveland, Ohio. Cuyahoga processed aluminum dross. Alloys & Chemicals was a major producer of secondary aluminum alloys for general foundries and other processors supplying material to the automotive, appliance, machinery and equipment, and other industries.

TABLE 5.—Stocks and consumption of new and old aluminum scrap and sweated pig in the United States in 1963 [1]

(Short tons)

Class of consumer and type of scrap	Stocks, Jan. 1 [2]	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks, Dec. 31
Secondary smelters: [3]						
New Scrap:						
Segregated 2S sheet and clips	500	7,397	7,332	----------	7,332	565
Segregated 3S sheet and clips	571	11,345	11,277	----------	11,277	639
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 0.6 percent Cu	1,689	40,739	40,116	----------	40,116	2,312
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 0.6 percent Cu	525	10,522	10,316	----------	10,316	731
Segregated 75S, 76S, 77S, 78S, 80S type sheet and clips, more than 0.6 percent Cu	466	7,911	7,965	----------	7,965	412
Mixed low Cu clips 0.6 percent maximum Cu	1,250	43,094	42,082	----------	42,082	2,262
Mixed clips, more than 0.6 percent Cu	1,363	35,905	35,296	----------	35,296	1,972
Cast scrap	266	7,748	7,571	----------	7,571	443
Borings and turnings:						
Segregated 14S, 17S, 24S, 25S	276	14,365	14,290	----------	14,290	351
Segregated 75S, 76S, 77S, 78S, 80S type	233	15,397	15,234	----------	15,234	396
Segregated other	620	24,015	23,669	----------	23,669	966
Mixed, Zn 1.0 percent maximum	1,235	26,279	26,521	----------	26,521	993
Mixed, Zn over 1.0 percent	1,452	45,225	44,953	----------	44,953	1,724
Dross and skimmings	5,105	70,434	69,284	----------	69,284	6,255
Foil (includes both new and old)	290	2,944	2,837	----------	2,837	397
Miscellaneous	304	9,331	8,709	----------	8,709	926
Old scrap:						
Wire and cable	324	3,839	----------	3,721	3,721	442
Pots and pans	539	23,334	----------	22,871	22,871	1,002
Mixed alloy sheet	264	8,546	----------	8,190	8,190	620
Aircraft	384	3,443	----------	3,664	3,664	163
Castings and forgings	739	25,684	----------	25,526	25,526	897
Pistons	144	4,036	----------	4,008	4,008	172
Irony aluminum	588	14,357	----------	14,042	14,042	903
Miscellaneous	827	8,066	----------	7,269	7,269	1,624
Purchased pig	3,590	37,461	----------	36,425	36,425	4,626
Total	23,544	501,417	367,452	125,716	493,168	31,793
Foundries, fabricators, and chemical plants:						
New scrap:						
Segregated 2S sheet and clips	125	7,460	7,367	----------	7,367	218
Segregated 3S sheet and clips	793	28,463	27,399	----------	27,399	1,857
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 0.6 percent Cu	331	13,255	13,171	----------	13,171	415
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 0.6 percent Cu	----------	51	51	----------	51	----------
Segregated 75S, 76S, 77S, 78S, 80S, type sheet and clips, more than 0.6 percent Cu	175	2,467	2,559	----------	2,559	83
Mixed low Cu clips, 0.6 percent maximum Cu	309	9,997	9,965	----------	9,965	341
Mixed clips, more than 0.6 percent Cu	352	2,629	2,612	----------	2,612	369
Cast scrap	264	995	1,259	----------	1,259	----------
Borings and turnings:						
Segregated 14S, 17S, 24S, 25S	----------	5	5	----------	5	----------
Segregated 75S, 76S, 77S, 80S type	136	----------	136	----------	136	----------
Segregated other	79	12	90	----------	90	1
Mixed, Zn 1.0 percent maximum	154	1,332	1,219	----------	1,219	267
Dross and skimmings	182	1,737	1,604	----------	1,604	315
Foil (includes both new and old)	497	2,348	2,000	----------	2,000	845
Miscellaneous	536	11,833	11,803	----------	11,803	566
Old scrap:						
Wire and cable	5	1,160	----------	1,004	1,004	161
Pots and pans	----------	40	----------	40	40	----------
Mixed alloy sheet	----------	298	----------	297	297	1
Aircraft	1	2	----------	3	3	----------
Castings and forgings	34	494	----------	488	488	40
Pistons	1	29	----------	29	29	1
Irony aluminum	1	680	----------	645	645	36
Miscellaneous	422	339	----------	759	759	2
Purchased pig	3,725	24,366	----------	24,931	24,931	3,160
Total	8,122	109,992	81,240	28,196	109,436	8,678

See footnotes at end of table.

TABLE 5.—Stocks and consumption of new and old aluminum scrap and sweated pig in the United States in 1963 [1]—Continued

(Short tons)

Class of consumer and type of scrap	Stocks, Jan. 1 [2]	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks, Dec. 31
Primary producers:						
New and old scrap:						
Segregated 2S sheet and clips	97	2,537	2,593		2,593	41
Segregated 3S sheet and clips	26	6,979	6,836		6,836	169
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 0.6 percent Cu	186	18,480	17,923		17,923	743
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 0.6 percent Cu	52	1,514	1,541		1,541	25
Segregated 75S, 76S, 77S, 78S, 80S type sheet and clips, more than 0.6 percent Cu	33	728	753		753	8
Mixed low Cu clips—0.6 percent maximum Cu	41	2,716	2,723		2,723	34
Mixed clips, more than 0.6 percent Cu		60	60		60	
Cast scrap	13	2,787	2,736		2,736	64
Borings and turnings:						
Segregated 14S, 17S, 24S, 25S		78	61		61	17
Segregated 75S, 76S, 77S, 78S, 80S type		8	8		8	
Segregated other	12	380	387		387	5
Mixed, Zn 1.0 percent maximum						
Mixed, Zn over 1.0 percent		88	88		88	
Dross and skimmings	25	32	27		27	30
Foil (includes both new and old)	46	2,843	2,889		2,889	
Miscellaneous	171	6,054	6,024		6,024	201
Wire and cable		219		212	212	7
Miscellaneous		4		4	4	
Purchased pig		21		20	20	1
Total	702	45,528	44,649	236	44,885	1,345
Grand total of all scrap consumed:						
New scrap:						
Segregated 2S sheet and clips	722	17,394	17,292		17,292	824
Segregated 3S sheet and clips	1,390	46,787	45,512		45,512	2,665
Segregated 51S, 52S, 61S, etc., sheet and clips, less than 0.6 percent Cu	2,206	72,474	71,210		71,210	3,470
Segregated 14S, 17S, 24S, 25S, etc., sheet and clips, more than 0.6 percent Cu	577	12,087	11,908		11,908	756
Segregated 75S, 76S, 77S, 78S, 80S type sheet and clips, more than 0.6 percent Cu	674	11,106	11,277		11,277	503
Mixed low Cu clips, 0.6 percent maximum Cu	1,600	55,807	54,770		54,770	2,637
Mixed clips, more than 0.6 percent Cu	1,715	38,594	37,968		37,968	2,341
Cast scrap	543	11,530	11,566		11,566	507
Borings and turnings:						
Segregated 14S, 17S, 24S, 25S	276	14,448	14,356		14,356	368
Segregated 75S, 76S, 77S, 78S, 80S type	369	15,405	15,378		15,378	396
Segregated other	711	24,407	24,146		24,146	972
Mixed Zn 1.0 percent maximum	1,389	27,611	27,740		27,740	1,260
Mixed, Zn over 1.0 percent	1,452	45,313	45,041		45,041	1,724
Dross and skimmings	5,312	72,203	70,915		70,915	6,600
Foil (includes both new and old)	833	8,135	7,726		7,726	1,242
Miscellaneous	1,011	27,218	26,536		26,536	1,693
Old scrap:						
Wire and cable	329	5,218		4,937	4,937	610
Pots and pans	539	23,374		22,911	22,911	1,002
Mixed alloy sheet	264	8,844		8,487	8,487	621
Aircraft	385	3,445		3,667	3,667	163
Castings and forgings	773	26,178		26,014	26,014	937
Pistons	145	4,065		4,037	4,037	173
Irony aluminum	589	15,037		14,687	14,687	939
Miscellaneous	1,249	8,409		8,032	8,032	1,626
Purchased pig	7,315	61,848		61,376	61,376	7,787
Total	32,368	656,937	493,341	154,148	647,489	41,816

[1] Includes imported scrap.
[2] Revised figure.
[3] Excludes secondary smelters owned by primary aluminum companies.

TABLE 6.—Production and shipments of scondary aluminum alloys, by independent smelters

(Short tons) [1]

Product	1962		1963	
	Production [2]	Shipments [3]	Production [2]	Shipments [3]
Pure aluminum (Al minimum, 97.0 percent)	27,130	26,868	25,114	24,666
Aluminum-silicon (maximum Cu, 0.6 percent)				
95/5 Al-Si, 356, etc. (0.6 percent Cu maximum)	16,211	15,885	19,305	18,533
13 percent Si, 360, etc. (0.6 percent Cu maximum)	32,112	31,629	35,921	35,022
Aluminum-silicon (Cu, 0.6 to 2 percent)	9,353	9,262	8,403	8,209
No. 12 and variations	4,061	4,130	4,714	4,361
Aluminum-copper (maximum Si, 1.5 percent)	1,327	1,402	1,621	1,552
No. 319 and variations	42,991	44,246	48,111	47,456
Nos. 122, 138	2,896	3,167	3,225	3,245
AXS-679 and variations	154,971	154,719	190,367	187,574
Aluminum-silicon-copper-nickel	19,719	19,446	24,857	23,977
Deoxidizing and other destructive uses				
Grades 1 and 2	10,628	10,422	10,086	10,143
Grades 3 and 4	14,457	14,733	14,573	14,630
Aluminum-base hardeners	15,687	16,001	21,699	21,096
Aluminum-magnesium	1,812	1,624	1,636	1,664
Aluminum-zinc	5,065	5,292	5,121	4,913
Miscellaneous	25,225	24,461	22,584	21,683
Total	383,645	383,287	437,337	428,724

[1] Gross weight, including copper, silicon, and other alloying elements. Secondary smelters used 11,534 and 10,306 tons of primary aluminum in 1962 and 1963 respectively in producing pure aluminum and secondary alloys.
[2] No allowance was made for consumption by producing plants.
[3] No allowance was made for receipts by producing plants.

CONSUMPTION AND USES

Total apparent consumption of aluminum reached a new record of about 3 million tons, 12 percent higher than in 1962. Primary metal sold or used by producers increased 8 percent.

According to industry estimates, by the Aluminum Association the distribution of shipments of aluminum metal to various industries was as follows: Building products, 24 percent; transportation, 24 percent; consumer durables, 10 percent; electrical equipment, 11 percent; machinery and equipment, 7 percent; containers and packaging, 8 percent; and other industries, 9 percent. The remainder was exported. Use of aluminum in the container and packaging industry appeared to be the fastest growing, increasing almost 30 percent over 1962.[3]

[3] Steel. Aluminum: Is '64 Turning Point? V. 154, No. 2, Jan. 13, 1964, pp. 25–28.

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
1954-58 (average)	1,562,421	200,606	68,924	254,911	2,086,862
1959	1,988,560	139,828	78,006	281,921	2,488,315
1960	1,866,251	-180,057	62,703	266,747	2,015,644
1961	1,956,167	24,004	102,137	238,109	2,320,417
1962	2,184,876	[4] 117,935	[4] 127,756	[4] 332,734	[4] 2,763,301
1963	2,353,626	174,548	115,164	389,263	3,032,601

[1] Includes shipments to the Government: 1957, 324,311 tons; 1958, 323,128 tons; 1959, 73,235 tons; 1960, 37,002 tons; 1961, 52,138 tons; 1962, 41,544 tons; 1963, 24,293 tons.
[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.
[4] Revised figure.

Aluminum was used for the inner sphere of the nation's largest hydrogen storage tank built at Sacramento, Calif. The tank has a capacity of about 90,000 cubic feet of liquid hydrogen weighing about 200 tons. In other new application at cryogenic temperatures, aluminum tanks, 71 feet long, 37 feet wide, and 47 feet deep, were used for transporting liquid methane at −250° F from North Africa to England. Huge pressure vessels, 22 inches in diameter and 17.5 feet long, for holding gases in spacecraft were fabricated from a single piece of aluminum without welds or seams.

The building products industry continued to be a major outlet for aluminum products. Major segments in this market were commercial, industrial, and farm buildings, residing of older homes, and new home construction.

The world's largest space vehicle, the Saturn I, scheduled to be tested in 1964, contained 30 tons of aluminum in structural members and tankage. The fuel system of the first stage, comprising a central tank, 105 inches in diameter, with eight, 70-inch cylinders grouped about it, required 17 tons of the metal. Aluminum forgings were used in the structural members and fuel tank attachments. About 8 tons went into the second stage in tankage and castings. The weight of the 164-foot-high vehicle, including fuel, was expected to total 560 tons at launching.

Aluminum's light weight and corrosion resistance was utilized in two new types of temporary airplane landing mats being developed. In one, waffle-shaped aluminum plates, about 48 inches long, 25 inches wide, and 1½ inches thick, were diecast. In another, aluminum mats, 12 feet long, 2 feet wide, and 1½ inches thick, were extruded. Some 3,000 tons of aluminum were being utilized in fabricating a temporary Marine Corps landing field of the extruded type.

A report indicated that the need for greater mobility in modern military weapons would lead to increased usage of aluminum.[4] A major use of aluminum was in lightweight, highly mobile vehicles such as the M-113, an amphibious personnel carrier, a 105-millimeter howitzer, and an amphibious landing craft. Military items using

[4] Iron Age. Aluminum Wins Promotion in Defense Weapons Burying. V. 192, No. 7, Aug. 14, 1963, pp. 97-98.

aluminum that were under development included an assault bridge and armored tractors.

Spherical aluminum powder was used in the solid fuel for the new Titan III space exploration rocket. The aluminum powder causes uniform burning of the fuel in flight. A report indicated that aluminum powder comprised almost 20 percent by weight of the solid fuels used in the Nation's major new missile systems.[5]

Aluminum continued to broaden and expand applications in the transportation industries. Despite a loss in the automobile market because some manufacturers reverted from aluminum engine blocks to steel blocks, the total average use of aluminum per car in the 1964 models increased to about 72 pounds per car compared with 70 pounds per car in the 1963 models.[6]

A report on the use of aluminum in railroad equipment in the United States since 1960 indicated that 4,500 aluminum tank cars had been built and more than 4,300 box and refrigerator cars were equipped with aluminum doors.[7] In addition 1,500 boxcars had aluminum roofs, 1,900 refrigerator cars had aluminum floor racks, and 1,900 boxcars utilized aluminum bulkheads. Aluminum roofing, side panels, floors and structural members were scheduled for use in construction of new rapid transit cars for the city of Chicago.

During the year, the Hamm Brewing Co. and Anheuser-Busch, Inc., announced they would begin using all aluminum 12-ounce beer cans. Other new container uses included an aluminum bottle cap that can be removed without an opener and a new type lid for a tomato juice product. An estimated 25 percent of the frozen citrus juice marketed in 1963 was in composite aluminum foil-fiber cans.[8]

Two hundred tons of aluminum plate and piping was used in the largest barge ever constructed of the light metal. Rated load-carrying capacity was 2,264 tons, 14 percent more than a similar barge constructed of steel. A 73-foot racing sloop was being built almost entirely of aluminum. A 41-ton ship propeller was fabricated of an aluminum-nickel-bronze alloy that required 15 tons of aluminum.

About 8 miles of hollow aluminum conductor tubing measuring 1½ inches by 2 inches was used in fabricating the magnetic coils of a synchrocyclotron. A 24-inch-in-diameter, 2-mile-long pipe was being built of aluminum to support a linear accelerator under construction at Stanford University.

Finely ground aluminum particles mixed with asphalt were used experimentally to provide a light-reflecting road surface.[9]

Virginia Electric and Power Co. ordered 11,000 tons of aluminum electrical cable for use in a 350-mile, 500,000-volt transmission line scheduled to serve northern and central Virginia.[10] Another 500,000

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[5] American Metal Market. Space Needs Give Boost to Powdered Aluminum. V. 70, No. 23, July 11, 1963, p. 10.

[6] Modern Metals. Producers Push for Major New Aluminum Applications in Autos. V. 20, No. 1, February 1964, pp. 46, 48, 50.
Rosenthal, A. G. Aluminum in the '64 Models. Modern Metals, v. 19, No. 11, December 1964, pp. 30–36.

[7] American Metal Market. Rail Equipment Use Rises. Volume Seen Doubled by 1965. V. 70, No. 195, Oct. 9, 1963, p. 19.

[8] American Metal Market. Kaiser's Curtin Predicts 7-Percent Climb in Foil Shipments, Another Record. V. 71, No. 79, Apr. 23, 1964, p. 17.

[9] Light Metals. New Road Surface. V. 27, No. 209, Feb. 6, 1964, p. 23.

[10] E&MJ Metal & Mineral Markets. Reynolds to Fill Order for 11,000 Tons of Aluminum Cable. V. 34, No. 50, Dec. 16, 1963, p. 6.

volt aluminum transmission line was planned by the Tennessee Valley Authority.

A new market for aluminum was opened up by the development of all aluminum strip-wound coils for both the primary and secondary windings of electrical transformers.[11]

The following distribution for wrought products was obtained from figures published by the Bureau of the Census:

	Percent 1962	Percent 1963
Plate, sheet, and foil:		
Non-heat-treatable	38.6	41.3
Heat-treatable	6.3	5.7
Foil	7.8	7.5
Rolled rod, bar, and wire:		
Rod, bar, etc	3.6	2.9
Bare wire, conductor and nonconductor	1.4	1.4
Bare cable (including steel-reinforced)	6.7	6.4
Wire and cable, insulated or covered	2.0	2.1
Extruded shapes:		
Alloys other than 2000 and 7000 series [1]	25.7	25.4
Alloys in 2000 and 7000 series	1.6	1.6
Tubing:		
Drawn	2.0	1.5
Welded, non-heat-treatable [2]	1.1	1.2
Powder, flake, and paste:		
Atomized	.6	.5
Flaked	.1	.1
Paste	.4	.4
Forgings (including impact extrusions)	2.1	2.0
Total	100.0	100.0

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

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

(Short tons)

	1962	1963
Wrought products:		
Plate, sheet, and foil	1,004,146	1,161,807
Rolled structural shapes, rod, bar, and wire	260,721	270,828
Extruded shapes, rod, bar, tube blooms, and tubing	579,268	634,681
Powder, flake, and paste	21,841	22,405
Forgings	39,684	42,082
Total	1,905,660	2,131,803
Castings:		
Sand	73,366	72,003
Permanent mold	147,348	149,844
Die	240,717	253,806
Other	(2)	(2)
Total	463,414	[3] 476,399
Grand total	2,369,074	2,608,202

[1] Net shipments are total shipments less shipments to other metal mills for further fabrication.
[2] Figure withheld because estimates did not meet publication standards of the Bureau of the Census because of the associated standard error.
[3] Includes a small quantity of "All other aluminum" castings shipped for sale.

Source: Bureau of the Census.

[11] American Metal Market. Aluminum Strip-Wound Coils Called Distribution Transformer Advance. V. 71, No. 41, Feb. 28, 1964, p. 12.

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STOCKS

The quantity of aluminum metal in the national (strategic) stockpile was 1,128,989 short tons. An additional 851,816 short tons was in the DPA inventory. The DPA inventory included 27,443 short tons of metal, committed to sale, that was unshipped.

Inventories of aluminum ingot at primary reduction plants declined from 140,100 tons on January 1 to 99,100 tons on December 31. Based on the December production rate, closing 1963 industry stocks were equal to 15 days of output. 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 increased 36 percent to 32,000 short tons, equivalent to a 27-day supply based on shipments for the entire year. Consumer's yearend inventories of aluminum scrap increased to 41,816 tons, equivalent to a 24-day supply based on the total quantity melted or consumed during the year.

PRICES

The published domestic market price for unalloyed primary aluminum ingot was unchanged through September at 22.5 cents per pound. The price was increased to 23 cents per pound on October 2. The price quoted for superpure (99.99 percent) aluminum at yearend was 42.5 to 43 cents per pound, compared with 42 cents per pound at the beginning of the year.

The average of prices quoted by the American Metal Market for clippings, old sheet and castings, and borings and turnings of scrap aluminum increased 1.5 to 2 cents per pound during the year. All grades of smelters' alloys increased 1 to 2.5 cents per pound, and steel deoxidizing grades increased 2 cents per pound.

Prices quoted at the end of 1963 for various grades of aluminum scrap clippings ranged from 11.5 to 12 cents per pound for 2075 (75S) to 15.5 to 16 cents per pound for 1100(2S). Mixed aluminum clippings were quoted at 14 to 14.5 cents per pound. Old aluminum sheets and castings were quoted at 12 to 12.5 cents per pound, and aluminum borings and turnings were quoted at 12.5 to 13 cents per pound.

Effective September 27, quoted delivery prices for 10 ton lots of various grades of smelters' alloys ranged from 21 to 21.5 cents per pound for 380(AXS–679) alloy containing 3 percent zinc to 29.25 to 29.75 cents per pound for 218 alloy grades. Steel deoxidizing grades ranged from 19.5 cents per pound for 85 percent aluminum (minimum) grade to 23.25 cents per pound for 95 percent aluminum grade.

FOREIGN TRADE

Imports.—A 44-percent decline in imports of aluminum circles and disks, plates, sheet, rods and bars, etc., was offset by a 40-percent increase in imports of crude aluminum metal and alloys, and scrap.

Total imports of crude and semicrude aluminum metal increased 24 percent.

As in past years, most of the crude aluminum metal and alloys came from Canada which shipped 63,000 tons more metal into the United States in 1963 than in 1962. Most of the plate, sheet, rods, bars, circles, and disks came from Belgium-Luxembourg, France, Italy, and Japan.

Exports.—Exports of all classes of crude and semicrude aluminum products, except castings and forgings, increased during the year. Total exports of the crude and semicrude products increased 13 percent over 1962. Exports of ingots, slabs, and crude aluminum, as well as scrap increased 9 percent.

The United Kingdom was the destination of most of the aluminum ingots slabs and crude, accounting for 32 percent of the total. West Germany, Italy, Argentina, France, and Belgium-Luxembourg accounted for most of the remainder. West Germany, Italy, and Japan were the principal destinations for aluminum scrap.

Tariff.—The duty on unwrought aluminum alloys (except aluminum silicon alloys and aluminum in coils) was 1.25 cents per pound. Wrought aluminum was subject to a duty of 2.50 cents per pound. Suspension of the 1.50 cents per pound duty on aluminum scrap was extended to June 30, 1964. There was no quota for aluminum scrap.

TABLE 9.—U.S. imports for consumption of aluminum, by classes

Class	1962		1963	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Metal and alloys, crude	[1] 310,955	[1] $129,997	[2] 415,668	[2] $163,524
Circles and disks	6,434	4,255	[2] 5,656	[2] 3,687
Plates, sheets, etc., n.e.s	43,251	27,755	[2] 32,032	[2] 19,252
Rods and bars	9,503	5,137	[2] 3,555	[2] 2,501
Scrap	6,496	1,864	9,306	2,307
Total	[1] 376,639	[1] 169,008	466,217	[2] 191,271
Manufactures:				
Foil less than 0.006 inch thick	5,060	6,395	4,817	5,569
Folding rules	(3)	6	(3)	356
Leaf (5.5 by 5.5 inches)	(4)	15	(4)	16
Powder and powdered foil (aluminum bronze)	112	120	158	167
Powder in leaf (5.5 by 5.5 inches)	(5)	(6)	---	---
Table, kitchen, hospital utensils, etc	2,878	4,943	2,788	3,402
Other maufactures	(7)	9,255	(7)	6,994
Total	(7)	20,734	(7)	16,504
Grand total	(7)	[1] 189,742	(7)	[2] 207,775

1 Revised figure.
2 Data known to be not strictly comparable to earlier years.
3 1962, 5,202 rules; 1963, 1,605 rules; equivalent weight not recorded.
4 1962, 4,107,090 leaves; 1963, reported 2,770,839 leaves and 11,457,002 square inches of leaf.
5 24,000 leaves.
6 Less than $1,000.
7 Quantity not recorded.

Source: Bureau of the Census.

TABLE 10.—U.S. imports for consumption of aluminum, by classes and countries

(Short tons)

Country	1962			1963		
	Metal, and alloys, crude	Plates, sheets, bars, etc.[1]	Scrap	Metal, and alloys, crude[2]	Plates, sheets, bars, etc.[1] [2]	Scrap
North America:						
Canada	209,892	11,396	6,260	272,884	2,511	8,489
Other	----------	----------	10	----------	5	39
Total	209,892	11,396	6,270	272,884	2,516	8,528
South America: Argentina	----------	----------	----------	----------	234	----------
Europe:						
Austria	2,157	1,331	----------	1	1,026	----------
Belgium-Luxembourg	11	13,489	33	493	14,594	29
France	37,987	6,713	----------	34,677	5,044	----------
Germany, West	1,097	3,745	----------	467	2,534	----------
Italy	3	4,380	----------	6	3,622	----------
Norway	[3] 50,360	56	13	87,087	4	----------
Spain	4,329	1,469	----------	2,058	1,417	9
Sweden	----------	510	119	701	591	257
Switzerland	(4)	----------	----------	1,251	297	----------
United Kingdom	24	7,010	44	375	2,592	175
Yugoslavia	(5)	2,436	----------	4	1,418	----------
Other	(4)	834	----------	11	111	157
Total	[3] 95,968	41,973	209	127,131	33,250	627
Asia:						
Japan	3,883	5,730	----------	11,615	5,191	----------
Taiwan	1,102	39	----------	442	48	----------
Other	----------	17	17	175	----------	90
Total	4,985	5,786	17	12,232	5,239	90
Africa	110	----------	----------	2,849	----------	61
Oceania	----------	33	----------	572	4	----------
Grand total:						
Short tons	[3] 310,955	59,188	6,496	415,668	41,243	9,306
Value, thousands	[3] $129,997	$37,147	$1,864	$163,524	$25,440	$2,307

[1] Includes circles and disks, bars and rods, and plates, sheets, etc.
[2] Data known to be not strictly comparable to earlier years.
[3] Revised figure. [4] Less than 1 ton. [5] Revised to none.

Source: Bureau of the Census.

TABLE 11.—U.S. exports of aluminum, by classes

Class	1962		1963	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Ingots, slabs, and crude	[1] 151,197	[1] $66,596	165,340	$71,875
Scrap	65,534	20,183	71,040	21,369
Plates, sheets, bars, etc	[1] 40,128	[1] 32,970	53,363	39,276
Castings and forgings	[1] 1,541	5,522	1,431	4,017
Semifabricated forms, n.e.c	[1] 304	[1] 356	495	55
Total	[1] 258,704	[1] 125,627	291,669	136,592
Manufactures:				
Foil and leaf	2,487	3,052	1,832	2,493
Powders and pastes (aluminum and aluminum bronze) (aluminum content)	478	589	490	639
Cooking, kitchen, and hospital utensils	811	2,191	802	2,228
Sash sections, frames (door and window)	1,394	2,324	1,220	2,037
Venetian blinds and parts	749	943	761	994
Wire and cable	11,054	6,155	12,225	6,840
Total	16,973	15,254	17,330	15,231
Grand total	[1] 275,677	[1] 140,881	308,999	151,823

[1] Revised figure.

Source: Bureau of the Census.

TABLE 12.—U.S. exports of aluminum, by classes and countries

(Short tons)

Destination	1962			1963		
	Ingots, slabs, and crude	Plates, sheets, bars, etc.[1]	Scrap	Ingots, slabs, and crude	Plates, sheets, bars, etc.[1]	Scrap
North America:						
Canada	4,219	[2] 6,533	1,099	1,478	25,140	1,621
Mexico	7,680	[2] 1,997	113	4,498	1,856	24
Other	171	1,433	135	513	1,829	143
Total	12,070	[2] 9,963	1,347	6,489	28,825	1,788
South America:						
Argentina	5,130	44	----------	7,571	41	----------
Brazil	4,860	178	7	4,884	112	----------
Colombia	2,525	308	----------	4,934	353	10
Venezuela	1,453	587	38	800	1,172	10
Other	729	[2] 315	14	1,203	735	17
Total	14,697	[2] 1,432	59	19,392	2,413	37
Europe:						
Belgium-Luxembourg	3,922	470	52	6,367	354	164
France	2,665	1,120	201	6,670	331	45
Germany, West	16,313	858	24,466	18,971	1,057	26,552
Greece	[2] 1,978	[2] 971	----------	3,342	55	----------
Italy	6,461	1,391	19,135	13,217	935	21,771
Netherlands	2,818	1,351	2,600	4,047	2,792	93
Sweden	90	790	14	2,314	733	----------
Switzerland	2,163	316	553	1,917	162	217
United Kingdom	37,517	7,251	4,331	52,265	4,288	4,453
Other	10,728	877	687	3,058	998	1,049
Total	[2] 84,655	[2] 15,395	52,039	112,168	11,705	54,344
Asia:						
India	9,836	11,074	----------	4,128	8,240	5
Israel	830	110	----------	1,274	265	----------
Japan	2,385	221	11,024	3,124	865	14,390
Korea, Republic of	8,225	2	229	3,376	12	----------
Philippines	1,505	83	----------	4,311	52	----------
Other	2,198	704	146	3,316	761	204
Total	24,979	12,194	11,399	19,529	10,195	14,599
Africa	663	1,066	----------	2,771	1,458	1
Oceania	14,133	1,923	690	4,991	693	271
Grand total:						
Short tons	[2] 151,197	[2] 41,973	65,534	165,340	55,289	71,040
Value, thousands	[2] $66,596	[2] $38,848	$20,183	$71,875	$43,348	$21,369

[1] Includes plates, sheets, bars, extrusions, castings, forgings, and unclassified "semifabricated forms."
[2] Revised figure.

Source: Bureau of the Census.

WORLD REVIEW

Estimated world output of primary aluminum rose 9 percent to a record 6.1 million short tons. Of the major producing countries in Europe and North America, the United States had the largest increase on a percentage and quantity basis, followed by West Germany and Norway. On a percentage basis, Brazil and Yugoslavia, which increased output by 49 and 28 percent, respectively, had the largest increases. French production increased only 1 percent. Output in only two countries, Poland and the United Kingdom, declined.

Australia almost tripled its primary aluminum production rate during 1963 and output in Japan and India increased 30 and 56 percent, respectively, over that of 1962.

Primary aluminum capacity of the free world, estimated by the Bureau of Mines, was 5.3 million short tons, an average annual increase of 5 percent over the 4.8 million tons estimated in 1961.

During the 1961–63 period productoin capacity was increased in virtually all of the principal producing countries through construction of new facilities or metallurgical improvements.

TABLE 13.—World production of aluminum by countries [1]

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	596,316	593,630	762,012	663,173	690,297	719,390
United States	1,583,701	1,954,112	2,014,498	1,903,711	2,117,952	2,312,528
Total	2,180,017	2,547,742	2,776,510	2,566,884	2,808,249	3,031,918
South America: Brazil	6,652	19,950	20,034	22,078	22,202	[2] 33,100
Europe:						
Austria	61,261	72,271	74,924	74,578	81,668	84,287
Czechoslovakia	22,946	28,700	44,100	55,100	55,100	[2] 65,000
France	160,428	190,712	262,890	308,047	324,630	328,929
Germany:						
East [2]	33,100	38,600	44,000	60,000	65,000	65,000
West	155,260	166,631	186,221	190,212	196,017	230,142
Hungary	37,287	50,340	54,602	56,386	58,127	61,176
Italy	69,056	82,658	92,206	91,881	89,549	100,884
Norway	97,446	160,881	181,662	189,109	226,966	241,583
Poland (includes secondary)	19,886	25,143	28,640	52,488	53,007	51,365
Spain	11,357	24,959	31,680	41,500	45,953	47,982
Sweden (includes alloys)	13,327	17,100	17,619	18,023	18,629	[2] 19,800
Switzerland	32,822	37,886	43,795	46,530	54,640	67,439
U.S.S.R. [2]	500,000	690,000	745,000	990,000	1,000,000	1,060,000
United Kingdom	31,223	27,462	32,390	36,169	38,113	34,243
Yugoslavia	15,317	21,214	27,635	30,211	30,843	39,567
Total [2]	1,260,000	1,635,000	1,865,000	2,240,000	2,340,000	2,495,000
Asia:						
China [2]	15,400	77,600	88,100	110,000	110,000	110,000
India	7,739	19,131	20,123	20,263	39,025	60,856
Japan [3]	72,571	110,385	146,853	169,424	188,991	246,854
Taiwan	8,758	8,251	9,106	9,938	12,135	13,148
Total [2]	104,500	215,400	264,200	309,600	350,200	430,900
Africa: Cameroon, Republic of	[4] 21,711	46,644	48,436	52,446	57,596	58,334
Oceania: Australia	[5] 8,928	12,734	13,054	14,789	18,144	46,214
World total (estimate) [1]	3,580,000	4,480,000	4,985,000	5,205,000	5,595,000	6,095,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Includes superpurity: 1954–58 (average), 394 tons; 1959, 1,122; 1960, 2,187; 1961, 1,307; 1962, 1,969; and 1963, 2,060 tons.
[4] Average annual production 1957–58.
[5] Average annual production 1955–58.

Economic, political, and technical aspects of the worldwide aluminum industry were discussed in a special report.[12] Per capita consumption of aluminum in 1961 and 1962 was estimated as follows:

Countries:	*1961*	*1962*
United States	25.3	28.9
Switzerland	18.3	19.3
Austria	----	17.1
United Kingdom	16.1	14.2
West Germany	14.7	15.0
Norway	----	10.9
France	10.3	10.7
Italy	6.2	7.0
Netherlands	----	6.6
Belgium	----	4.4

A world directory of producers of alumina, primary and secondary aluminum metal, and aluminum mill product producers, was given in the report.

[12] Metal Bulletin. Aluminium (A Metal Bulletin World Survey) December 1963 special issue, 202 pp.

TABLE 14.—Producers of aluminum

(Short tons)

Country, company, and plant location	Annual capacity, 1963	Participants
FREE WORLD		
North America:		
Canada:		
Aluminum Company of Canada, Ltd. (Alcan).		Subsidiary of Aluminium, Ltd. (Canadian).
Arvida (Quebec)	380,000	
Shawinigan Falls (Quebec)	70,000	
Isle Maligne (Quebec)	115,000	
Kitimat (British Colombia)	212,000	
Chryslum, Ltd: Beauharnois (Quebec)	38,000	Aluminum Company of Canada, Ltd. and Chrysler Corp. of Canada.
Canadian British Aluminium Co. Ltd		Subsidiary of British Aluminium Co. Ltd.
Baie Comeau (Quebec)	90,000	
Total Canada	905,000	
Mexico:		
Aluminio Mexicano S.A. de C.V.: Vera Cruz.	22,000	Alcoa 35 percent; American and Foreign Power Co., 14 percent; and Mexican interests, 51 percent.
United States [1]	2,511,250	
Total North America	3,438,250	
South America:		
Brazil:		
Alumino Minas Gerais, S.A. Ouro Preto (Minas Gerais).	18,200	Subsidiary of Aluminium, Ltd. (Canadian).
Companhia Brasileira de Alumino: Sao Paulo.	22,000	Industrias Votorantim, S.A., 80 percent, and other Brazilian interests, 20 percent.
Total South America	40,200	
Europe:		
Austria:		
Salzburger Aluminium G.m.b.H.: Lend	11,000	Subsidiary of Swiss Aluminium Ltd. (Swiss).
Vereinigte Metallwerke Ranshofen-Berndorf, A.G.: Ranshofen.	77,000	Government-owned.
Total	88,000	
France:		
Pechiney, Compagnie de Produits Chimique et Electrometallurgiques:		Privately owned (French).
Chedde (Haute-Savoie)	6,600	
La Praz (Savoie)	4,100	
La Saussaz (Savoie)	12,000	
St. Jean de Maurienne (Savoie)	76,000	
L'Argentière (Hautes-Alpes)	20,000	
Rioupèroux (Isère)	13,500	
Auzat (Ariège)	20,000	
Sabart (Ariège)	21,000	
Noguères (Hautes-Pyrennes)	99,200	
Soc. d'Electro-Chimie, d'Electro-Metallurgie et des Acièries Electriques d'Ugine:		Do.
Venthon (Savoie)	17,600	
Lannemèzan (Hautes-Pyrennes)	54,000	
Total	344,000	
Germany, West:		
Aluminium G.m.b.H.: Rheinfelden (Baden)	49,500	Subsidiary of Swiss Aluminium, Ltd. (Swiss).
Vereinigte Aluminium Werke A. G.		
Erftwerk, Grevenbroich	38,000	Government owned.
Innwerk, Toging	58,300	
Lippewerke, Lunen	42,000	
Norf	44,000	
Total	231,800	

See footnotes at end of table.

TABLE 14.—Producers of aluminum—Continued

(Short tons)

Country, company, and plant location	Annual capacity, 1963	Participants
FREE WORLD—Continued		
Europe—Continued		
Italy:		
Montecatini, Soc. Generale per l'Industria Mineraria e Chimica:		Privately owned (Italian).
Mori	27,600	
Bolzano	66,100	
Soc. Alluminio Veneto per Azioni (SAVA): Porto Marghera.	30,000	Subsidiary of Swiss Aluminium, Ltd. (Swiss) Alusuisse.
Soc. dell'Alluminio Italiana (SAI): Borgofranco, d'Ivrea.	6,100	Subsidiary of Aluminium, Ltd. (Canadian).
Total	129,800	
Norway:		
A/S Aardal og sunndal Verk		Government-owned.
Aardal	146,700	
Sunnadalsora	55,000	
Det Norske Nitrid A/S		Aluminium, Ltd. (Canadian), 50 percent, and British Aluminium Co., 50 percent.
Eydehavn	10,200	
Tyssedal	19,300	
Norsk Aluminium A/S, Hoyanger	15,400	Aluminium, Ltd. (Canadian), 50 percent, and privately owned (Norwegian) 50 percent.
Mosjøen Aluminium A/S: Mosjøen	62,000	Alcoa, 50 percent and Elektrochemisk A/S (Norwegian) 50 percent.
Total	308,600	
Spain:		
Empresa Nacional del Aluminio, S.A.		Spanish companies with majority government participation.
Valladolid	12,100	
Aviles	8,200	
Aluminio Espanol, S.A.: Sabinanigo (Huesca).	6,600	Pechiney (French), 85 percent, and Kaiser Aluminum & Chemical Corp. (American), 15 percent.
Aluminio de Galicia, La Coruna	13,300	Pechiney (French) and Kaiser (American), 30 percent, and Spanish interests, 70 percent.
Total	40,200	
Sweden:		
A/B Svenska Aluminiumkompaniet		Privately owned (Swedish), 50 percent, and Aluminium, Ltd. (Canadian), 50 percent.
Mansbo	2,400	
Kubikenborg	33,000	
Total	35,400	
Switzerland:		
Swiss Aluminium, Ltd		Privately owned (Swiss).
Chippis	30,800	
Steg	22,000	
Usine d'Aluminium de Martigny, S.A.: Martigny.	5,500	
Total	58,300	
United Kingdom:		
British Aluminium Co., Ltd		Tube Investments, Ltd. (British), 47 percent; Reynolds Metals Co. (American), 45 percent; Reynolds Tube Investments, Ltd., 4 percent; and miscellaneous shareholders, 4 percent.
Kinlochleven	11,200	
Lochaber	28,000	
Total	39,200	
Yugoslavia:		
State Concerns		Government-owned.
Razine	4,500	
Lozovac	5,500	
Strnisce (Kidricevo)	33,000	
Total	43,000	
Total Europe	1,318,300	

See footnotes at end of table.

TABLE 14.—Producers of aluminum—Continued

(Short tons)

Country, company, and plant location	Annual capacity, 1963	Participants
FREE WORLD—Continued		
Asia:		
India:		
Aluminium Corp. of India, Ltd: Asansol	2,800	Privately owned (Indian).
Indian Aluminium Co., Ltd		Aluminium, Ltd. (Canadian), 65 percent, and Indian-owned, 35 percent.
Alwaye	11,000	
Hirakud	22,400	
Hindustan Aluminium Corp. Ltd.: Rihand	22,400	Birla interests (Indian), 73 percent and Kaiser Aluminum & Chemical Corp. (American), 27 percent.
Total	58,600	
Japan:		
Showa Denko K.K. (Showa Electro-Chemical Industry Co., Ltd.).		Privately owned (Japanese).
Kitikata	37,500	
Omachi	33,000	
Goi	17,600	
Nippon Keikinzoku K.K. (Japan Light Metals Co.).		Aluminium, Ltd. (Canadian), 50 percent, and privately owned (Japanese), 50 percent.
Kambara	78,000	
Niigata	34,200	
Sumitomo Kagaku K.K. (Sumitomo Chemical Co., Ltd.).		Privately owned (Japanese).
Kikumoto	34,600	
Nagoya	29,000	
Mitsubishi Chemical Co.: Naoetsu, Niigata	33,000	Privately owned (Japanese).
Total	296,900	
Taiwan: Taiwan Aluminium Corp.: Takao	15,400	Government-owned.
Total Asia	370,900	
Africa: Cameroun: Cie. Camerounaise de l'Aluminium Pechiney-Ugine (ALUCAM): Edea.	58,000	Pechiney-Ugine (French), Caisse Centrale de la France d'Outremer (French), and Cameroun Government.
Oceania: Australia: Comalco Aluminium (Bell Bay) Ltd.: Bell Bay, Tasmania.	58,200	Tasmanian government, 1/3; Consolidated Zinc Corp. Ltd. (Australian), 2/3.
Alcoa of Australia, Pty., Ltd.:		
Geelong	40,000	Alcoa (U.S.), 51 percent; Western Mining Corp. and other Australian interests, 49 percent.
Total Oceania	98,200	
Total free world	5,323,850	
SINO-SOVIET BLOC [2]		
U.S.S.R.: Soviet Aluminium Trust		Government-owned.
Kamensk-Uralskiy	137,500	
Kandalakaha	27,500	
Kransnotourinsk-Bogoslovsk	137,500	
Stalinsk	132,000	
Volkhov	49,500	
Yerevan (Erivan)	44,000	
Zaporozhye (Dneprovskiy)	110,000	
Sumgait	77,000	
Nadvoitsy	27,500	
Stalingrad	220,500	
Total U.S.S.R.	963,000	
Czechoslovakia: Ziar Aluminium Works Svaty Kriz.	62,000	Do.
Germany: East: Elektrochemisches Kombinat:		
Bitterfeld	38,500	Do.
Lautawerk	22,000	
Total	60,500	

See footnotes at end of table.

TABLE 14.—Producers of Aluminum—Continued

(Short tons)

Country, company, and plant location	Annual capacity, 1963	Participants
SINO-SOVIET BLOC[2]—Continued		
Hungary: Magyarsoviet Bauxit Ipar		Do.
Felsogalla-Totis	16,500	
Ajka	20,000	
Inota	33,000	
Total	69,500	
Poland: Skawina Aluminium Works	50,000	State-owned.
China: Nationalized plants	170,500	Do.
North Korea	40,000	Do.
Total, Soviet bloc	1,415,500	
Total, world	6,739,350	

[1] For breakdown of companies and plants, see table 4 of this chapter.
[2] In a number of instances it was impossible to confirm the data on plants of the Sino-Soviet bloc.

NORTH AMERICA

Canada.—The Aluminum Company of Canada, Ltd. (Alcan), completed a 20,000-ton-per-year expansion at its Kitimat, British Columbia, aluminum smelter, bringing the plant's annual capacity to 212,000 tons. Power and raw materials basis for eventual expansion of the reduction plant to 310,000 tons in about 3 years, were established.

The Canadian British Aluminum Company, Ltd., suspended indefinitely plans to expand its Baie Comeau Aluminum reduction plant in Quebec from 90,000 to 135,000 tons per year.

Mexico.—Aluminio Mexicano, S.A. de C. V., began production of primary aluminum from its new 22,000-ton-per-year plant at Vera Cruz. Aluminio, which spent $16 million on the plant, is owned 35 percent by Alcoa, 14 percent by a subsidiary of American & Foreign Power Co., Inc., and 51 percent by Mexican interests, including Intercontinental, S.A. Electric energy for the smelter is provided under an agreement with Comision Federal de Electricidad, an agency of the Mexican Government. Raw material requirement—alumina, aluminum fluoride, cryolite, and electrode material—are being met by Alcoa's Point Comfort, Tex., operations.

SOUTH AMERICA

Brazil.—Coplan, The Brazilian Alliance for Progress Agency, estimated that by 1967 demand for primary aluminum would reach 72,800 tons, of which 39,700 tons would be produced domestically.[13] Production by the two producers, Aluminio Minas Gerais (a subsidiary of Aluminium, Ltd.) and Cia Brasilerira do Aluminio, was estimated at 33,000 tons. Annual capacity of Cia Brasileira's São Paulo plant was to be increased to about 15,000 tons in 1964.

[13] Metal Bulletin (London) Brazil's Aluminum Needs. No. 4786, Apr. 5, 1963, p. 21.

Surinam.—Construction of Surinam Aluminum Company's 60,000-ton-per-year aluminum smelters at Paranam continued and is expected to be completed in late 1965.

Venezuela.—A $5-million plant with capacity to produce 10,000 tons of aluminum ingot per year by a new direct reduction process was reportedly planned by Reynolds International, Inc., a subsidiary of Reynolds Metals Co.,[14] and the Corporacion Venezolana de Guyana.[15] Plans were made to double the capacity of the plant, which was to be built in the Guayana zone, by 1966. The plant was to operate under the name of Aluminio del Caroni S.A. (ALCASA).[16]

EUROPE

France.—Production of primary aluminum increased only 1 percent over 1962 output, compared with a 9-percent increase in the world total. Reported expansion of existing facilities through improvements in processing brought total aluminum productive capacity at the end of 1962 to 344,000 short tons.[17]

TABLE 15.—Europe: Aluminum consumption, by end uses, 1962 [1]

(Short tons)

	West Germany	France [2]	Italy	United Kingdom	All other [3]	Total
Transportation	109,019	88,233	74,406	106,535	11,429	389,622
Machinery and equipment	45,085	24,445	12,125	25,978	7,865	115,498
Electrical engineering	77,162	31,054	13,228	38,009	15,906	175,359
Building and construction	29,321	18,647	19,290	30,653	15,838	113,749
Packaging	42,219	27,365	17,637	26,884	19,462	133,567
Home and office appliances	14,991	27,480	12,677	40,492	15,248	110,888
All other [4]	74,846	47,632	25,904	76,519	25,828	250,729
Total	392,643	264,856	175,267	345,070	111,576	1,289,412

[1] Organisation for European Economic Cooperation and Development, Non-Ferrous Metal Statistics, 1962, pp. 140–141.
[2] Includes Algeria.
[3] Includes Austria, Belgium, Netherlands, and Norway.
[4] Includes chemical, food, and agricultural appliances; powder; iron, steel, and other metal-producing industries; metal industries not elsewhere specified; and miscellaneous.

Greece.—Aluminum di Grece S.A., established by the Government and American, French, and Greek companies, started construction of a $75 million aluminum complex at Aspra Spitea on the northern coast of the Corinthian Gulf. Planned annual productive capacity was 200,000 tons of alumina and 67,500 tons of aluminum. Power costs were expected to average 3.6 mills per KWH.

Hungary.—Because of an acute power shortage, the Government entered into an agreement with the Soviet Union to exchange 358,000 tons of alumina produced in Hungary for 169,000 tons of aluminum produced in the U.S.S.R.[18]

Netherlands.—Total cost of the planned aluminum smelter at Delfzijl, province of Groningen, was expected to exceed $27 million.

[14] Metalworking News. Reynolds Int'l Sets Facility in Venezuela. V. 4, No. 175, Dec. 30, 1963, p. 8.
[15] Light Metals. International News Review. Venezuela. V. 26, No. 301, June 1963, p. 7.
[16] Foreign Trade (Ottawa, Canada). Venezuela. V. 120, No. 1, July 13, 1963, p. 23.
[17] Bureau of Mines. Mineral Trade Notes. V. 57, No. 3, September 1963, p. 4.
[18] E&MJ Metal and Mineral Markets. Hungary to Increase Aluminum Production With Russian Help. V. 34, No. 50, Dec. 16, 1963, pp. 3, 8.

Half of this amount was to be provided by the Royal Netherlands Blast Furnace & Steel Works (Hoogovens), one-sixth by the Billiton Group and the remaining one-third by Swiss Aluminum Ltd. The scheduled capacity of the plant was 33,000 short tons per year.

Norway.—A new company, Alnor A/S, was formed by Norsk-Hydro-Elektrisk A/S (Hydro) and Harvey Aluminum, Inc. to build a 66,000-ton aluminum smelter near Hangesund in the Karmoey district of West Norway. Hydro owned 51 percent of the shares in Alnor.[19] Production at the $85-million plant was expected in 1967.

Negotiations were completed between the Aluminum Company of America and Elektrokemisk A/S to form a company to own and operate the existing 62,000-short-ton aluminum smelter at Mosjøen. In 1963, Mosjøen Aluminium A/S, a subsidiary of Elektrokemisk, operated the plant, which was formerly owned jointly by Elecktrokemisk and Swiss Aluminium, Ltd.

Sør-Norge Aluminium A/S owned by Swiss Aluminium Ltd., Compagnie pour l'Etude et le Developpment des Echanges Commerciaux S.A. (Compadec), and Norwegian interests planned a 66,000-ton-per-year smelter at Husnes, Hardanger Fjord, to be completed in 1966.

Norsk Aluminium A/S planned to double annual capacity of its aluminum smelter at Hoyanger to 6,100 tons.

Rumania.—Construction of a 55,000-ton aluminum smelter at Slatina near Craioval to be completed in 1965 was planned with the cooperation of French, German, Swiss, and Italian firms. Péchiney was expected to design the facility and to provide technical assistance to operate the plant, which is scheduled to use domestic alumina produced at a plant in Oradea from bauxite deposits in the Bihor Mountains.[20]

Sweden.—Svenska Aluminumkompdoniet, A/B, the only producer, completed a new 19,000 ton aluminum smelter at Sundsvall, bringing total capacity to about 33,000 tons per year. Production of primary metal at Svenska's 2,400-ton reduction plant at Mansbo was to be phased out and capacity of the secondary smelter there increased to 5,500 tons per year.[21]

U.S.S.R.—A report indicated that development of the open-pit nepheline mine and completion of the alumina and aluminium production facilities being built at Krosnoyarsk in the Yenisei River Valley would make Eastern Siberia the main aluminum producing center in the U.S.S.R.[22]

ASIA

Taiwan.—The Taiwan Aluminium Corp. produced 13,148 short tons of aluminum ingots and planned to complete a 2 year expansion program at its Takao smelter to raise capacity to 22,000 ton per year.[23]

India.—A report indicated that expansion of existing plants and construction of planned new plants would bring total primary capacity to 157,000 tons per year.[24] Proposed new plants at Koyna, Mahar-

[19] Mining Journal (London). More Aluminum Capacity for Norway. V. 260, No. 6670, June 21, 1963 p. 629.
[20] Engineering and Mining Journal. V. 165, No. 1, January 1964, p. 108.
[21] Mining Journal (London). Production. Sweden's Aluminium Programme. V. 262, No. 6699, Jan. 17, 1964, p. 51.
[22] Metal Bulletin (London). Eastern Siberia. Future Industrial Heart of the Soviet Union. No. 4867, Jan. 28, 1964, p. 4.
[23] Mining Journal (London). Formosan Aluminium Output. V. 261, No. 6672, July 5, 1963, p. 17.
[24] Bhandari, S. R. The Indian Aluminium Industry. The Eastern Metals Review. V. 16, No. 1, Feb. 4, 1963, pp. 55–57.

ashtra (Madras Aluminium Co. Ltd. and Vereinigte Aluminium Werke, A. G.); at Karwar, Mysore (Bharat Reynolds Aluminium Corp. Ltd.); and at Korba, Madhya Pradesh (Inoian), were in various stages of preliminary planning.

Indonesia.—The Government planned to build a 2,000-ton aluminum smelter at Medan, North Sumatra, on the Asahan River. The Soviet Union was providing technical aid.[25]

Japan.—The Mitsubishi Chemical Co. began operation of its 33,000 ton aluminum smelter at Naoetsu, Niigata Prefecture. Mitsubishi announced it had spent 12 billion yen on construction and planned to increase capacity to 66,000 tons by late 1965.[26] Power is based on natural gas. The company reportedly contracted for 60,000 tons of alumina annually from Alcoa of Australia Pty. Ltd.

Capacity of the Showa Denko K. K. Omachi aluminum smelter was raised from 13,300 tons to 33,000 tons per year and capacity of the Nagoya plant of Sumitomo Chemical Co. was raised to 29,000 tons.[27]

AFRICA

Angola.—Owing to insufficient power from the hydroelectric station at Comkambe, Aluminio Portugues (SARL) of Angola postponed its plans for a 25,000-short-ton aluminum smelter at Dondo.[28]

Congo, Republic of the.—Italian consultant engineers were asked to prepare a development plan for the use of the hydroelectric potential of the Inga Falls on the Lower Congo.[29]

Guinea, Republic of.—The Harvey Corp. of Delaware signed a 75-year agreement with the Government to exploit the Boke bauxite deposits through Compagnie des Bauxites de Guinea (CBG). Then Harvey signed a second agreement in which it promised to submit plans for alumina and aluminum producing plants within 3 years of start of Boke mining operations.

United Arab Republic (Egypt Region).—The Government reportedly accepted an offer of financial and technical aid from Poland to construct a small aluminum smelter.

OCEANIA

Australia.—Comalco Aluminium (Bell Bay) Ltd. completed additional expansion of its aluminium smelter at Bell Bay, Tasmania, in April, bringing total capacity to 48,000 tons per year. Another 10,200 tons capacity was expected to be completed by yearend.[30]

Alcoa of Australia, Pty., Ltd. started production of primary aluminium from its 40,000 ton plant at Port Henry, near Geelong, Victoria.

New Zealand.—Agreement was reached between the Government and Bechtel Corp. on an order under which work will be started on the Manopouri project to supply hydroelectric power to Comalco

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[25] Metal Bulletin (London). Indonesian Smelter Plans. No. 4839, Oct. 18, 1963, p. 26.
[26] American Metal Market. Newest Japanese Works Operating. V. 70, No. 194, Oct. 8, 1963, p. 16.
[27] Metal Bulletin (London). Japan's Primary Aluminium Capacity. No. 4832, Sept. 24, 1963, p. 23.
[28] Metal Bulletin (London). Slow Start for Aluminio Portugues. No. 4815, July 23, 1963, p. 20.
[29] Light Metals. V. 27, No. 308, January 1964, p. 5.
[30] American Metal Market. Progress in Australia. Weipa Bauxite Shipping Starts: Capacity Rises at Bell Bay. V. 70, No. 63, Apr. 2, 1963, p. 16.

Industries Pty., Ltd. for development of the planned aluminum smelter in Southland.[31]

TECHNOLOGY

Despite continued efforts to develop methods for producing aluminum metal directly from bauxite, the conventional Hall-Heroult electrolytic process using alumina continued to be the only method in commercial use.

Aluminum Ltd. continued pilot plant studies of its process for producing aluminum from an impure metal made by direct reduction of bauxite. Aluminum trichloride was reacted with the impure metal at 1,000° to 1,200°C to form aluminum monochloride, which was subsequently cooled to about 700°C and decomposed to pure aluminum metal and to the trichloride, which in turn was recirculated. Based on the experience of operating its pilot plant, the company completed construction of a new installation at Arvida and planned to determine capital and production costs which would be expected from large-scale operation of the process.[32]

Another direct reduction process, developed by Pechiney of France, also was believed to be operating on a pilot plant scale. In the French process, bauxite is partially reduced with carbon in an electric furnace, then it is further reduced with carbon to produce a mixture of aluminum and aluminum carbides. The aluminum was separated and the aluminum carbide recycled.[33]

Reynolds Metals Co. reportedly tested a direct reduction thermal process in a pilot plant of undisclosed size.[34]

The conventional Hall-Heroult process for making aluminum by electrolysis of aluminum oxides, dissolved in molten cryolite, continued to be improved. Refractory hard materials (RHM), such as titanium carbide and boride, were used to decrease the resistance between the floor of the cell (the cathode), the anode, and the molten metal. RHM electrodes, were inserted into the cell floor and protruded into the molten metal.[35]

A discussion of the role of sodium in the swelling of carbon cathodes in aluminum reduction cells was published.[36] Penetration of the carbon by sodium atoms produced in a reaction between aluminum metal and sodium fluoride in the bath, causes the swelling. It was concluded that the sodium diffuses through the carbon lattice and not through the pores. Aluminum carbides were believed to be formed by the reaction between the free sodium, sodium aluminum fluoride, and carbon in the liner. Activity of the sodium was found to be a function of the temperatures used in preparing the carbon.

A new primary aluminum plant at New Johnsonville, Tenn., was the first in North America to use the elevated cell floor principle,

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[31] Metal Industry (London). Aluminium Smelting Plant for New Zealand—Agreement Reached. V. 102, No. 9, Feb. 28, 1963, p. 290.

[32] Aluminum Ltd. 1963 Annual Report. Montreal, Canada, 1963, pp. 6–7.

[33] Chemical Trade Journal and Chemical Engineer. New Techniques of Producing Aluminum. V. 152, No. 3958, Apr. 19, 1963, p. 634.

[34] Chemical and Engineering. Top News Stories and What They Mean to CPI Technical Decision-Makers. V. 70, No. 15, July 22, 1963, pp. 69, 71.

[35] South African Mining & Engineering Journal. Cheaper Aluminum Production. V. 74, pt. 2, No. 3676, July 19, 1963, p. 389.

[36] Dewing, E. W. The Reaction of Sodium With Nongraphitic Carbon: Reactions Occuring in the Linings of Aluminum Reduction Cells. AIME Trans. V. 227 (Met. Soc.), No. 6, December 1963, pp. 1328–1334.

to simplify cell repair and replacement. Direct current for the plant was supplied with a silicon rectifier that provides close control of amperage under fluctuating voltage conditions. A continuous casting unit provided output of 0.25-inch coiled aluminum strip from the molten metal.[37]

A laboratory scale alumina reduction cell with a graphite crucible and a boron nitride liner was described.[38] Operating conditions in the cell such as temperature, time, current density, electrolyte and electrode materials may be varied easily. The cell can be used for experiments not readily performed in a large cell, and some results can be interpreted in terms of plant scale operation.

About 40 to 60 pounds of aluminum fluoride and cryolite are lost in reduction plant residues for each ton of aluminum produced. The Bureau of Mines investigated a flotation process for recovering up to 77 percent of the fluorine and 63 percent of the aluminum losses.[39]

General limits in size and shape of available aluminum extrusions of interest to designers were discussed in a report.[40] The maximum crosssectional dimensions available from most extruders was 6 inches. Minimum wall thickness was about 0.050 inches (slightly less for small and simple sections). Aluminum was extruded in 40- to 60-foot lengths but because of limitations imposed by shipping, extrusions were shipped in lengths up to about 22 feet. The report recommended that surfaces of wide, flat extrusions be broken with serrations, ridges, or contours to eliminate or minimize minor defects. Wide extrusions (over 12 inches) were not readily available. Parts could be extruded in round or semicircular shape and could be flattened to obtain a wide shape but this was not recommended because of residual stresses. Redesign was recommended to permit interlocking extrusions to obtain the desired width.

The trend of recent years toward greater integration of sheet and wire forming operations with a continuous casting process continued. In these systems, molten aluminum was poured into a machine designed to produce a continuous strip or bar of metal and to feed it directly into hot rolling mills.[41] In some installations finished products such as tubing,[42] or building siding [43] were made from the continuously produced sheet or strips. Rolling of sheet or bar in this manner permits full-time utilization of equipment which is not afforded by conventional rolling and re-rolling of individual ingots.

A new technique for bypassing the ingot stage in producing mill products was developed.[44] Molten aluminum is poured into a perforated, cylindrical-shaped cup and spun at a high speed, throwing

[37] American Metal Market. New Aluminum Producer Operating Six Weeks, Starts Expansion Program. V. 70, No. 210, Oct. 30, 1963, pp. 1, 12.

[38] Schlain, David, Charles B. Kenahan, and Joseph H. Swift. A Small Alumina Reduction Cell. BuMines Rept. of Inv. 6265, 1963, 41 pp.

[39] McClain, R. S., and G. V. Sullivan. Beneficiation of Aluminum Plant Residues. BuMines Rept. of Inv. 6219, 1963, 17 pp.

[40] Shinsky, R. L. Designing With Extruded Aluminum. Mater. in Design. Eng., V. 57, No. 4, April 1963, pp. 94–97.

[41] Iron Age. Fast Line Casts Aluminum Bars. V. 192, No. 14, Oct. 3, 1963, p. 69.

[42] Metal Industry (London). Aluminum Strip for Tube Production. V. 103, No. 23, Dec. 5, 1963, pp. 822–824.

[43] Darby, H. K. Continuous Casting: Key to Low-Cost Siding. Modern Metals, v. 19, No. 4, May 1963, pp. 38–44.

[44] Daugherty, T. S. Method of Forming Wrought Aluminous Metal. U.S. Pat. 3,976,706, Feb. 5, 1963.
Industrial and Engineering Chemistry. New Process Rolls Aluminum Sheet From Pellets. V. 55, No. 7, July 1963, pp. 30–31.
Starin, F. J. Aluminum Pellets Form Sheets. Iron Age, v. 191, No. 10, Mar. 7, 1963, pp. 102–103.

aluminum through the perforations. Air jets break metal strings thus formed into rice-size pellets. The pellets are heated and gravity-fed to a standard 4-high mill tipped on end and are rolled directly into sheet. Savings on plant investment and production costs in producing aluminum sheet as well as lower scrap generation were claimed.

A lubricant was developed which reportedly reduced the friction on aluminum parts to one-fifth of that encountered with standard lubricants.[45] The composition of lubricant was not reported but it was said to form a single layer of long-chain molecules which adhered tightly to aluminum surfaces. Use of the new lubricant reduced the force needed in cutting, drawing, and rolling operations.[46]

A fluxless method for joining aluminum components utilized the low melting temperature (several hundred degrees Fahrenheit below the melting point of aluminum) of aluminum-copper alloys.[47] A foil of the alloy is placed between the aluminum parts to be joined. When the parts are heated, differential expansion of the aluminum and its oxide coating cracks the coating and the copper alloys with the exposed metal. Application of pressure squeezes the low melting alloy out carrying with it entrapped oxides and most of the copper. A strong ductile joint is formed with good electrical conductivity. Another method for joining aluminum to other metals as well as to itself utilizes a fused aluminum rivet.[48]

In a method for brazing and welding of sintered aluminum powders (SAP) developed in the U.S.S.R., thin SAP sheet was clad with various aluminum alloy sheet material prior to joining.[49] Information on solders, soldering fluxes, methods used in joining aluminum, the solderability of aluminum alloys, physical and chemical properties of soldered aluminum joints, and safety practices recommended for use in soldering aluminum was reported.[50]

Except in manual welding of small components, direct current straight polarity variation or inert gas metal arc welding was replacing the alternating current tungsten arc welding method for joining aluminum alloys used in space craft.[51] The straight polarity method provided better weld metal homogeneity and higher strength whereas greater production rates were attained by the inert gas metal arc process. Shot peening of longitudinal butt welds and the heat-affected zone in welded aluminum plate improved the fatigue life of the weld.[52]

Availability of water-soluble polyalkylene oils and development of safe techniques for handling liquid metal have led to increased interest in these media for quenching heat-treated aluminum. A report indicated that these materials may be superior to water, as residual stresses resulting from thermal gradiants in quenched, thick

[45] Modern Metals. New Lubricants for Aluminum. V. 19, No. 1, February 1963, p. 56.
[46] Young, A. W. Compound Brightens Aluminum. Iron Age, v. 192, No. 6, Aug. 8, 1963, pp. 52–63.
[47] Industrial Heating. New Method for Joining Aluminum Compounds. V. 30, No. 3, March 1963, pp. 452, 454, 456, 464.
[48] Chemical & Engineering News. "Fused Rivet" Joins Aluminum, Other Metals. V. 41, No. 33, Aug. 19, 1963, pp. 50–51.
[49] U.S. Department of Commerce. Brazing and Welding Sintered Aluminum Powder—USSR. Mar. 18, 1963, p. 23.
[50] Modern Metals. How to Solder Aluminum. Pt. 1, v. 18, No. 11, December 1962, pp. 61, 64, 66–67, 70; pt. 2, v. 18, No. 12, January 1963, pp. 36, 38, 40, 44, 45; pt. 3, v. 19, No. 1, February 1963, pp. 40, 42, 44; pt. 4, v. 19, No. 2, March 1963, pp. 50, 52, 54, 56, 58.
[51] Groth, Willis. What the Space Program Can Tell Us About . . . Trends in Welding Aluminum. Metal Prog., v. 83, No. 6, June 1963, pp. 76–77, 112, 114, 116, 118, 120.
[52] Nordmark, G. E. Peening Increases Fatigue Strength of Welded Aluminum. Metal Prog., v. 84, No. 5, November 1963, pp. 101–103.

sections were reduced when they were used.[53] The time required to attain desired strength levels was reduced by two new quench-aging processes in which both oil and liquid metal were utilized.[54]

A continuous method for anodizing one side of coiled aluminum sheet was described.[55] Features of the process said to distinguish it from other processes were a large graphite anode area, a vaccuum method of holding down the sheet, and a rubber belt mechanism for agitating the bath adjacent to the sheet.

New alloys that were under development included two casting alloys (X310 and X335) that were machinable without the use of lubricants.[56] Experimental structural alloys (X5053, X6070, and X6071) reportedly had improved strength characteristics. One newly developed heat treatable alloy (X7039) had excellent properties at cryogenic temperatures.

A foundry alloy containing 7 percent magnesium reportedly developed all its properties immediately after casting without subsequent heat treating or room temperature aging.[57]

A new aluminum powder (X–AP001) was reportedly the strongest available in the 600° to 900° F range.[58] A large variety of high-strength aluminum alloys were available with varying combinations of strength and physical properties.[59]

The strength of sintered aluminum powders was improved by removing hydrogen trapped in lattice defects and in the discontinuties. Removal of entrapped gas is difficult.[60] Sources of hydrogen contamination in aluminum castings included charge materials (surface moisture, cutting oil, etc.), combustion products (most fuels contain 10 to 20 percent water vapor), atmospheric moistures, fluxes, and tools.[61]

An investigation of the poorer mechanical properties of cast alloys as compared with wrought alloys of the same composition indicated that dispersed phases and voids in the cast alloys were the chief cause.[62] The study also indicated that generally strength properties of alloy systems could be correlated with their physical structures.

The use of high-purity aluminum as the base metal together with careful grain refinement and extensive chilling resulted in ductile castings with high strength.[63]

Metallographic examination and tensile tests conducted over a period of 6 years disclosed that the strength of aluminum alloys containing more than about 10.2 percent magnesium, increases slowly but continuously when aged at room temperature for at least 5 years.[64]

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[53] Singleton, O. R., Jr. Ideas for Quenching Aluminum. Iron Age, v. 192, No. 8, Aug. 22, 1963, p. 72–73.
[54] Singleton, O. R., Jr. Quench-Aging Makes Headway With 6061 Aluminum. Iron Age, v. 192, No. 24, Dec. 12, 1963, pp. 94–95.
[55] Church, F. L. Continuous Process Anodizes One Side of Coiled Sheet at High Speed, Low Cost, Modern Metals, v. 19, No. 2, March 1963, pp. 32–34, 36–37.
[56] Holcomb, E. J. More Data on New Aluminum Alloys. Mater in Design Eng., v. 58, No. 7, December 1963, pp. 81–84.
[57] Steel. New Aluminum-Magnesium Alloy Added by Reynolds. V. 153, No. 6, Aug. 5, 1963, p. 56.
[58] Wyma, Bruch H. Aluminum Alloys. Industrial & Engineering, v. 55, No. 12, December 1963, pp. 53–59.
[59] Nock, J. A., Jr., and H. Y. Hunsicker. J. Metals, v. 15, March 1963, pp. 216–224.
[60] Solomir, John G. Progress in Sintered Aluminum Alloys. Metal Prog., v. 83, No. 1, January 1963, pp. 105–108.
[61] Kissling, R. J., and J. F. Wallace. Gas Porosity. Foundry, v. 91, No. 2, February 1963, pp. 70–75.
[62] Watkins, A. K., and V. Kondic. Structure and Tensile Properties of Aluminum Alloys. Foundry, v. 91, No. 11, November 1963, pp. 58–63.
[63] Flemings, Merton C. Premium Quality Aluminum Casting. Foundry, v. 91, No. 8, July 1963, pp. 60–63.
———. Premium Quality Aluminum Casting. Foundry, v. 91, No. 7, August 1963, pp. 47–49.
[64] Pollard W. A. Aging Behavior of Al-10% Mg. Casting Alloys at Room Temperature and Up to 150° C (300° F). Dept. of Mines and Tech. Surveys, Ottawa, Canada, R 120, November 1963, p. 34.

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The use of a reverberatory furnace for melting aluminum was described. One ton of aluminum could be melted in 25 minutes using 26 therms of gas or 14 gallons of oil.[65] A mobile ladle capable of transporting 500 pounds of molten aluminum was described.[66] Various methods of purifying molten aluminum by fluxing [67] or filtering [68] were reported. Joining of roll-formed plates, continuous casting of tubes, or the roll extruding of cylinders for fabricating solid propellant rockets of aluminum as high as a ten-story building were suggested.[69]

Several published articles on the effect of grain refiners on cast aluminum indicated that titanium, boron, fluoroborates, and fluorotitanates were among the most effective materials tested for promoting solidification of a fine-grained, equiaxed structure.[70] Several theories on the grain-refining mechanism were described. The most commonly accepted one was that titanium (or titanium diboride) precipitated out of solution and served as a nucleous for the grain.

To avoid the loss caused by long holding time of the effectiveness of titanium in refining the grain in cast aluminum alloys, one company made smaller and more frequent additions of a master alloy containing titanium and boron.[71] Titanium-boron salts were less sensitive to holding time, but air pollution controls restricted the total use of the salts.

Corrosion of aluminum is chiefly dependent on the competing processes of formation and dissolution of the oxide film on the metal.[72] When pure aluminum is exposed to dry oxygen at room temperature an oxide film, about 10 Angstroms thick, is formed in 40 minutes. Further increase in thickness is limited. In moist air, however, the oxide film grows rapidly to 20 Angstroms and after about a month it reaches 45 Angstroms in thickness. The thin film is the most coherent and is less permeable to cations and electrons.

One investigation revealed that corrosion of aluminum was promoted by active chemicals such as sulfur and some of its compounds and was inhibited by surface amalgamation, especially with zinc oxide-saturated solutions and by alkyldimethylbenzyl-ammonium salts.[73]

Another investigation showed that contamination of the media by corrosion products may also influence the corrosion rate in the media.[74]

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[65] Metallurgia (Manchester, England). Aluminum Melting. Use of the Reverberatory Furnace. V. 68, No. 410, December 1963, pp. 279–280.

[66] American Metal Market. British Firm Develops Mobile Ladle for Molten Aluminum. V. 70, No. 212, Nov. 1, 1963, p. 10.

[67] Kissling, R. J., and J. F. Wallace, Fluxing To Remove Oxide From Aluminum Alloys. Foundry, v. 91, No. 3, March 1963, pp. 76–81.

[68] Metalworking News. Kaiser Offers Licensing for Al Casting Process. V. 4, No. 176, Dec. 30, 1963, p. 16.

[69] Metalworking Weekly Steel. Lincoln Electric's Cost Cutting Formula Still Good. V. 152, No. 6, Feb. 11, 1963, p. 31.

[70] Hefferman, R. W. Aluminum Alloys and the Effects of the Additions of Master Alloys. Light Metal Age, v. 21, Nos. 5 and 6, June 1963, pp. 19–22.

Kissling, R. J., and J. F. Wallace. Grain Refinement of Aluminum Castings. Foundry, v. 91, No. 6, June 1963, pp. 78–82.

——. Grain Refinement of Aluminum Castings. Foundry, v. 91, No. 7, July 1963, pp. 45–49.

Rowe, Donald. Aluminum Grain Refining Seminar. Light Metal Age, v. 21, Nos. 5 and 6, June 1963, pp. 15–16.

[71] Light Metal Age. Grain Refining Practice at Hunter Engineering Co. V. 21, Nos. 5–6, June 1963, p. 18.

[72] Metal Progress. Corrosion of Aluminum. V. 83, No. 4, April 1963, pp. 152, 154.

[73] Bockstie, L., D. Trevethan, and S. Zaromb. Control of Al Corrosion in Caustic Solutions. J. Electrochem. Soc., v. 110, No. 4, April 1963, pp. 267–271.

[74] Draley, J. E., Shiro Mari, and R. E. Loess. The Corrosion of 1100 Aluminum in Oxygen-Saturated Water at 70° C. J. Electrochem. Soc., v. 110, No. 6, sec. 2, June 1963, pp. 622, 627.

Antimony

By Donald E. Moulds [1]

SALIENT STATISTICS of the antimony industry for 1963 indicate an improvement in all areas except price, which remained unchanged throughout the year. The supply of antimony slightly exceeded consumption, and total industry stocks of primary antimony increased 4 percent compared with stocks reported at the close of the previous 2 years.

Antimony was acquired by barter under the Commodity Credit Corporation program of exchange of surplus agricultural materials for strategic and critical materials. Deliveries during the year amounted to 3,568 tons, and Government inventory in all stockpiles at yearend totaled 52,126 tons.

DOMESTIC PRODUCTION

MINE PRODUCTION

Production of antimony as a byproduct of silver-lead ore refining in the Idaho area and recovered as an impure cathode metal was 645 tons. The Sunshine Mining Co. was again the major producer; output was curtailed by a labor strike in December. Output of antimony also was reported by the Hecla Mining Co. and Antimony Gold Ores Co., both in Idaho.

SMELTER PRODUCTION

Primary.—Production of 12,100 tons of primary antimony at domestic smelters represented a 3-percent increase over the 1962 total. The increase was attributed, in part, to improved industrial demand and to the smelting of foreign ores for delivery of metal to the Government under a barter transaction. Smelter output was derived from the following sources: 88 percent from foreign ores and concentrates, 7 percent as byproduct antimony recovered from comingled domestic lead ores, and 5 percent from domestic mine production. Byproduct antimony recovered at lead refineries from both foreign and domestic ores accounted for 2,500 tons, or 20 percent, of the total primary output.

Smelter output was divided as follows: metal, 34 percent; oxide, 49 percent; antimony in antimonial lead, 12 percent; and the remaining 5 percent in sulfide and residues. Antimony metal was produced by

[1] Commodity specialist, Division of Minerals.

National Lead Co. and Sunshine Mining Co. Oxide was produced by American Smelting and Refining Company, Harshaw Chemical Co., McGean Chemical Co., M&T Corp., (formerly M&T Chemicals, Inc.), and National Lead Co. Antimony sulfide, including ground high-grade ore, was produced by Foote Mineral Co., Hummel Chemical Co., and McGean Chemical Co.

TABLE 1.—Salient antimony statistics

(Short tons)

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Production:						
Primary:						
Mine	681	678	635	689	631	645
Smelter [1]	10,447	8,748	9,954	11,329	11,727	12,117
Secondary	22,449	20,043	20,104	19,466	19,362	20,803
Imports, general (antimony content)	12,541	13,273	14,519	13,942	16,833	17,781
Exports	95	174	906	44	45	143
Consumption [2]	14,210	13,317	13,271	12,697	15,452	16,532
Price: New York, average cents per pound	32.89	31.30	31.30	33.89	34.75	34.75
World: Production	54,400	58,700	58,800	57,400	58,700	61,100

[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 alloys imported.

TABLE 2.—Antimony mine production and shipments in the United States

(Short tons)

Year	Antimony concentrate		Antimony	
	Quantity	Antimony content, percent	Produced	Shipped
1954-58 (average)	3,948	17.8	681	(1)
1959	4,671	14.5	678	146
1960	4,256	14.9	635	1,086
1961	4,245	16.2	689	1,646
1962	3,941	16.0	631	732
1963	3,540	18.2	645	503

[1] Data not available.

TABLE 3.—Primary antimony produced in the United States

(Short tons, antimony content)

Year	Class of material produced					Total
	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	
1954-58 (average)	3,220	4,616	107	611	1,893	10,447
1959	2,667	4,411	70	430	1,170	8,748
1960	3,665	5,188	60	385	656	9,954
1961	4,558	4,609	84	355	1,723	11,329
1962	4,407	4,788	53	366	2,113	11,727
1963	4,160	5,983	76	392	1,506	12,117

Secondary.—Antimony recovered from antimony-bearing lead and tin scrap processed mainly at secondary smelters amounted to 20,800 tons valued at $14.5 million. This is a 7-percent increase in output and a 7-percent increase in value compared with the 1962 figures. Secondary-lead smelters recovered 19,200 tons of antimony, and primary smelters recovered 400 tons from scrap. Manufacturers and foundries reclaimed 1,200 tons in 1963, compared with 800 tons in both 1961 and 1962. Old scrap contributed about 89 percent of the material processed, and new scrap, consisting of reprocessed drosses from smelting old scrap, contributed the remaining 11 percent. Battery plate scrap was the dominant source, supplying 12,400 tons of the secondary antimony. Other sources were type metal scrap, 3,400 tons; drosses, 2,200 tons; bearing metal scrap, 1,500 tons; and antimonial lead scrap, 900 tons. All of the antimony reclaimed from scrap was processed into lead- and tin-base alloys, of which antimonial lead constituted 71 percent. Secondary smelters and remelters used, in addition to the reclaimed antimony, 3,300 tons of primary antimony in producing the various alloys.

TABLE 4.—Secondary antimony produced in the United States, by kind of scrap and form of recovery

(Short tons, antimony content)

Kind of scrap	1962	1963	Form of recovery	1962	1963
New scrap:			In antimonial lead [1]	13,706	14,874
Lead-base	2,082	2,156	In other lead alloys	5,630	5,904
Tin-base	82	96	In tin-base alloys	26	25
Total	2,164	2,252	Total	19,362	20,803
			Value (millions)	$13.5	$14.5
Old scrap:					
Lead-base	17,158	18,512			
Tin-base	40	39			
Total	17,198	18,551			
Grand total	19,362	20,803			

[1] Includes 136 tons of antimony recovered in antimonial lead from secondary sources at primary plants in 1962 and 384 tons in 1963.

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
1954–58 (average)	61,755	1,208	685	1,365	3,258	5.3
1959	37,487	676	494	754	1,924	5.1
1960	30,230	456	200	919	1,575	5.2
1961	35,080	1,010	713	171	1,894	5.4
1962	33,325	1,361	752	136	2,249	6.7
1963	41,077	836	670	384	1,890	4.6

[1] Includes primary residues and small quantity of antimony ore.
[2] Includes foreign base bullion and small quantities of foreign antimony ore.

CONSUMPTION AND USES

Industrial consumption of primary antimony was 16,500 tons, 7 percent more than in 1962 and 18 percent above the annual average for 1954–62. Consumption increased for all classes of material consumed except as byproduct antimonial lead. Antimony metal and antimony oxide each represented 43 percent of the material consumed, and antimonial lead about 9 percent.

Consumption of primary antimony in metal products increased 9 percent in relation to 1962. Use of antimonial lead continued at a high level, some 6 percent above the 1962 figure and 40 percent above the average for the relatively stable period of 1954–61. Bearing use increased significantly in 1963, as did use in type metal. Other historical uses such as cable covering, castings, and sheet and pipe, maintained the decline in consumption shown in prior years.

Nonmetal products required 5 percent more antimony in 1963 than in 1962; also there was a 17-percent increase over the average use in 1954–61. There was a major increase in antimony used in flameproofing chemicals and compounds compared with prior years shown. Consumption in plastics and in rubber products continued the upward trend shown in previous years. Use in ceramics and glass products rose somewhat, reversing the decrease in consumption registered in 1961 and 1962. The amount of antimony required for pigments and nonmetal products other than those listed here declined.

TABLE 6.—Industrial consumption of primary antimony in the United States

(Short tons, antimony content)

Year	Class of material consumed						Total
	Ore and concentrate	Metal [1]	Oxide	Sulfide	Residues	Byproduct antimonial lead	
1954–58 (average)	720	4,844	6,038	105	611	1,892	14,210
1959	270	5,420	5,948	79	430	1,170	13,317
1960	226	5,892	6,033	78	386	656	13,271
1961	106	4,994	5,450	69	355	1,723	12,697
1962	137	6,126	6,642	68	366	2,113	15,452
1963	266	7,124	7,173	71	392	1,506	16,532

[1] Includes antimony in imported alloys.

STOCKS

Industrial stocks of antimony increased 4 percent to 6,700 tons at year end. Ore and concentrate stocks at 2,000 tons were well above those of the prior 2 years. Stocks of residues also increased. Metal and oxide stocks, however, continued the downward trend initiated in 1962.

Government stocks of antimony totaled 52,126 tons at yearend. Of the total inventory the strategic stockpile contained 30,301 tons, and the Commodity Credit Corporation and supplemental stockpiles combined contained 21,825 tons. Deliveries in 1963 under the agricultural barter program amounted to 3,568 tons.

TABLE 7.—Industrial consumption of primary antimony in the United States, by class of material produced

(Short tons, antimony content)

Product	1954–58 (average)	1959	1960	1961	1962	1963
Metal products:						
Ammunition	7	(1)	(1)	(1)	(1)	(1)
Antimonial lead [2]	4,823	4,141	4,398	4,708	6,090	6,462
Bearing metal and bearings	862	886	803	737	682	992
Cable covering	177	157	146	141	114	101
Castings	76	84	72	53	64	49
Collapsible tubes and foil	28	33	17	24	112	72
Sheet and pipe	245	202	202	147	127	81
Solder	123	113	130	97	172	188
Type metal [2]	963	883	580	448	429	652
Other	143	130	148	152	271	199
Total [2]	7,447	6,629	6,496	6,507	8,061	8,796
Nonmetal products:						
Ammunition primers	16	11	11	15	14	15
Fireworks	33	28	33	20	23	36
Flameproofing chemicals and compounds	1,017	1,033	1,177	1,138	1,215	1,601
Ceramics and glass	1,777	1,727	1,640	1,223	1,146	1,465
Matches	19	19	17	(1)	9	5
Pigments	1,261	1,167	1,282	845	1,161	1,009
Plastics	790	1,034	1,013	1,228	1,269	1,352
Rubber products	166	217	238	287	460	597
Other	1,684	1,452	1,364	1,434	2,094	1,656
Total	6,763	6,688	6,775	6,190	7,391	7,736
Grand total	14,210	13,317	13,271	12,697	15,452	16,532

[1] Included with "Other" to avoid disclosing individual company confidential data.
[2] Includes antimony content of imported antimonial lead consumed.

TABLE 8.—Industry stocks of primary antimony in the United States, December 31

(Short tons, antimony content)

Stocks	1959	1960	1961	1962	1963
Ore and concentrate	2,884	2,356	850	1,450	1,970
Metal	1,422	1,346	1,680	1,599	1,420
Oxide	1,659	2,187	2,398	1,895	1,861
Sulfide	115	94	107	90	81
Residues and slags	685	938	873	999	1,081
Antimonial lead [1]	373	242	538	403	282
Total	7,138	7,163	6,446	6,436	6,695

[1] Inventories from primary sources at primary lead smelters only.

PRICES

The quoted price of RMM brand antimony metal, 99.5 percent antimony, remained at 32.5 cents per pound, f.o.b., Laredo, Tex., in bulk, throughout the year. The New York equivalent price was 34.25 cents per pound. The last domestic metal price change occurred on April 3, 1961. The price of antimony trioxide also continued unchanged at 30 cents per pound, delivered in carload lots.

Withdrawal of offerings of crude antimony on the European market by the U.S.S.R. and China, early in the year, resulted in a price increase in mid-April for imported ore and metal, and prices continued to rise during the remainder of the year. Prices of foreign metal, 99.5 percent, duty paid, New York, increased from a range of 28.5 to 29.5 cents per pound to 35 to 35.5 cents at yearend. Antimony ore, 65 percent, lump, New York, increased from a range of $4.10 to $4.50 per short-ton unit to $4.75 to $4.85 at yearend.

TABLE 9.—Antimony price ranges in 1963

Type of antimony:	Price
Domestic metal [1] ____ cents per pound	32.50
Foreign metal [2] ____ do	28.50 to 35.50
Antimony trioxide [3] ____ do	30.00
Antimony ore,[3] 50 to 55 percent__dollars per short-ton unit	3.25 to 4.15
Antimony ore, minimum 60 percent ____ do	3.90 to 4.70
Antimony ore, minimum 65 percent ____ do	4.10 to 4.85

[1] RMM brand, f.o.b., Laredo, Tex.
[2] Duty-paid delivery, New York.
[3] Quoted in E&MJ Metal and Mineral Markets.

FOREIGN TRADE

Imports.—General imports were 17,800 tons, antimony content, an increase of 6 percent compared with the 16,800 tons imported in 1962. Imports of ore and concentrate increased about 14 percent and metal about 20 percent, while oxide imports decreased 28 percent. Imports consisted of ore and concentrate, 55 percent; metal, 32 percent; oxide, 10 percent; and sulfide and miscellaneous alloys, 3 percent. Ore and concentrate were supplied by Mexico, 41 percent; Republic of South Africa, 41 percent; Bolivia, 10 percent; Chile, 7 percent; and Peru, Guatemala, and Brazil, 1 percent. The major metal suppliers were Yugoslavia, 45 percent; United Kingdom, 22 percent; and Belgium-Luxembourg, 19 percent. Other suppliers were Mexico, Peru, France, Spain, Thailand, Republic of South Africa, and Poland. The United Kingdom supplied 48 percent of the oxide; Belgium-Luxembourg, 37 percent; and France, 13 percent. Small lots of oxide were received from Bolivia, West Germany, and the Netherlands.

Exports.—Exports of ore, metal, and alloys amounted to about 143 tons in comparison with the 45 tons exported in 1962. Ore and concentrate exported, principally to Belgium-Luxembourg, amounted to 129 tons. Metal and alloys in crude form totaled 14 tons of which the Republic of Korea, Viet-Nam, the United Kingdom, and India were the major importers.

TABLE 10.—U.S. imports [1] of antimony, by countries

Year and country	Antimony ore			Needle or liquated antimony		Antimony metal		Antimony oxide	
	Short tons (gross weight)	Antimony content		Short tons (gross weight)	Value (thousands)	Short tons	Value (thousands)	Short tons (gross weight)	Value (thousands)
		Short tons	Value (thousands)						
1954–58 (average)	15,236	6,087	$1,509	60	$27	4,119	$1,991	1,740	[2] $729
1959	15,307	6,466	1,236	163	74	4,395	2,023	2,056	825
1960	16,406	6,455	1,214	24	11	5,437	2,495	2,368	972
1961	16,204	6,713	1,389	13	6	4,912	2,347	1,980	935
1962:									
North America:									
Canada						(3)	10		
Guatemala	51	32	11						
Mexico	12,746	4,072	725			266	91		
Total	12,797	4,104	736			266	101		
South America:									
Bolivia	1,303	830	300			59	27		
Peru						524	221		
Total	1,303	830	300			583	248		
Europe:									
Belgium-Luxembourg				11	5	1,515	791	849	426
Finland						40	22		
France	1	(3)	(4)					427	213
Germany, West						28	15	11	5
Netherlands								22	11
Spain						165	67		
United Kingdom				6	3	950	483	1,601	736
Yugoslavia						1.193	582		
Total	1	(3)	(4)	17	8	3,891	1,960	2,910	1,391
Africa: South Africa, Republic of	6,021	3,668	1,132						
Grand total	20,122	8,602	2,168	17	8	4,740	2,309	2,910	1,391
1963:									
North America:									
Canada						(3)	15		
Guatemala	51	31	9						
Mexico	13,163	3,999	732			338	132		
Total	13,214	4,030	741			338	147		
South America:									
Bolivia	1,567	982	317					6	2
Brazil	44	30	11						
Chile	962	638	225						
Peru	183	133	37			210	88		
Total	2,756	1,783	590			210	88	6	2
Europe:									
Belgium-Luxembourg				15	8	1,091	594	782	415
France						82	47	274	131
Germany, West								11	5
Netherlands								8	4
Poland and Danzig						24	12		
Spain						55	22		
United Kingdom				7	3	1,234	654	1,008	481
Yugoslavia						2,569	1,347		
Total				22	11	5,055	2,676	2,083	1,036
Asia: Thailand						54	22		
Africa: South Africa, Republic of	6,837	3,971	1,344			39	25		
Grand total	22,807	9,784	2,675	22	11	5,696	2,958	2,089	1,038

[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] 1957 data known to be not comparable with other years.
[3] Less than 1 ton.
[4] Less than $1,000.

Source: Bureau of the Census.

TABLE 11.—U.S. imports for consumption of antimony [1]

Year	Antimony ore			Needle or liquated antimony		Antimony metal		Type metal and antimonial lead [2] (short tons)	Antimony oxide	
	Short tons (gross weight)	Antimony content		Short tons (gross weight)	Value (thousands)	Short tons	Value (thousands)		Short tons (gross weight)	Value (thousands)
		Short tons	Value (thousands)							
1954-58 (average)	15,236	6,087	$1,509	60	$27	4,097	$1,982	849	1,738	[3] $728
1959	15,307	6,466	1,236	177	79	4,422	2,039	592	2,056	825
1960	16,406	6,455	1,214	24	11	5,437	2,495	645	2,368	972
1961	16,204	6,713	1,389	13	6	4,912	2,347	665	1,980	935
1962	20,122	8,602	2,168	17	8	4,720	2,300	1,064	2,910	1,391
1963	22,807	9,784	2,675	22	11	5,717	2,968	[4] 552	2,089	1,038

[1] Does not include antimony contained in lead-silver ore.
[2] Estimated antimony content; for gross weight and value, see Lead chapter.
[3] 1957 data known to be not comparable with other years.
[4] Data not comparable with earlier years.

Source: Bureau of the Census.

WORLD REVIEW

Bolivia.—Production of antimony, mainly as antimony ore and to a minor extent as smelter products derived from smelting other ores, continued relatively stable in 1963. Empresa Minera Unificada, S.A., was the major contributor, but several other medium-sized mines had significant output. Numerous small mines operated on an erratic or part-time basis, with the Banco Minero de Bolivia acting as agent for the individual owners and operators.

Canada.—Antimony production decreased from about 970 tons in 1962 to 760 tons in 1963. The antimony recovered in the smelting of lead-silver ores by Consolidated Mining & Smelting Co. of Canada, Ltd., was used mainly in manufacture of lead-antimony alloys.

China.—Production of antimony in China has been estimated at 16,500 tons annually for several years and there is no information to indicate a change in production in 1963. Offerings of crude antimony on the European market were, however, sharply curtailed beginning in the first quarter of 1963. The resulting shortage of crude antimony and uncertainties surrounding output and exports significantly affected world antimony prices the last half of the year.

Mexico.—Antimony ore production from Mexican mines increased slightly and continued to be a major source of feed for the Laredo smelter of National Lead Co. Gross weight of ore exported to the United States increased slightly, but antimony content decreased compared with that of 1962.

TABLE 12.—World production of antimony (content of ore except as indicated), by countries [1]

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada [2]	768	829	826	666	966	763
Guatemala (U.S. imports)	[3] 31	97	119	71	32	31
Mexico [4]	4,510	3,622	4,664	3,978	5,257	5,320
United States	681	678	635	689	631	645
Total	6,000	5,226	6,244	5,404	6,886	6,759
South America:						
Argentina	8	4				
Bolivia (exports) [4]	6,027	6,065	5,872	7,430	7,331	8,337
Peru [4]	969	793	901	790	440	815
Total	7,004	6,862	6,773	8,220	7,771	9,152
Europe:						
Austria	471	631	676	668	767	548
Czechoslovakia [5]	1,800	1,800	1,800	1,800	1,800	1,800
France	80					
Greece	11					
Italy	290	231	236	277	369	270
Portugal	6	7				
Spain	205	180	243	190	175	93
U.S.S.R. [6]	5,700	6,100	6,300	6,300	6,600	6,700
Yugoslavia (metal)	1,820	2,514	2,657	2,715	2,966	2,933
Total [6]	10,400	11,500	11,900	12,000	12,700	12,300
Asia:						
Burma [4]	73	240	180	175	138	126
China [6]	14,000	16,500	16,500	16,500	16,500	16,500
Iran [7]	85	[6] 160	[6] 55			
Japan	408	340	299	215	190	212
Pakistan	[8] 95	119	69	15	85	[6] 85
Ryukyu Islands	[9] 8	26	159	112		
Thailand	30	11		36	49	686
Turkey	1,380	[10] 1,380	1,507	1,502	1,962	1,981
Total [6]	16,100	18,800	18,800	18,600	18,900	19,600
Africa:						
Algeria	1,893	1,658	886	720	149	
Morocco	477	252	358	406	449	756
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	120	104	100	68	61	66
South Africa, Republic of	11,957	13,619	13,538	11,804	11,697	12,410
Total	14,447	15,633	14,882	12,998	12,356	13,232
Oceania: Australia	423	703	172	132	74	[6] 77
World total (estimate) [1]	54,400	58,700	58,800	57,400	58,700	61,100

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Antimony content of smelter products exclusively from mixed ores.
[3] Average annual production 1957–58.
[4] Includes antimony content of smelter products derived from mixed ores.
[5] Estimate according to the annual issues of Minerais et Metaux (France), except 1963
[6] Estimate.
[7] Year ended March 20 of year following that stated.
[8] Average annual production 1956–58.
[9] Average annual production 1955–58.
[10] Exports.

South Africa, Republic of.—Consolidated Murchison (Transvaal) Goldfields & Development Co., Ltd., was the only producer and recovered antimony as a high-grade ore and also antimony concentrates from a gold-antimony ore deposit. Production was expanded in 1963 both as cobbed ore and mill concentrate, and total production of antimony in ore and concentrate increased from 11,700 tons to 12,400 tons. Activity was underway at yearend on mine development and further expansion of mill capacity, following successful exploration which had disclosed new ore bodies.

Thailand.—Production of antimony increased as the Bansang mine in south Thailand advanced from the development stage to a stable operation. The antimony potential in Thailand is receiving further attention, and production may reach 1,200 tons annually in comparison with the 49 tons reported in 1962.

Turkey.—A 200-ton-per-day combination quantity-flotation concentrator was placed in operation at Turhal, Turkey. This plant replaces direct reverberatory smelting of mixed antimony-arsenic ores and aims to produce a 65 percent antimony concentrate and two grades of hand-sorted lump ore ranging from 40 to 55 percent antimony.

TECHNOLOGY

A detailed report on investigations in metallography of bearing alloys was published in Poland,[2] an investigation of structure of antimony pentachloride compounds was accomplished in India,[3] and the electrode kinetics of antimony chloride were investigated.[4]

U.S. patents were issued relative to cyclic compounds of antimony [5] and to a process for purifying intermetallic binary antimonides.[6]

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[2] Kosovinc, Ivan. (Autoradiography by As^{76} in Metallography. The Distribution of Arsenic in Pb-Sn-Sb Bearing Alloys.) Rudarsko-Metallurski, Min. and Met. Quarterly (Warsaw, Poland), No. 2, 1962, pp. 141–150.

[3] Jain, S. R., and S. Soundaraeajan. Dipole Moments and Structure of Molecular Compounds of Antimony Pentachloride. Chem. and Ind. (London), No. 16, Apr. 20, 1963, pp. 652–653.

[4] Mayer, S. W., and W. E. Brown, Jr. Electrode Kinetics for Chlorides of Tungsten, Antimony, and Phosphorous. J. Electrochem. Soc., v. 110, No. 4, April 1963, pp. 306–311.

[5] Worsley, Michael, Bruce N. Wilson, and Blaine O. Schoepfle (assigned to Hooker Chemical Corp., Niagara Falls, N.Y.). Cyclic Compounds of Antimony and Bismuth. U.S. Pat. 3, 109,853, Nov. 5, 1963.

[6] Hulme, Kenneth Fraser, and John Brian Millin (assigned to National Research Development Corp., London). Process for Purifying Intermetallic Binary Antimonides Containing Zinc and Cadmium Impurities. U.S. Pat. 3,116,113, Dec. 31, 1963.

Arsenic

By Arnold M. Lansche [1]

PRODUCTION of white arsenic in the United States declined 4 percent in 1963. Shipments increased 23 percent and exceeded production by 17 percent. Stocks at yearend were down 24 percent.

Some arsenic compounds have been found capable of converting electric energy directly into infrared radiation.

TABLE 1.—Salient white arsenic statistics

(Short tons)

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Production	11,630	5,189	(1)	(1)	(1)	(1)
Shipments	13,158	7,239	(1)	(1)	(1)	(1)
Imports for consumption	7,630	19,386	12,825	19,483	15,758	14,559
Stocks Dec. 31: Producer	6,902	1,058	(1)	(1)	(1)	(1)
Consumption, apparent [2]	20,788	26,625	(1)	(1)	(1)	(1)
Price: Refined, carlots [3] cents per pound	5½	4-5	4-5	4	4	5.1
Free world: Production	41,800	[4] 46,800	[4] 57,300	[4] 55,200	[4] 53,900	53,200

[1] Figure withheld to avoid disclosing individual company confidential data.
[2] Producers' shipments, plus imports, minus exports; no exports were reported by producers, 1954-63.
[3] E&MJ Metal and Mineral Markets. Beginning with 1963, quoted in barrels, f.o.b., Laredo, Tex.
[4] Revised figure.

DOMESTIC PRODUCTION

Domestic production of white arsenic declined 4 percent in 1963. The entire output was derived as a byproduct of smelting arsenic-containing copper ores by The Anaconda Company at Anaconda, Mont., and American Smelting and Refining Company at Tacoma, Wash. Arsenic metal was not produced in 1963.

[1] Commodity specialist, Division of Minerals.

TABLE 2.—Production and shipments of white arsenic in the United States

Year	Crude			Refined			Total		
	Production (short tons) [1]	Shipments		Production (short tons)	Shipments		Production (short tons)	Shipments	
		Short tons	Value		Short tons	Value		Short tons	Value
1954–58 (average)	10,991	12,496	$515,244	639	662	$52,840	11,630	13,158	$568,084
1959	4,897	6,922	293,940	292	317	27,315	5,189	7,239	321,255
1960–63	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)

[1] Excludes crude consumed in making refined.
[2] Figure withheld to avoid disclosing individual company confidential data.

CONSUMPTION AND USES

In 1963 most of the white arsenic produced was consumed in manufacturing lead and calcium arsenate insecticides. Production of lead arsenate has ranged from 5,000 to 10,000 tons a year since 1951, compared with a peak of 45,000 tons in 1944. The downward trend has resulted from substitution of organic insecticides.

Arsenic compounds also were used in weedkillers, glass manufacture, cattle and sheepdips, dyestuffs, and wood preservatives. Minute quantities of arsenic compounds were used in masers and lasers. Apparent consumption of white arsenic increased 5 percent from 1962.

TABLE 3.—Production of arsenical insecticides and consumption of arsenic wood preservative in the United States

(Short tons)

Year	Production of insecticides [1]		Consumption of wood preservatives [2]		
	Lead arsenate (acid and basic)	Calcium arsenate (70 percent $Ca_3(AsO_4)_2$)	Wolman salts (25 percent sodium arsenate)	Other	Total
1954–58 (average)	6,901	6,354	1,041	779	1,820
1959	6,452	3,212	1,357	1,274	2,631
1960	5,031	3,295	1,275	1,150	2,425
1961	5,223	[3] 3,972	1,344	1,329	2,673
1962	4,965	2,330	1,358	1,758	3,116
1963	(4)	(4)	[5] 1,524	[5] 1,278	[5] 2,802

[1] Bureau of the Census, U.S. Department of Commerce.
[2] Forest Service, U.S. Department of Agriculture
[3] Revised figure.
[4] Data not available.
[5] Preliminary figure.

STOCKS

Stocks declined 24 percent because shipments of white arsenic increased 23 percent, and total new supply (production and imports for consumption) was about 1,700 tons less than in 1962.

PRICES

White arsenic was quoted at 5.1 cents a pound, in barrels, f.o.b., Laredo, Tex.; and at 4 cents a pound, in barrels, carlots, New York, N.Y., throughout 1963. The Oil, Paint and Drug Reporter quoted lead arsenate packed in 3- to 50-pound bags at 26 cents a pound and 1-pound bags at 36 cents a pound during the year.

The London price, quoted from the London Mining Journal and the London Mining Magazine, for white arsenic in 1963 was £40 to £45 a long ton (equivalent to 5.00 to 5.63 cents a pound) for 98 percent minimum purity; arsenic metal on the London market sold for £400 a long ton (50 cents a pound).

FOREIGN TRADE

Imports.—Imports for consumption of white arsenic totaled 14,600 tons, 8 percent less than in 1962. Mexico supplied 73 percent of the total imports with the remainder divided among France, about 14 percent, Sweden, about 12 percent, and Canada less than 1 percent.

Nearly all of the 169 tons of arsenic metal imported came from Sweden. Canada and the United Kingdom supplied small quantities. Belgium-Luxembourg supplied 18 tons of arsenic sulfide; France and the United Kingdom supplied 66 and 70 tons, respectively, of sodium arsenate; 10 tons of sheepdip came from Australia.

Exports.—No exports of white arsenic were reported. Calcium arsenate shipments totaled 93 tons valued at $17,610; Brazil, Israel, and Hong Kong received 22, 66, and 5 tons, respectively.

Exports of lead arsenate totaled 401 tons valued at $134,726. Colombia was the chief recipient with 160 tons, followed by Peru with 135, Costa Rica 38, Guatemala 34, and Canada 22. The remainder, in lots of less than 5 tons each, went to seven other countries.

Tariff.—White arsenic, arsenic sulfide, and sheepdip containing arsenic were duty free. The duty on arsenic acid remained at 3 cents a pound. The duty on metallic arsenic was continued at 2.5 cents a pound when other rates were changed on August 31, 1963; paris green was removed from the free list and the duty became 10.25 to 25 percent ad valorem; lead arsenate duty became 1.5 to 3.0 cents a pound; and compounds of arsenic not specified in the Tariff Act of 1930 were changed from a duty of 21.5 percent of their foreign market value to 10.5 to 25 percent ad valorem. The higher duties applied to Soviet Bloc countries.

TABLE 4.—U.S. imports for consumption of white arsenic (As_2O_3 content), by countries

Country	1954–58 (average)		1959		1960	
	Short tons	Value	Short tons	Value	Short tons	Value
North America:						
Canada	825	$64,781	607	$49,116	503	$40,249
Mexico	5,875	609,135	12,528	962,894	9,857	856,327
Total	6,700	673,916	13,135	1,012,010	10,360	896,576
Europe:						
France	463	18,741	3,504	153,336	2,252	129,724
Sweden	463	20,923	2,746	176,043	213	19,357
Other countries [1]	4	313	1	122	(2)	382
Total	930	39,977	6,251	329,501	2,465	149,463
Grand total	7,630	713,893	19,386	1,341,511	12,825	1,046,039

Country	1961		1962		1963	
	Short tons	Value	Short tons	Value	Short tons	Value
North America:						
Canada	192	$12,022			2	$264
Mexico	14,058	1,068,164	10,935	$799,097	10,641	811,643
Total	14,250	1,080,186	10,935	799,097	10,643	811,907
Europe:						
France	4,188	262,470	4,003	226,975	2,116	130,781
Sweden	1,042	74,406	804	49,666	1,800	115,767
Other countries [3]	3	4,654	16	783		
Total	5,233	341,530	4,823	277,424	3,916	246,548
Grand total	19,483	1,421,716	15,758	1,076,521	14,559	1,058,455

[1] Includes Poland-Danzig and United Kingdom.
[2] Negligible.
[3] Includes Netherlands and Portugal.

Source: Bureau of the Census.

TABLE 5.—U.S. imports and exports of arsenicals, by classes

(Pounds)

Class	1954–58 (average)	1959	1960	1961	1962	1963
Imports for consumption:						
White arsenic (As_2O_3 content)	15,260,471	38,771,199	25,649,095	38,966,394	31,515,599	29,117,679
Metallic arsenic	126,623	84,769	145,085	132,389	229,439	337,542
Sulfide	69,412	41,872	30,352	55,116	66,160	35,824
Sheepdip	46,969	116,785			14,765	19,656
Calcium arsenate	20,509		4,001			
Sodium arsenate	215,348	152,769	209,956	211,034	255,466	272,946
Exports:						
Calcium arsenate	1,708,690	122,920	289,700	669,932	942,399	186,577
Lead arsenate	1,533,909	1,398,900	1,888,149	928,797	1,422,795	802,664

Source: Bureau of the Census.

WORLD REVIEW

World production of white arsenic was estimated at 53,200 tons, about 1 percent less than in 1962. Sweden was the major producer of the arsenic compound. Output in Mexico and the United States declined about 3 and 4 percent, respectively.

Rhodesia and Nyasaland, Federation of.—A small white arsenic refining plant is to be built at Que Que, Southern Rhodesia, to serve the domestic market. The roasting plant at Que Que[2] in use since 1942 will be closed. White arsenic produced there was sold to African Explosives & Chemical Industries Ltd., and refined at the Rodia plant.

TABLE 6.—Free world production of white arsenic, by countries[1] [2]

(Short tons)

Country [1]	1954-58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	1,056	789	862	209	80	94
Mexico	3,467	11,536	13,372	13,537	12,000	[3] 11,700
United States	11,630	5,189	([4])	([4])	([4])	([4])
South America:						
Brazil	730	367	233	64	164	[3] 165
Peru	105	524	433	388	572	[3] 550
Europe:						
Belgium (exports)	2,028	3,161	([5])	([5])	([5])	([5])
France	6,523	8,842	9,200	10,500	10,300	[3] 11,000
Germany, West (exports)	326	180	110	150	75	[3] 65
Greece	22	11	[3] 11	[3] 3		
Italy	1,039	1,254	654	979	140	
Portugal	[6] 1,463	596	810	330	634	[3] 770
Spain	62	320	435	343	234	[3] 190
Sweden	10,969	12,300	12,950	12,153	[3] 12,100	[3] 12,100
Asia: Japan	1,656	1,185	1,247	1,047	[3] 1,100	[3] 1,100
Africa: Rhodesia and Nyasaland, Federation of: Southern Rhodesia	723	528	204		1,207	605
Free world total (estimate) [1] [2]	41,800	46,800	57,300	55,200	53,900	53,200

[1] Arsenic may be produced in Argentina, Austria, China, Czechoslovakia, East Germany, Finland, Hungary, U.S.S.R., and United Kingdom, but there is too little information to estimate production.
[2] This table incorporates a number of revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Figure withheld to avoid disclosing individual company confidential data; included in world total.
[5] Data not available; estimate included in the world total.
[6] Exports.

TECHNOLOGY

Arsenic in the form of an arsenide was investigated in 1962 and 1963 for use in the quantum electronic devices called masers and lasers.[3] Gallium arsenide, gallium arsenide phosphide, indium arsenide, and indium-gallium arsenide were used as diode components of masers and lasers. These devices are small, relatively simple in construction, and have a high efficiency in converting electrical energy into infrared radiation. The radiation output can be magnetically modulated.

[2] Mining Journal (London). Que Que Arsenic. V. 261, No. 6688, Oct. 25, 1963, p. 396.
[3] Product Engineering. V. 34, No. 19, Sept. 16, 1963, pp. 63–64.
Lax, Benjamin. Semiconductor Lasers. Science, v. 141, No. 3587, Sept. 27, 1963, pp. 1247–1255.

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Asbestos

By Timothy C. May [1]

PRODUCTION of asbestos in the United States increased 25 percent in 1963 over 1962 due chiefly to greater output from California mines. Despite this increase, the United States produced only 9 percent of its requirements, while consuming 23 percent of the world production. Canada continued to be the world's leading supplier with 40 percent of the total. The United States ranked sixth among world producers.

LEGISLATION AND GOVERNMENT PROGRAMS

The Office of Minerals Exploration (OME) offered financial assistance up to 50 percent of approved costs in approved exploratory programs for strategic grades of asbestos. No contract was made for asbestos in 1963.

Under the Agricultural Trade Development and Assistance Act of 1954 (Public Law 480, 83d Cong.) the Department of Agriculture through the Commodity Credit Corporation (CCC) bartered surplus agricultural commodities for amosite, chrysotile, and crocidolite asbestos. A total of 16,467 tons was acquired under the program in 1963, consisting of 8,003 tons of amosite, 513 tons of chrysotile, and 7,951 tons of crocidolite.

TABLE 1.—Salient asbestos statistics

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Production (sales) .... short tons..	44,227	45,459	45,223	52,814	53,190	66,606
Value .... thousands..	$4,794	$4,391	$4,231	$4,347	$4,677	$5,425
Imports for consumption (unmanufactured) .... short tons..	687,157	713,047	669,496	616,529	[1] 675,953	667,860
Value .... thousands..	$59,434	$65,006	$63,345	$58,942	[1] $64,112	$61,739
Exports (unmanufactured) short tons..	2,710	4,461	5,525	3,799	2,949	10,044
Value .... thousands..	$342	$793	$857	$759	$598	$1,304
Exports of asbestos products (value)[2] thousands..	$13,396	$12,921	$13,703	$13,825	$14,274	$16,315
Consumption, apparent [3] short tons..	728,674	754,045	709,194	665,544	[1] 726,194	724,422
World: Production .... do....	1,949,000	2,260,000	2,440,000	2,770,000	3,055,000	3,200,000

[1] Revised figure.
[2] Includes reexports.
[3] Measured by quantity produced, plus imports, minus exports.

[1] Commodity specialist, Division of Minerals.

DOMESTIC PRODUCTION

Asbestos production in the United States in 1963 showed a substantial increase over 1962. Production increased 25 percent in quantity and 16 percent in value compared with 1962. Most of the rise in quantity came from the California mines.

The largest producer of asbestos in the United States continued to be the Vermont Asbestos Mines Division of Ruberoid Co. which operates at Belvidere Mountain near Hyde Park, Vt. Second largest producer was Jefferson Lake Asbestos Corp., Calaveras County, Calif.

Production and shipments were reported by the following California companies: Jefferson Lake Asbestos Corp., Calaveras County; Atlas Mineral Corp. (new producer), and Coalinga Asbestos Co., Inc., Fresno County; Asbestos Bonding Co., Napa County; and Union Carbide Corp. (Nuclear Division), San Benito County.

Four companies reported shipments from mines in Gila County, Ariz.; Asbestos Manufacturing Co. (new producer), Jaquays Mining Corp., Metate Asbestos Corp., and Phillips Asbestos Mines. Pan American Fiber Corp. discontinued mining operations.

Amphibole asbestos was produced at the Burnsville mine of the Powhatan Mining Co., in Yancey County, N.C.

No asbestos was produced in Oregon in 1963.

Union Carbide Corp. commenced operation of its experimental pilot plant for processing asbestos fiber near King City, Calif.[2]

Western States Minerals Company announced discovery of an asbestos deposit in the Big Blue Hills area of western Fresno County. The company leased 720 acres of land in the area.

CONSUMPTION AND USES

Total consumption of asbestos was 724,000 tons in 1963 compared with 726,000 tons in 1962. The consumption of chrysotile represented 96 percent of the total U.S. consumption of asbestos. Domestic mines supplied 11 percent of short fiber chrysotile consumed. Amosite consumption, represented by imports, was 22,000 tons compared with 20,000 tons in 1962, and crocidolite consumption decreased to 11,000 tons from 17,000 tons in 1962.

STOCKS

Strategic stockpile inventories on December 31, 1963, were as follows: Amosite, 11,705 tons; chrysotile, 6,224 tons; crocidolite (soft), 1,567 tons. Supplemental and CCC stockpiles consisted of the following: Amosite, 28,600 tons; chrysotile, 2,852 tons; crocidolite, 27,437 tons. Also, 2,348 tons of non-stockpile-grade chrysotile was held in the Defense Production Act stockpile and 3,193 tons in the supplemental stockpile. Maximum objectives remained at 45,000 tons for amosite and 11,000 tons for chrysotile. No objective was set for crocidolite. The total acquisition cost for stockpile-grade amosite was $9,724,100 and for chrysotile, $5,215,500.

[2] Mining World. Union Carbide Building Pilot Plant for Asbestos Production. V. 25, No. 3, March 1963, pp. 38–39.

PRICES

Market quotations for Canadian (Quebec and British Columbia) chrysotile, f.o.b. mine, and United States (Vermont) chrysotile f.o.b. Hyde Park or Morrisville, remained unchanged from prices listed for 1962. Arizona chrysotile quotations remained the same in 1963 as in 1962 except for Group No. 5, which increased from a range of $225 to $375 in 1962 to $250 to $400 in 1963.

Market quotations were not available for African, Australian, and South American asbestos because sales were negotiated separately. U.S. Department of Commerce reports show the following figures for imports in 1962 and 1963, per short ton:

	Per short ton	
Imports:	*1962*	*1963*
Amosite: South Africa	$164	$158
Crocidolite:		
Australia	201	190
South Africa, Republic of	221	212

FOREIGN TRADE

Total imports of asbestos were 1 percent less than in 1962. Imports of amosite increased 5 percent, crocidolite decreased 35 percent, and chrysotile decreased 1 percent compared with 1962.

Imports of low-iron spinning-length chrysotile from British Columbia, Canada decreased from 5,077 tons in 1962 to 4,698 tons and imports of all grades of fiber increased from 12,930 tons to 14,088 in 1963. Ninety-seven percent of the total chrysotile imported was fiber of less than spinning length.

Imports from Australia consisted of crocidolite. The Republic of South Africa was the only source of amosite, and it supplied both crocidolite and chrysotile. Only chrysotile was imported from other countries.

Exports of unmanufactured asbestos rose to 10,000 short tons compared with 3,000 tons in 1962.

TABLE 2.—U.S. imports for consumption of asbestos (unmanufactured), by classes and countries

Year and country	Crude (including blue fiber)		Textile fiber [1]		All other		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1962:								
North America: Canada	[2] 238	$55,411	14,816	$5,875,484	608,757	$49,003,906	[2] 623,811	$54,934,801
South America: Bolivia [3]	1	300					1	300
Europe:								
Finland					440	18,150	440	18,150
Italy [1]	9	10,585			28	5,123	37	15,708
Portugal [1]					23	2,374	23	2,374
Yugoslavia	3,444	119,614			11	542	3,455	120,156
Africa:								
Rhodesia and Nyasaland, Federation of [1] [4]	[2] 4,091	[2] 821,144			1,908	366,056	[2] 5,999	[2] 1,187,200
South Africa, Republic of [1]	30,250	5,514,426			4,412	803,274	34,662	6,317,700
Oceania: Australia	7,525	1,515,323					7,525	1,515,323
Total	[2] 45,558	[2] 8,036,803	14,816	5,875,484	615,579	50,199,425	[2] 675,953	[2] 64,111,712
1963:								
North America: Canada	470	89,017	13,852	5,216,206	604,420	48,706,010	618,742	54,011,233
Europe:								
Finland	55	2,000			398	22,246	453	24,246
Italy [1]	6	7,525					6	7,525
Portugal [1]					29	3,193	29	3,193
Yugoslavia	6,331	215,955			1,177	45,224	7,508	261,179
Africa:								
Portuguese Western Africa, n.e.c.					20	2,601	20	2,601
Rhodesia and Nyasaland, Federation of [1] [4]	2,328	449,231	330	143,117	1,480	303,897	4,138	896,245
South Africa, Republic of [1]	33,172	5,830,022	136	27,845	3,646	673,044	36,954	6,530,911
Oceania: Australia	10	1,896					10	1,896
Total	42,372	6,595,646	14,318	5,387,168	611,170	49,756,215	667,860	61,739,029

[1] Data reported by the Bureau of the Census have been adjusted by the Bureau of Mines.
[2] Revised figure.
[3] Reported by the Bureau of the Census as Chile.
[4] All believed to be from Southern Rhodesia.

Source: Bureau of the Census.

TABLE 3.—U.S. imports for consumption of asbestos, from specified countries, by grades

(Short tons)

Grade	1962			1963		
	Canada	Southern Rhodesia [1]	Republic of South Africa [2]	Canada	Southern Rhodesia [1]	Republic of South Africa [2]
Chrysotile:						
Crudes	[3] 238	[3] 4,091	413	470	2,188	452
Spinning or textile	14,816			13,852	330	136
All other	608,757	1,908	4,412	604,420	1,480	3,646
Crocidolite (blue)			9,602		140	10,776
Amosite	(4)		20,235			21,944
Total	[3] 623,811	[3] 5,999	34,662	618,742	4,138	36,954

[1] Reported by the Bureau of the Census as Federation of Rhodesia and Nyasaland. Believed to be from Southern Rhodesia. Excludes data adjusted by the Bureau of Mines.
[2] Includes data adjusted by the Bureau of Mines.
[3] Revised figure.
[4] Excludes data adjusted by the Bureau of Mines.

Source: Bureau of the Census.

TABLE 4.—U.S. exports[1] and reexports[2] of asbestos and asbestos products

Product	1962		1963	
	Quantity	Value	Quantity	Value
Exports:				
Unmanufactured:				
Crude and spinning fibers ....short tons..	655	$162,130	847	$228,666
Nonspinning fibers ....do....	968	204,797	3,169	506,725
Waste and refuse ....do....	1,201	211,456	5,962	553,272
Total unmanufactured ....do....	2,824	578,383	9,978	1,288,663
Products:				
Brake lining and blocks-molded, semimolded, and woven	(3)	4,645,844	(3)	4,888,141
Clutch facing and lining ....number..	2,277,461	1,561,659	2,519,467	1,760,767
Construction materials, n.e.c. ....short tons..	9,064	2,343,404	13,469	3,355,256
Pipe covering and cement ....do....	2,890	1,242,752	4,100	1,607,754
Textiles, yarn, and packing ....do....	1,453	3,311,355	1,496	3,499,384
Manufactures, n.e.c.	(4)	1,164,908	(4)	1,183,752
Total products	----------	14,269,922	----------	16,295,054
Reexports:				
Unmanufactured:				
Crude and spinning fibers ....short tons..	95	14,193	66	14,651
Waste and refuse ....do....	30	5,437	----------	----------
Total unmanufactured ....do....	125	19,630	66	14,651
Products:				
Brake lining and blocks-molded, semimolded, and woven	(3)	1,905	----------	----------
Construction materials, n.e.c. ....short tons..	7	1,756	28	10,637
Pipe covering and cement ....do....	----------	----------	(5)	5,670
Manufactures, n.e.c.	----------	----------	(4)	3,800
Total products	----------	3,661	----------	20,107

1 Materials of domestic origin, or foreign material that has been milled, blended, or otherwise processed in the United States.
2 Material that has been imported and later exported without change.
3 Values have been summarized; quantities not shown.
4 Quantity not recorded.
5 Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW[3]

NORTH AMERICA

Canada.—Canada has maintained its position as the major supplier of asbestos to the world market. For the fifth successive year, the industry set a production record. During 1963 1.27 million tons was shipped, an increase of 5 percent over 1962. Almost all of the Canadian production is expected and in 1963, over 50 percent was shipped to the United States.

Golden Age Mines granted a working option to Falconbridge Nickel Mines, Ltd., to explore the property of its subsidiary, Kingsbury Asbestos Mines, Ltd. The ground consists of 2,000 acres in Melbourne Township, about 8 miles from the Johns-Manville Corp. operation at Asbestos, Quebec. It is reported that some 15 million tons havê been indicated grading $7 per ton, with values predominantly in Group 5 fiber.[4]

3 Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
4 Northern Miner (Toronto). Golden Age Deals With Falconbridge on Asbestos Group. No. 19, Aug. 1, 1963, p. 3.

TABLE 5.—World production of asbestos by countries [1] [2]
(Short tons)

Country [1]	1954-58 (average)	1959	1960	1961	1962	1963
North America:						
Canada (sales)	994,716	1,050,429	1,118,456	1,173,695	1,215,814	1,272,024
United States (sold or used by producers)	44,227	45,459	45,223	52,814	53,190	66,606
Total	1,038,942	1,095,888	1,163,679	1,226,509	1,269,004	1,338,630
South America:						
Argentina	477	320	----	----	----	----
Bolivia (exports)	43	168	66	57	56	10
Brazil	3,230	[3] [4] 3,700	[3] [4] 3,900	[3] [4] 3,400	[3] [4] 4,900	[5] 1,440
Venezuela	5,016	5,095	4,333	650	----	----
Total	8,766	9,283	8,299	[3] 4,100	[3] 5,000	1,450
Europe:						
Austria	----	----	215	564	503	638
Bulgaria	1,168	1,100	1,200	1,200	[3] 1,100	[3] 1,100
Finland [6]	8,759	9,579	10,534	10,339	10,869	10,201
France	15,505	23,360	28,662	30,746	28,000	26,455
Italy	36,872	52,538	60,532	62,816	61,233	63,418
Portugal	56	40	144	21	----	----
Spain	35	19	4	11	----	----
U.S.S.R.[3]	475,000	600,000	660,000	880,000	1,100,000	1,200,000
Yugoslavia	4,829	4,748	5,970	6,709	7,401	9,074
Total [3]	540,000	690,000	770,000	990,000	1,210,000	1,310,000
Asia:						
China [3]	33,000	90,000	90,000	100,000	100,000	110,000
Cyprus	15,502	14,424	23,316	16,207	22,391	[3] 22,000
India	1,321	1,464	1,886	1,618	1,705	2,989
Japan	629	13,633	17,042	18,799	15,407	18,210
Korea, Republic of	95	88	740	341	1,333	2,037
Philippines	----	56	36	83	1,037	[3] 1,100
Taiwan	200	150	485	44	525	604
Turkey	375	411	238	496	709	408
Total [3]	60,000	120,000	135,000	138,000	143,000	157,000
Africa:						
Bechuanaland	1,528	1,410	1,282	1,924	2,375	2,368
Kenya	155	43	117	151	212	78
Morocco	348	----	----	----	----	----
Mozambique	209	37	22	162	370	[3] 370
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	112,691	119,699	133,963	161,610	142,196	142,254
South Africa, Republic of	139,697	182,405	175,867	194,834	221,302	205,744
Swaziland	29,724	24,806	32,027	30,792	32,830	33,350
United Arab Republic (Egypt)	101	502	496	254	606	192
Total	284,453	328,902	343,774	389,726	399,890	384,356
Oceania:						
Australia	10,245	17,875	15,613	16,746	18,392	[3] 15,000
New Zealand	245	640	319	373	457	439
Total	10,490	18,515	15,932	17,119	18,849	[3] 15,440
World total (estimate) [1] [2]	1,940,000	2,260,000	2,440,000	2,770,000	3,055,000	3,200,000

[1] Asbestos also is produced in Czechoslovakia, Eritrea, North Korea, and Rumania. No estimates for these countries are included in the total, as production is believed to be negligible.
[2] This table incorporates some revisions. Data do not add to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Revised data represents fiber.
[5] Bahia only.
[6] Includes asbestos flour.

Most of Quebec's chrysotile asbestos production was derived from 12 mining and milling operations in the eastern area of the Province; 8 of the mines are open pits, 2 are almost entirely underground, and 2 combine underground and open pit mining. The Jeffrey mine at Asbestos is the largest, handling 30,000 tons per day of ore.[5]

A comprehensive report on industrial engineering at the Jeffrey mine was presented in three parts: Part I.—Department responsibilities and techniques; part II.—An outline of wage incentives; and part III.—Maintenance control plan.[6]

TABLE 6.—Canada: Sales of asbestos by grades

Grades	1962			1963		
	Short tons	Value		Short tons	Value	
		Total (thousands)	Average per ton		Total (thousands)	Average per ton
Crude No. 1, 2, and other	205	$159	$776	[1] 1,272,024	$124,806	$98
Milled group:						
3	30,374	11,268	371			
4	355,121	59,030	176			
5	161,952	18,233	113			
6	209,572	15,626	75			
7	451,521	16,089	36			
8	7,069	146	21			
Total, all grades	1,215,814	120,551	99	[1] 1,272,024	124,806	98

[1] Breakdown by grades not available.

Source: Dominion Bureau of Statistics.

Hedman Mines Ltd. continued to operate its pilot plant at Matheson, northern Ontario, to conduct further research on its process and to produce test shipments of its asbestos fiber for use in experimental work by potential consumers. The pilot plant includes complete laboratory facilities, capable of carrying out all normal asbestos testing. A production-scale plant has been designed and a plant site has been acquired adjacent to Matheson. The initial stage of the plant is designed for a product capacity of 100 tons per day.[7]

Canadian Johns-Manville Co., Ltd., announced plans to develop an asbestos deposit in Reeves Township, 40 miles southwest of Timmins. A development shaft is planned to open two underground levels to provide bulk samples for pilot plant processing. The deposit was acquired by the company several years ago and is expected to provide a source of fiber to supplement the output of Munro mine, east of Matheson in northern Ontario.[8]

The Asbestos Hill deposit in the Ungava district, 30 miles south of Deception Bay on Hudson Straits, discovered by the Murray Mining Corp., was held under option by the Asbestos Corporation, Ltd. Under the option agreement, $1 million has been spent in exploring the deposit and the Asbestos Corporation planned to spend an additional $500,000 up to April 1, 1964 on further exploration

[5] Gartshore, J. L. Quebec Asbestos Mining and Milling. Canadian Min. and Met. Bull. (Montreal), v. 55, No. 602, June 1962, pp. 400–402.

[6] Fletcher, J. M., R. H. McDougall, and A. R. Dennis. Industrial Engineering at the Jeffrey Mine. Canadian Min. and Met. Bull. (Montreal), v. 56, No. 616, August 1963, pp. 645–656.

[7] Northern Miner (Toronto). Hedman Pilot Plant Producing Asbestos for Test Purposes. No. 18, July 25, 1963, pp. 13, 18.

[8] Woodrooffe, H. M. Asbestos. Canadian Min. J., v. 85, No. 2, Feb. 1, 1964, pp. 125–126.

and feasibility studies. The ore reserve was estimated at 23.8 million tons with additional reserves indicated.[9]

Advocate Mines Ltd., near Baie Verte, Newfoundland, Canada's newest asbestos producer, reached capacity of 5,000 tons per day of asbestos ore. At this rate Advocate expects to produce 60,000 tons per year of asbestos fiber. The $25 million project has been financed by Johns-Manville (49.62 percent), The Patino Mining Corp. of Canada (17.3 percent), and Amvet Corp. and Financière Belge De L'Abeste-Ciment (16.54 percent each). Proven ore reserves total about 41.3 million tons, averaging 3.5 percent Group 4 fiber. Recovery of fiber as low as Group 6 is seen, with "short" Group 7 fiber discarded as waste. Advocate's concession covers about 750 square miles, of which only a small portion has been tested.[10]

Production capacity at Cassiar Asbestos Corp., Ltd., increased in 1963 with opening of several new mines producing principally asbestos-cement-grade fiber. During the year the mine produced 756,574 tons of ore of which 597,202 tons was treated in the rock rejection circuit to eliminate 219,825 tons of rock. Stripping operations removed from the pit and peak 2,824,197 tons of waste rock. Ore and concentrate milled totaled 588,733 tons. Production of asbestos fiber amounted to 62,214 tons, an increase of 8 percent over 1962 production.[11]

With a view to improving its market position, Cassiar will introduce two new asbestos-cement grades. Cassiar AD will be a premium-grade asbestos-cement fiber which will replace in part production of AC and other grades now produced, but will not increase total fiber output. In addition, the mill will be expanded to recover a new cement grade, tentatively named Cassiar AY. The new grade will be of shorter length than now produced at Cassiar and will sell at a price below the AX grade. Production of the AY grade will be principally from material now discarded and will represent additional recovery from the ore treated. During the year a magnetometer survey was carried out at the Clinton Creek asbestos property, west of Dawson, Yukon Territory. Limited followup drilling has indicated an extension of the ore body where approximately 7 million tons of ore was developed previously.[12]

Mexico.—Exploration was underway on a large asbestos deposit in the state of Tamaulipas, northeast of Mexico City. National Financira, a Government lending institution, is sponsoring the project. The deposit has been known to exist for many years but it was never measured. A pilot plant designed to determine the different types of fiber is under construction at the site.[13]

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[9] Bank of Nova Scotia (Toronto). Resource and Industrial Development in Canada, Annual Summary. Sept. 18, 1963.
Northern Miner (Toronto). Asbestos Corp. Taking Long Look at Murray Mining. No. 2, Apr. 4, 1963, p. 24.

[10] Engineering and Mining Journal. Advocate To Treat 5,000 tpd of Asbestos Ore. V. 164, No. 10, October 1963, p. 114.

[11] Cassiar Asbestos Corporation, Limited (Toronto). Twelfth Annual Report, Dec. 31, 1963, p. 4.

[12] Northern Miner (Toronto). Cassiar Asbestos Holds Profits. No. 39, Dec. 19, 1963, pp. 1–2.

[13] Engineering and Mining Journal. V. 164, No. 5, May 1963, p. 152.

EUROPE

Greece.—A new company, Greek Asbestos Manufacturing Co., Ltd., has been formed to build and operate an asbestos plant expected to be completed by mid-1964.[14]

Ireland.—Canadian Johns-Manville will search for abestos in cooperation with Northern Canada Mines, Ltd., which already holds prospecting rights to an area of about 11 square miles in Counties Sligo and Leitrim. Exploratory work has been carried on and chrysotile fiber has been found. The program will continue on a basis of 49 percent Northern Canada and 51 percent Canadian Johns-Manville.[15]

Portugal.—The Portuguese company CIMIANTO (Sociedade Tecnica de Hidráulica), manufacturers of fibro-cement products and users of Canadian asbestos, is setting up a new factory near Valencia, Spain.[16]

ASIA

Cyprus.—Exports of asbestos in 1962 totaled 15,544 short tons valued at $2,247,000 compared with 17,702 tons with a value of $2,596,000 in 1961.[17] Approximately 50 percent of the ore mined is treated in the mills and recovery is more than 0.7 to 0.8 ton of asbestos per 100 tons mined or 1.4 to 1.6 percent of the ore milled.[18]

India.—During 1962 imports of asbestos amounted to 24,660 short tons valued at $4,889,000 compared with 21,679 tons valued at $4,927,000 in 1961.

AFRICA

Nigeria.—A new asbestos-cement factory near Enugu, capital of Eastern Nigeria, began production of roofing sheets. Manufacture of cement pipe was to commence later. The factory was operated by Turner Asbestos Cement Products (Nigeria) Ltd., and was a joint enterprise of Turner & Newall Ltd., group and the Eastern Nigerian Government.[19]

Rhodesia and Nyasaland, Federation of.—Production of chrysotile asbestos was 142,254 short tons compared with 142,196 short tons in 1962. Exports of crude asbestos in 1962 totaled 145,414 tons valued at $21,377,000. The United Kingdom, the traditional market, took more than half of the total exported; the remainder was shipped to 40 other countries.[20]

The new $4.2 million Pangani Asbestos mine at Filabusi, Southern Rhodesia was officially opened on August 9. It will be developed in three stages. In the first, 10,000 tons of fiber per year will be produced. In the last two stages production will be boosted to 30,000 tons per year. Mining will be mainly open pit, which requires re-

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[14] Mining Journal (London). Greek Asbestos Venture. V. 260, No. 6667, May 31, 1963, p. 546.

[15] Engineering and Mining Journal. Canadian Firms Hunt Asbestos in Ireland. V. 164, No. 10, October 1963, p. 154.

[16] Foreign Trade (Ottawa). Fibro-Cement. V. 118, No. 4, Aug. 25, 1962, p. 25.

[17] Republic of Cyprus (Nicosia). Statistics of Imports and Exports for Year Ending 31 December 1962. Department of Statistics and Research, Ministry of Finance, October 1963, p. 47.

[18] Mining World. V. 25, No. 5, Apr. 25, 1963, p. 107.

[19] Rock Products. Asbestos. V. 66, No. 11, November 1963, p. 127.

[20] Bureau of Mines. Mineral Trade Notes. V. 57, No. 3, September 1963, p. 8.

moval of 4.5 million tons of overburden before recovery can begin. Asbestos Investments (Pty.) Ltd., is the parent company of Pangani Asbestos Mine Ltd.[21]

TABLE 7.—Southern Rhodesia: Asbestos production

Year	Short tons	Value (thousands)	Year	Short tons	Value (thousands)
1959	119,699	$20,735	1962	142,196	$20,467
1960	133,963	20,888	1963	142,254	16,791
1961	161,610	24,453			

South Africa, Republic of.—Exports of the various varieties of asbestos by countries for 1961 and 1962 were published. The United Kingdom and the United States were the principal markets for amosite in 1962; the United States and Italy were the leading purchasers of crocidolite; Spain and Australia took the major portion of chrysotile exports.[22]

Cape Asbestos S.A. (Pty.), Ltd. announced steps were taken to increase underground drilling capacity at the Penge mine where 90 percent of the world's output of amosite is obtained. Increased power for underground drilling has been obtained as a result of the installation of the first automatic remotely controlled air compressor.[23]

TABLE 8.—Republic of South Africa: Asbestos production, by varieties and sources

(Short tons)

Variety and source	1959	1960	1961	1962	1963
Amosite (Transvaal)	71,720	68,630	69,234	74,883	77,618
Chrysotile (Transvaal)	29,326	29,471	31,726	29,993	28,928
Blue (Transvaal)	13,113	11,185	11,176	14,296	11,205
Blue (Cape)	68,024	66,567	82,624	102,034	87,965
Tremolite (Transvaal)	222	14	74	96	28
Total	182,405	175,867	194,834	221,302	205,744

TABLE 9.—Republic of South Africa: Production and exports of asbestos

Year	Production (short tons)			Exports	
	Transvaal	Cape Province	Total	Short tons	Value (thousands)
1959	114,381	68,024	182,405	151,515	$25,971
1960	109,300	66,567	175,867	174,810	28,965
1961	112,210	82,624	194,834	180,684	29,830
1962	119,268	102,034	221,302	184,170	30,787
1963	117,779	87,965	205,744	183,861	29,908

Turners Asbestos Products, Ltd., announced the production of asbestos roofing sheets at its new factory at Mobeni, near Durban. The plant will manufacture about 2,000 sheets per day.[24]

[21] E&MJ Metal and Mineral Markets. Southern Rhodesia Asbestos Mine Opened. V. 34, No. 33, Aug. 19, 1963, p. 7.
[22] Bureau of Mines. Mineral Trade Notes. V. 57, No. 6, December 1963, pp. 7–10.
[23] South Africa Mining & Engineering Journal (Johannesburg). Penge Steps Up Amosite Production. V. 74, No. 3670, June 7, 1963, pp. 17–18.
[24] South African Mining & Engineering Journal (Johannesburg). Asbetsos Roofing Plant Begins Production. V. 74, No. 3650, Jan. 18, 1963, p. 143.

Swaziland.—The Havelock mine, controlled by Turner-Newall, Ltd., has modernized its mill and a 1,200-foot vertical shaft neared completion. Havelock owns 100 claims on mineral concession No. 41 and has undertaken a detailed survey and exploration program on the concession.[25]

OCEANIA

Australia.—Production in 1962 consisted of 901 short tons of chrysotile and 17,491 tons of crocidolite.

A new company was installing an asbestos treatment plant at Marble Bar, Western Australia. The asbestos deposits cover a 90-mile radius of Marble Bar.[26]

TECHNOLOGY

A report by the Geological Survey describes the geology and mineral resources of the upper Missisquoi Valley and vicinity, Vermont, an area in which 80 percent of the asbestos produced in the United States has been mined. The history and development of the asbestos deposits are described; a geologic map and structure sections of the area are included.[27]

The Fiber Testing Committee of the Asbestos Textile Institute issued its initial publication on test procedures and techniques for the evaluation of asbestos fiber characteristics and properties. Nineteen test procedures are included.[28]

The asbestos fiber laboratory recently completed at Trafford Park, Manchester, England, by Turner and Newall, Ltd., is devoted to fundamental research on asbestos fibers. Serving a group of companies which mine asbestos and manufacture it into different forms, effort is concentrated on problems basic to the material so that the research staffs of the unit companies can concentrate on product development such as classification equipment. A classifier developed by the company sorts milled asbestos into given fiber lengths. The fiber sample is dispersed in water and then passes downwards through a series of vessels containing progressively smaller mesh screens. By the rapid migration of shorter elements into the lower vessels, fibers are classified by length to give the precise breakdown important to the producers and users of fibers. The elutriator which classifies fibers according to diameter, thus making possible an estimate of the degree of subdivision of any sample, consists of two vessels in each of which fibers of small diameter are carried upwards by a current of water, larger diameters remaining behind. Progressive separation is obtained by the smaller flow velocity in the second vessel.[29]

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[25] South African Mining & Engineering Journal (Johannesburg). Swaziland Mineral Prospects Must Be Regarded as Bright. V. 74, No. 3653, Feb. 8, 1963, p. 307.
[26] Engineering and Mining Journal. V. 164, No. 8, August 1963, p. 182.
[27] Cady, W. M., A. L. Albee, and A. H. Chidester. Bedrock Geology and Asbestos Deposits of the Upper Missisquoi Valley and Vicinity, Vermont. Geol. Survey Bull. 1122–B, 1963, 78 pp.
[28] Asbestos. V. 44, No. 8, February 1963, p. 4.
[29] Mining Journal (London). V. 260, No. 6656, Mar. 15, 1963, pp. 253, 255.

Past, present, and probable future methods of testing and classifying various grades of commercial asbestos produced by the Quebec asbestos industry were reviewed.[30]

Use of asbestos-reinforced plastics in nose cones and solid motor chambers of rockets was mentioned. Research at the Taylor Corporation, Valley Forge, Pa., indicates other types of asbestos reinforcing may out-perform the long fiber material in many applications.[31]

A study was made of reactions of chrysotile at temperatures and pressures higher than those used in making asbestos-cement products.[32]

Amosite mining at Penge mine in Eastern Transvaal, Republic of South Africa was reviewed. Amosite seams occur in banked ironstones of dolomite series of Transvaal system and the ore is produced from semishrinkage stopes operated on "herring-bone" system.[33]

Investigations were made into the possibilities of making paper from chrysotile, amosite, and crocidolite.[34]

Investigations were made into basic properties and nature of asbestiform materials. Studies include cleavability of asbestos and crystal structure of chrysotile; particle-size analysis and selective physiochemical methods of separating chemically similar particles; and tensile strength and elasticity of different varieties of asbestos.[35]

Deposits of chrysotile asbestos that have been developed or extensively explored in California since 1959 were discussed. Names of companies that filed claims in the Copperopolis and Napa areas are mentioned. Included is a map of California showing principal asbestos deposits and an index map to asbestos deposits and mills in the vicinity of Coalinga, Fresno County.[36]

Sheet packing for gaskets to be used in contact with steam, water, petroleum oils, and refinery gas has been developed from asbestos fibers bonded under pressure with styrene-butadiene rubber compounds.[37]

Research indicates that chemical resistance of asbestos-cement pipe is determined by the chemical resistance of the cement paste. Data also provide support for the adoption of the uncombined calcium hydroxide test and limits on the calcium hydroxide content in the specifications for asbestos-cement pipe to ensure that the product has maximum chemical stability and will resist satisfactorily the chemical action normally encountered in field service.[38]

Development of four asbestos-resin materials were announced: (1) Asbestos-resin felts to meet weight requirements for missiles and aerospace vehicles. They are composed of long, spinning-grade asbestos fibers and resins. The basic advantages claimed for these products

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[30] Wiser, J. P. Asbestos Industry Testing and Quality Control. Canadian Min. and Met. Bull. (Montreal), v. 55, No. 602, June 1962, pp. 403–405.

[31] Douglas, B. F. Research Uncovers Asbestos Potential. Missiles and Rockets, v. 12, No. 3, Jan. 21, 1963, pp. 31–32.

[32] Ball, M. C., and H. F. W. Taylor. X-ray Study of Some Reactions of Chrysotile. J. Appl. Chem., v. 13, No. 4, April 1963, pp. 145–150.

[33] Mine and Quarry Engineering. Asbestos Mining at Penge. V. 29, No. 3, March 1963, pp. 126–129.

[34] Mining Journal (London). Asbestos Ores for Paper Making. V. 260, No. 6648, Jan. 18, 1963, p. 61.

[35] South African Mining & Engineering Journal (Johannesburg). Growing Uses of Asbestos Coupled With New Research Organization. V. 74, No. 3661, Apr. 5, 1963, pp. 765–766.

[36] Rice, Salem J. California Asbestos Industry. California Division of Mines and Geol., Min. Inf. Serv., v. 16, No. 9, September 1963, 11 pp.

[37] Materials in Design Engineering V. 58, No. 6, November 1963, p. 155.

[38] Materials Research and Standards. V. 3, No. 9, November 1963, pp. 918–922.

are resistance to heat, flames, chemicals and water; high elasticity and strength modulus at room or elevated temperatures; and dimensional stability; (2) wet asbestos-phenolic compound recommended for molding techniques; (3) an asbestos reinforced plastic for insulating areas of aerospace vehicles where rapid changes in temperature occur; and (4) a combination plastic-elastomeric tube is claimed to be resistant to most corrosive chemicals to 160° F.[39]

Sprayed asbestos provides protection against fire for road tankers which carry ethylene oxide or propylene oxide, both at ambient temperature. The asbestos fiber and cement mixture is applied in a spray with jets of atomized water and then lightly pressed back with a float to the required density and thickness. The range of thickness is from 1/4 inch to 6 inches.[40]

A new application of molded asbestos cement was found in the construction of high cooling tower fan stacks.[41]

A method is presented for the microscopic examination of asbestos-cement products. The use of petrographic thin sections and polished sections in determining composition, texture, grain size, and cement-silica reaction is described. The preparation of thin sections and polished sections, using epoxy resin as an impregnant is outlined.[42]

Considerable information was presented in the Canadian Institute of Mining Transactions on the application of asbestos fibers in the major product groups of the construction industry in North America. Principal categories considered include flooring materials, asbestos-cement pipes and building products, high temperature insulation, textiles, saturated asbestos felts, and asphalt compounds. The use of short-fiber asbestos grades for extending the life of asphalt pavement was described.[43]

New Hampshire specified that all asphalt curbing must contain 2.5 percent asbestos. According to Johns-Manville engineers, incorporation of asbestos fiber in curbing mixes eliminates such problems as excessive slumping, tearing, and slow rate of replacement. The addition of 2.5 percent asbestos fiber has allowed an increase in asphalt contents from 6.5 percent to as much as 8 percent and placing temperatures from 250° to 340° F. At these levels curbing has been placed at rates of more than 4 feet per minute without tearing or slumping, and with no waste. Costs in New Hampshire are reported to be $1 per foot, or less.[44]

Three new grades of asbestos-rubber gasketing materials have been introduced for us in oil and water hydraulic systems. Three levels of compressibility (under 5,000 psi) are offered by the materials: Duroid 3390 has 40 percent, Duroid 3380 has 30 percent, and Duroid 3370, 25 percent.[45]

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[39] Industrial and Engineering Chemistry. Raybestos-Manhattan, Inc. Reinforced Plastics Dept. V. 55, No. 9, September 1963, p. 132.

[40] Chemical Age (London). New I.C.I. Tankers Have Asbestos Fire Protection. V. 90, No. 2306, September 1963, p. 399.

[41] Steel and Coal (London). New Application of Asbestos Cement at Steel Works. V. 186, No. 4939, March 1963, p. 52.

[42] Bailey, Donald. Microscopy of Steam-Cured Portland Cement Products. J. Am. Ceram. Soc., v. 46, No. 7, July 1963, pp. 348–351.

[43] Montpetit, L. D. Asbestos in the Construction Industry. Canadian Min. and Met. Bull. (Montreal), v. 56, No. 617, September 1963, pp. 737–742.

[44] Engineering News Record. Asphalt-Asbestos Curbs Gain. V. 171, No. 3, July 18, 1963, p. 56.

[45] Materials in Design Engineering. What's New in Materials. V. 57, No. 2, February 1963, p. 162.

A sulfur-free gasket material has been developed from neoprene filled with long chrysotile asbestos fibers. When used with flanges of copper, magnesium, aluminum, or steel, the material is said to be completely corrosion resistant. The gasketing material has good flexibility; it can be bent around four times its own thickness without cracking. In addition, the material withstands synthetic and petroleum oils and fuels.[46]

A new plywood product called Fyretech 100, has been developed by a Jamaica, N.Y., firm. Layers of light asbestos foam separate natural wood veneer; the panels are three-fourths of an inch thick and easy to shape and nail.[47]

Investigations into the possibilities of making paper from inorganic fibers have recently been undertaken by the Departmet of Engineering, University of Florida, Gainesville, Fla., and among the materials studied for use in this field have been the various asbestos ores such as chrysotile, amosite, and crocidolite. Paper made from inorganic fibers is used extensively as an electrical insulator where high ambient temperatures are encountered. Prior to World War II high-grade chrysotile asbestos fibers by themselves had been used for these special-purpose papers.[48]

Low density asbestos-phenolic molding mat has been developed for lightweight thermal shielding. The material, designated 383, is composed of unbonded felt containing 100 percent ASTM grade AAAA long, randomly dispersed chrysotile asbestos fiber, and lightweight fillers saturated with phenolic resin conforming to MIL-R-9299. A laboratory test run on the material shows that it offers the same thermal protection at 310° F mean temperature as asbestos-phenolic resins nine times heavier and three times thicker.[49]

The application of asbestos fibers in the major product groups of the construction industry in North America was surveyed. Principal categories considered include flooring materials, asbestos-cement pipes and building products, high-temperature insulation, textiles, saturated asbestos felts, and asphalt compounds.[50]

A process was patented for asbestos paper manufacture. An ultra-high-molecular-weight anionic polymer is added to the aqueous slurry of asbestos fiber and causes the water to drain with increased speed during the sheeting operation.[51]

An improved pneumatic apparatus for opening and cleaning asbestos fiber was patented.[52]

A method was patented for the use of asbestos fiber in the preparation of asbestos paper containing minor amounts of vinyl alkyl ether-maleic anhydride copolymer as a binder.[53]

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[46] Materials in Design Engineering. Asbestos-Neoprene for Corrosion-Free Gaskets. V. 57, No. 5, May 1963, pp. 222, 224.

[47] Rock Products. V. 66, No. 4, April 1963, p. 12.

[48] Mining Journal (London). Asbestos Ores for Paper Making. V. 260, No. 6648, Jan. 18, 1963, p. 61.

[49] Materials in Design Engineering. Asbestos-Phenolic for High-Temperature Protection. V. 57, No. 5, May 1963, pp. 147–148.

[50] Montpetit, L. O. Asbestos in the Construction Industry. Canadian Min. and Met. Bull. (Montreal), v. 56, No. 617, September 1963, pp. 737–742.

[51] Reynolds Jr., W. F., and N. T. Woodberry (assigned to American Cyanamid Co.). Asbestos Paper Manufacture. U.S. Pat. 3,076,740, Feb. 5, 1963.

[52] Novotny, E. H. (assigned to Johns-Manville Corp.). Fiber Opener and Cleaner. U.S. Pat. 3,111,719, Nov. 26, 1963.

[53] Cukier, S. T. (assigned to General Aniline and Film Corp.). Asbestos Paper Containing Vinyl Alkyl Ether-Maleic Anhydride Copolymer and Method of Forming Same. U.S. Pat. 3,113,064, Dec. 3, 1963.

A patent was issued on the use of crocidolite fiber impregnated with polytetrafluoroethylene in the manufacture of sheet materials.[54]

Several processes for making materials with asbestos as an ingredient were patented: An acoustical insulating tile,[55] a filter aid material,[56] gaskets, friction elements, etc.[57] and a dry-type joint cement composition.[58]

Several patents were issued for processes and apparatus used in the manufacture of asbestos-cement products.[59]

In the removal of organic substances in the treatment of raw asbestos fiber, the fiber or fiber-containing product is treated with an aqueous solution of an alkali metal phosphate, and then washed.[60]

A design was patented for an improved pneumatic apparatus for separating grit from milled asbestos fiber. Feed material is rotated in a chamber, and fiber is drawn by suction through a restricted passage.[61]

A method and apparatus for pressure packing of milled asbestos fiber was patented. The fiber is first compressed into a relatively firm block, and the block is then wrapped to form a firm, easily handled package.[62]

An improved apparatus for removing dust particles from asbestos fiber was patented. The fiber is moved by screw conveyor through a plenum chamber in which jets of air blow out the dust and fine fibers.[63]

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[54] Holly, R. B. (assigned to Armstrong Cork Co.). Polytetrafluoroethylene Saturated Crocidolite Fiber Product. U.S. Pat. 3,097,990, July 16, 1963.

[55] Becker, N. V. (assigned to Johns-Manville Perlite Corp.). Insulating Material and the Like. U.S. Pat. 3,095,347, June 26, 1963.

[56] Kruger, J. S. Filter Construction. U.S. Pat. 3,083,157, Mar. 26, 1963.

[57] Painter, J. B. (assigned to Johns-Manville Corp.). Dry Cold Molding Composition Containing Thermosetting Resin Binder and Hydrated Mineral Absorbent. U.S. Pat. 3,084,130, Apr. 2, 1963.

[58] Sirota, J., and B. D. Jubilee (assigned to National Starch & Chemical Corp.). U.S. Pat. 3,084,133, Apr. 2, 1963.

[59] Barchioli, G. and G. Gemigni. British Pat. 922,668.
Dubecky, P. (assigned to Johns-Manville Corp.). Punch for Forming Perforations in Coated Asbestos-Cement Sheets. U.S. Pat. 3,078,574, Feb. 26, 1963.
Sfiscko, N. M., R. Nebel, and Wil. Van Derbeck (assigned to Johns-Manville Corp.). U.S. Pat. 3,095,346, June 26, 1963.

[60] Burger, W., and H. Lubbe (assigned to Flammer Seifenwerke K. G.). Canadian Pat. 659,058, Mar. 12, 1963.

[61] Bourne, R. F., and D. G. Cheyne. Canadian Pat. 656,174, Jan. 22, 1963.

[62] Roberts, J. W., H Daum, and W. T. Donahue (assigned to Johns-Manville Corp.). Canadian Pat. 654,604, Dec. 25, 1962.

[63] Donovan, R. A. British Pat. 938,513, Oct. 2, 1963.

747-149—64——18

Barite

By Harold J. Drake [1]

PRODUCTION of barite in the United States fell to 803,000 tons and imports dropped to 578,000 tons in 1963. Consumption of crude barite used in manufacturing ground barite and barium chemicals amounted to 1.2 million tons.

DOMESTIC PRODUCTION

The States leading in the mining of barite—Missouri, Arkansas, Georgia, and Nevada—accounted for 94 percent of total primary production. California, Idaho, Kentucky, Montana, New Mexico, South Carolina, Tennessee, and Texas also reported production. Stocks of primary barite at domestic mines decreased 10 percent.

Production and sales of crushed and ground barite were each about 1 percent higher, while inventories amounted to 33,793 tons, an increase of 13 percent over that of 1962.

Demand for barium chemicals continued to be fairly stable with only a slight decrease in sales.

The Rush Creek sanbornite deposit in Fresno County, Calif., was explored under a cooperative agreement between the California State Division of Mines and Geology and the Federal Bureau of Mines.

TABLE 1.—Salient barite and barium-chemical statistics

(Thousand short tons and thousand dollars)

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Primary:						
Mine or plant production	1,037	867	771	731	887	803
Sold or used by producers	1,008	902	714	797	860	824
Value	$10,644	$10,301	$8,574	$9,300	$9,820	$9,447
Imports for consumption	525	640	642	608	737	578
Value	$3,531	$4,825	$5,006	$5,185	$6,009	$4,637
Consumption [1]	1,515	1,396	1,190	1,391	1,210	1,200
Ground and crushed sold by producers	1,253	1,210	977	1,036	1,023	1,030
Value	$33,432	$30,431	$24,219	$25,182	$24,285	$25,517
Barium chemicals sold by producers	93	99	99	97	[2] 104	96
Value	$12,583	$13,657	$14,152	$13,770	[2] $14,656	$14,442
World: Production	2,930	[2] 3,080	[2] 3,130	[2] 3,160	[2] 3,440	3,200

[1] Includes some witherite.
[2] Revised figure.

[1] Commodity specialist, Division of Minerals.

TABLE 2.—Domestic barite sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

<table>
<tr><th rowspan="2">State</th><th colspan="2">1954-58 (average)</th><th colspan="2">1959</th><th colspan="2">1960</th></tr>
<tr><th>Quantity</th><th>Value</th><th>Quantity</th><th>Value</th><th>Quantity</th><th>Value</th></tr>
<tr><td>Arkansas</td><td>396</td><td>$3,541</td><td>339</td><td>$3,097</td><td>278</td><td>$2,578</td></tr>
<tr><td>California</td><td>(1)</td><td>(1)</td><td>28</td><td>326</td><td>16</td><td>181</td></tr>
<tr><td>Georgia
South Carolina
Tennessee</td><td>132</td><td>2,221</td><td>90</td><td>1,809</td><td>119</td><td>2,347</td></tr>
<tr><td>Missouri</td><td>315</td><td>3,624</td><td>296</td><td>3,924</td><td>181</td><td>2,588</td></tr>
<tr><td>Nevada</td><td>109</td><td>683</td><td>91</td><td>623</td><td>86</td><td>591</td></tr>
<tr><td>Other States [2]</td><td>56</td><td>575</td><td>58</td><td>522</td><td>34</td><td>289</td></tr>
<tr><td>Total</td><td>1,008</td><td>10,644</td><td>902</td><td>10,301</td><td>714</td><td>8,574</td></tr>
<tr><th></th><th colspan="2">1961</th><th colspan="2">1962</th><th colspan="2">1963</th></tr>
<tr><th></th><th>Quantity</th><th>Value</th><th>Quantity</th><th>Value</th><th>Quantity</th><th>Value</th></tr>
<tr><td>Arkansas</td><td>278</td><td>$2,630</td><td>259</td><td>$2,232</td><td>236</td><td>$2,161</td></tr>
<tr><td>California</td><td>21</td><td>295</td><td>7</td><td>133</td><td>5</td><td>76</td></tr>
<tr><td>Georgia</td><td>107</td><td>2,046</td><td>109</td><td>1,987</td><td>117</td><td>2,013</td></tr>
<tr><td>Kentucky</td><td>(1)</td><td>(1)</td><td>(1)</td><td>(1)</td><td>6</td><td>85</td></tr>
<tr><td>Missouri</td><td>227</td><td>3,052</td><td>304</td><td>3,994</td><td>287</td><td>3,680</td></tr>
<tr><td>Nevada</td><td>130</td><td>863</td><td>138</td><td>954</td><td>120</td><td>760</td></tr>
<tr><td>New Mexico</td><td>(1)</td><td>(1)</td><td>(1)</td><td>(1)</td><td>1</td><td>6</td></tr>
<tr><td>South Carolina</td><td rowspan="2">13</td><td rowspan="2">253</td><td rowspan="2">16</td><td rowspan="2">327</td><td>(1)</td><td rowspan="2">(1)
404</td></tr>
<tr><td>Tennessee</td><td>24</td></tr>
<tr><td>Other States [2]</td><td>21</td><td>161</td><td>27</td><td>193</td><td>28</td><td>262</td></tr>
<tr><td>Total</td><td>797</td><td>9,300</td><td>860</td><td>9,820</td><td>824</td><td>9,447</td></tr>
</table>

[1] Included with "Other States" to avoid disclosing individual company confidential data.
[2] Arizona (1954-55), Idaho (1959-63), Kentucky (1959-62), Montana (1959-63), New Mexico (1959-62), South Carolina (1963 only), and Texas (1961-63).

The report on the barium silicate mineral was placed on open file at the Bureau of Mines, 450 Golden Gate Avenue, San Francisco, Calif.

Barite deposits of Nevada were inventoried and the report was made available for 50 cents by the Nevada Bureau of Mines, University of Nevada, Reno, Nev.

CONSUMPTION AND USES

Consumption of primary barite produced in the United States was 4 percent less than in 1962. New supply (domestic production plus imports) of crude barite used for all purposes decreased 15 percent, while sales of crushed and ground material increased slightly.

The quantity of barite used in the production of barium chemicals was 9 percent below that of 1962.

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	Sales: Value	Year	Plants	Production (quantity)	Sales: Quantity	Sales: Value
1954-58 (average)	31	1,295	1,253	$33,432	1961	35	1,101	1,036	$25,182
1959	33	1,199	1,210	30,431	1962	35	1,012	1,023	24,285
1960	36	973	977	24,219	1963	34	1,027	1,030	25,517

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— Ground barite[2]	Barium chemicals and lithopone	Total	Year	In manufacture of— Ground barite[2]	Barium chemicals and lithopone	Tota
1954-58 (average)	1,339	176	1,515	1961	1,224	167	1,391
1959	1,227	170	1,396	1962	1,043	167	1,210
1960	1,005	185	1,190	1963	1,048	152	1,200

[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

Industry	1954-58 (average) Short tons	Percent of total	1959 Short tons	Percent of total	1960 Short tons	Percent of total
Well drilling	1,180,284	94	1,153,560	95	920,283	94
Glass	24,418	2	12,165	1	15,012	1
Paint	19,811	1	17,046	1	18,273	2
Rubber	21,475	2	19,806	2	17,082	2
Undistributed	7,364	1	7,330	1	6,180	1
Total	1,253,352	100	1,209,907	100	976,830	100

Industry	1961 Short tons	Percent of total	1962 Short tons	Percent of total	1963 Short tons	Percent of total
Well drilling	941,539	91	934,007	91	907,134	89
Glass	30,713	3	39,017	4	56,362	5
Paint	16,128	2	19,786	2	34,611	3
Rubber	24,007	2	26,235	3	28,479	3
Undistributed	23,395	2	4,045	----------	3,121	----------
Total	1,035,782	100	1,023,090	100	1,029,707	100

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]	
				Quantity	Value
Black ash: [4]					
1954–58 (average)	9	117,659	113,959	2,351	$193,857
1959	7	104,740	102,040	2,947	289,580
1960	9	116,995	113,466	3,136	298,741
1961	8	105,117	102,591	2,363	228,358
1962	9	107,023	104,767	3,393	365,904
1963	7	99,426	89,821	3,374	322,941
Carbonate (synthetic):					
1954–58 (average)	5	72,200	28,298	45,073	4,375,862
1959	6	77,048	29,398	47,137	5,099,366
1960	6	77,690	29,392	46,128	5,010,514
1961	7	78,665	28,599	47,401	5,119,826
1962	6	79,220	27,683	49,484	5,415,751
1963	6	65,848	25,688	41,126	4,495,735
Chloride (100 percent $BaCl_2$):					
1954–58 (average)	3	10,336	59	10,090	1,540,918
1959	4	(5)	(5)	(5)	(5)
1960	3	8,754	----------	9,401	1,535,188
1961	3	10,891	----------	10,290	1,697,606
1962	4	10,844	----------	10,276	1,703,123
1963	3	9,173	----------	9,846	1,637,165
Hydroxide:					
1954–58 (average)	5	13,541	150	13,451	2,439,129
1959	5	14,293	(5)	13,914	2,320,522
1960	5	17,579	----------	14,971	2,336,402
1961	4	13,715	----------	13,873	2,167,245
1962	4	16,328	----------	[6] 16,925	[6] 2,745,135
1963	4	18,746	----------	18,436	3,018,482
Other barium chemicals: [7]					
1954–58 (average)	--------	29,108	6,739	21,681	4,033,642
1959	--------	43,860	7,798	34,672	5,947,992
1960	--------	30,690	(8)	25,464	4,971,000
1961	--------	27,878	(8)	23,452	4,557,193
1962	--------	27,850	(8)	23,864	4,425,798
1963	(9)	26,555	(8)	23,462	4,967,844
Total: [10]					
1954–58 (average)	--------	----------	----------	92,646	12,583,408
1959	14	----------	----------	98,670	13,657,460
1960	14	----------	----------	99,100	14,151,845
1961	14	----------	----------	97,379	13,770,228
1962	14	----------	----------	[6] 103,942	[6] 14,655,711
1963	13	----------	----------	96,244	14,442,167

[1] Includes also purchased material.
[2] Of any barium chemical.
[3] Exclusive of purchased material and exclusive of sales by one producer to another.
[4] Black-ash data include lithopone plants.
[5] Included with "Other barium chemicals" to avoid disclosing individual company confidential data.
[6] Revised figure.
[7] Includes barium acetate, nitrate, oxide, peroxide, sulfate, and other compounds for which separate data may not be revealed.
[8] Figures withheld to avoid disclosing individual company confidential data.
[9] Barium acetate, 1 plant; nitrate, 3; oxide, 2; peroxide, 1; and sulfate (synthetic), 5.
[10] A plant producing more than 1 product is counted only once in arriving at total.

PRICES

Prices of crude and ground domestically produced or imported barite were unchanged from 1962.

TABLE 7.—Price quotations for barium chemicals in 1963

	January	December
Barium carbonate, precipitated, bags, carlots, works...short ton..	$111.50	Unchanged.
Barium chlorate, drums, works...pound..	.32 to .41	Do.
Barium chloride, anhydrous, bags, carlots, works...short ton..	176.00	Do.
Barium chloride, National Formulary, crystalline, drums, 400 pounds, works...pound..	.23	Do.
Technical crystalline, bags, carlots...100 pounds..	7.00	Do.
Barium dioxide (peroxide), drums, freight equalized...pound..	.20	$0.30.
Barium hydrate, crystalline, bags, carlots, truckloads, delivered..short ton..	208.00	$224.00.
Barium monohydrate, 99 percent, bags, carlots, delivered...100 pounds..	11.25	$12.00.
Barium nitrate, barrels, carlots, truckloads, delivered...pound..	.16	Unchanged.
Less carlots, less truckloads, delivered...do....	.17	Do.
Barium oxide, ground, drums, carlots, truckloads, freight, delivered...short ton..	275.00	$288.00.
Blanc fixe, direct process, bags, carlots, works...do....	160.00	Unchanged.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE

Imports.—Imports of crude barite dropped from the 1962 high to the level of preceding years. Tonnages from the three leading sources—Mexico, Canada, and Peru—declined 34, 32, and 14 percent, respectively. Greece, Brazil, and Morocco shipped nearly 113,000 tons to the United States, a 26-percent increase. The average declared per ton value of crude barite imports was Mexico, $6.76; Canada $7.87; Peru, $9.89; Greece, $7.54; Brazil, $7.26; Morocco, $8.30; Yugoslavia, $9.60; Spain, $9.75; and Ireland, $6.70.

Imports of ground barite were 296 tons.

Witherite, both crude and ground, was imported from the United Kingdom.

The quantity of barium chemicals entering the United States was 11 percent less than in 1962, chiefly due to a 44-percent reduction in deliveries of precipitated barium carbonate. Imports of barium chemicals usually are about 5 percent of the quantity marketed from domestic sources.

TABLE 8.—U.S. imports for consumption of barite, by countries

	1962		1963	
	Short tons	Value	Short tons	Value
Crude barite:				
North America:				
Canada	221,070	$1,883,119	150,881	$1,187,460
Mexico	243,138	1,716,263	159,964	1,081,821
Total	464,208	3,599,382	310,845	2,269,281
South America:				
Brazil	10,685	87,240	13,070	94,856
Peru	105,560	978,809	91,295	903,158
Total	116,245	1,066,049	104,365	998,014
Europe:				
Greece	34,328	260,525	48,081	362,454
Ireland	----	----	10,483	70,200
Italy	5,268	72,028	----	----
Spain	18,726	167,330	18,852	183,829
United Kingdom	(1)	400	----	----
Yugoslavia	53,019	424,564	33,688	323,571
Total	111,341	924,847	111,104	940,054
Africa: Morocco	44,934	418,402	51,784	430,028
Grand total	736,728	6,008,680	578,098	4,637,377
Ground barite:				
North America:				
Canada	18	690	13	375
Mexico	89	890	243	3,890
Total	107	1,580	256	4,265
Europe:				
Germany, West	32	1,401	23	896
Spain	----	----	17	450
Total	32	1,401	40	1,346
Grand total	139	2,981	296	5,611

[1] Less than 1 ton.

Source: Bureau of the Census.

TABLE 9.—U.S. imports for consumption of barium chemicals

Year	Lithopone		Blanc fixe (precipitated barium sulfate)		Barium chloride		Barium hydroxide	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1954-58 (average)	73	[1] $9,749	1,147	$95,904	1,193	[1] $98,092	72	$11,516
1959	73	8,752	1,757	122,067	1,510	134,663	232	35,104
1960	62	7,973	1,629	124,093	1,004	91,843	39	16,172
1961	74	8,843	1,378	122,174	1,019	93,105	11	1,880
1962	98	12,538	1,724	152,267	1,150	107,214	11	1,680
1963	159	21,360	1,602	157,332	1,152	103,890	----------	----------

Year	Barium nitrate		Barium carbonate, precipitated		Other barium compounds	
	Short tons	Value	Short tons	Value	Short tons	Value
1954-58 (average)	466	[1] $71,680	1,126	$78,178	484	[1] $102,835
1959	596	89,822	1,895	127,734	55	41,823
1960	736	106,818	1,406	104,674	172	132,294
1961	807	128,120	1,190	86,123	160	111,427
1962	807	125,253	1,501	112,406	126	95,931
1963	948	145,341	838	58,302	107	78,286

[1] Data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 10.—U.S. imports for consumption of crude, unground, and crushed or ground witherite

Year	Crude unground		Crushed or ground	
	Short tons	Value [1]	Short tons	Value [1]
1954-58 (average)	2,996	$117,532	(2)	(2)
1959	2,552	113,229	(3)	$478
1960	1,344	59,257	50	3,246
1961	1,716	67,280	87	22,659
1962	1,431	58,766	71	4,726
1963	2,690	113,813	90	5,956

[1] Valued at port of shipment.
[2] Class established June 1, 1956; no transactions; 1957, 8 tons ($533); 1958, 202 tons ($15,610).
[3] Less than 1 ton.

Source: Bureau of the Census.

TABLE 11.—U.S. exports of lithopone

Year	Short tons	Value: Total	Value: Average per ton	Year	Short tons	Value: Total	Value: Average per ton
1954-58 (average)	1,579	$259,133	$164.11	1961	608	$87,905	$144.58
1959	538	99,578	185.09	1962	350	68,317	195.19
1960	190	35,160	185.05	1963	839	135,874	161.95

Source: Bureau of the Census.

WORLD REVIEW [2]

Barite was produced in at least 41 countries during 1963. The estimated world production of 3.2 million short tons was 7 percent lower than the revised estimate for 1962.

Algeria.—Domestic production of barite was used principally in oil well drilling mud for local consumption.[3] Imports of barite were primarily from France.

Canada.—The Canadian Division of the Magnet Cove Barium Corp. Ltd. produced barite—about 95 percent of Canadian production—from an underground mine near Walton, Nova Scotia. Crude and ground ore was shipped to the Caribbean area from Walton, a tidal port. The geology of the barite deposits was described.[4]

Chile.—Production of barite in Chile has been gradually declining,[5] and in recent years, only three companies reported production. They were Sociedad Minera Godoy, Schwenger und Cía.; Minas and Planta "Pompilio Raggio"; and Industria Minera Vassalli.

Czechoslovakia.—Czechoslovakian interests ordered barite drying, grinding, and classifying equipment from the Erith works of General Electric Co., Ltd.[6] This was the second order for equipment for a bleach barite processing plant.

India.—Barite production in 1962 increased about 56 percent, although exports declined from 8,085 to 6,069 tons.[7] The value per ton of the exports in 1962 was $18.37.

Ireland.—Ballinoe Silvermines, Co. Tipperary, Eire, was anticipating annual production of about 100,000 tons of barite for use in oil well drilling muds in the United States.[8] A crushing plant and loading dock were being erected at the mine.

Italy.—Exports of barite in 1962 increased nearly 21 percent to about 52,000 tons. Value increased only 15 percent, indicating a decline in unit price.

Several Italian companies launched an industrialization project in Sardinia which involved open-pit mining of barite.[9]

Korea, Republic of.—The geology of barite deposits was described and available production data were given.[10] Very little barite was consumed locally and most was shipped to Japan, constituting about half the Japanese supply.

Pakistan.—Although Pakistan could grind over 16,000 tons annually, only about 3,000 tons of barite was ground. Requirements for the local oil industry did not exceed 6,000 tons, while the paint industry consumed about 2,500 tons.

Peru.—Barite was produced in 1962 by Barmine Co. and Cía. Perforadora de Pozos para Irrigación, S.A., from mines in the Rimac

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[2] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[3] Bureau of Mines. Mineral Trade Notes. V. 58, No. 2, February 1964, p. 5.
[4] Mining Magazine (London). Gypsum and Barytes in Nova Scotia. V. 108, No. 6, June 1963, pp. 371–372.
[5] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, p. 3.
[6] Chemical Age (London). V. 90, Nos. 2319–2320, Dec. 21–28, 1963, p. 963.
[7] Bureau of Mines. Mineral Trade Notes. V. 57, No. 6, December 1963, p. 12.
[8] Mining Journal (London). V. 260, No. 6670, June 21, 1963, p. 628.
[9] Mining Journal (London). V. 260, No. 6659, Feb. 1, 1963, p. 112.
[10] Gallagher, David. Mineral Resources of Korea. Min. Branch, Ind. and Min. Div., U.S. Operations Missions, Korea, in cooperation with Geol. Survey, Republic of Korea, v. 4A, 1963, pp. 61–68.

TABLE 12.—World production of barite, by countries[1,2]

(Short tons)

Country[1]	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	243,962	238,967	154,292	191,404	226,600	177,079
Cuba (exports)	6,946	----	----	----	----	----
Mexico	260,507	314,933	298,458	274,153	350,684	282,847
United States	1,036,579	867,201	771,318	730,381	886,964	803,106
Total	1,547,994	1,421,101	1,224,068	1,195,938	1,464,248	1,263,032
South America:						
Argentina	22,188	19,842	26,987	31,476	13,819	[3] 13,800
Brazil	31,505	56,009	[4] 44,464	68,834	60,241	59,609
Chile	1,292	[3] 880	1,440	1,551	1,086	1,123
Colombia	9,241	11,000	8,000	11,272	8,800	[3] 8,800
Peru	49,338	105,557	120,800	122,538	126,271	137,600
Total	113,564	193,288	201,691	235,671	210,217	220,932
Europe:						
Austria (marketable)	4,236	4,068	4,829	2,716	1,192	2,259
France	80,454	95,259	116,860	95,007	83,776	[3] 84,000
Germany, West (marketable)	456,303	486,810	549,134	518,951	512,230	[3] 460,000
Greece	77,544	143,014	112,203	85,000	[3] 90,000	95,000
Ireland	7,402	9,157	11,704	4,659	378	10,192
Italy	109,512	133,734	157,925	155,999	134,915	117,505
Poland	[5] 12,153	[3] 12,400	[3] 12,400	41,161	49,841	[3] 50,000
Portugal	658	3,760	4,310	2,285	1,489	[3] 1,400
Spain	16,355	28,186	28,596	37,449	42,923	[3] 40,000
U.S.S.R.[3]	115,000	130,000	140,000	165,000	200,000	220,000
United Kingdom [6]	82,592	68,408	67,431	91,677	84,754	61,066
Yugoslavia	112,716	118,267	120,691	114,872	143,300	115,176
Total [1,3]	1,110,000	1,270,000	1,360,000	1,350,000	1,380,000	1,300,000
Asia:						
Burma	[7] 907	1,120	1,792	2,248	4,462	[3] 4,400
China	([8])	[3] 55,000	[3] 65,000	[3] 90,000	[3] 90,000	[3] 100,000
India	13,731	14,939	14,976	17,325	26,980	41,129
Iran [9]	[7] 1,124	1,904	14,330	20,900	16,500	[3] 16,500
Japan	21,158	21,331	25,184	32,243	42,016	41,356
Korea:						
North	([8])	[3] 16,500	[3] 45,000	[3] 60,000	[3] 65,000	[3] 75,000
Republic of	400	----	220	772	1,014	3,040
Pakistan	[7] 342	569	709	489	3,164	[3] 3,200
Philippines	[10] 3,732	186	6,198	2,109	459	1,008
Turkey	[11] 4,073	2,513	1,653	----	2,094	1,081
Total [1,3]	75,000	114,000	175,000	226,000	252,000	287,000
Africa:						
Algeria	42,016	24,038	61,564	33,883	13,407	[3] 13,000
Morocco	26,675	40,574	92,945	90,591	98,980	104,228
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	7	239	----	----	----	1,953
South Africa, Republic of	2,607	2,355	1,878	1,962	1,873	2,704
Swaziland	431	461	200	454	68	93
United Arab Republic (Egypt)	553	2,017	2,900	[3] 2,900	1,356	[3] 1,300
Total	72,289	69,684	159,487	129,790	115,684	123,278
Oceania: Australia	8,003	6,960	12,787	21,523	14,038	[3] 6,600
World total (estimate) [1,2]	2,930,000	3,080,000	3,130,000	3,160,000	3,440,000	3,200,000

[1] Barite is produced in Bulgaria, Czechoslovakia, and East Germany, but data on production are not available. Estimates by author of chapter included in total, with the exception of Bulgaria.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] 1960 revised to include additional data.
[5] Average annual production 1955–58.
[6] Includes witherite.
[7] One year only as 1958 was first year of commercial production.
[8] Data not available for China and North Korea; estimate included in total for China only.
[9] Year ended March 20, of year following that stated.
[10] Average annual production 1956–58.
[11] Average annual production 1957–58.

Valley, near Lima.[11] All of the material was used in well drilling and was shipped to the United States, Chile, and Ecuador.

Rhodesia and Nyasaland, Federation of.—Dodge Mineral Production Co. was reported to be installing equipment that will triple production.[12] Chief markets were in South Africa and new ones were anticipated in the Middle East.

Turkey.—Production of barite resumed in 1962 with sales to an Istanbul paint manufacturer.[13]

TECHNOLOGY

A study of flotation and cyclone treatment of tailings containing about 21 percent barite was reviewed.[14] The investigation disclosed that pulp density should be between 350 and 400 grams per liter and that the ideal particle size is 10 to 40 microns. Barite recovery was about 70 percent.

A process was developed for the beneficiation of barite and fluorite in which the two were selectively floated using a fatty acid alcohol phosphate ester salt as the flotation agent.[15]

Mixing conditions and reagent concentrations relative to the precipitation of barium sulfate were studied.[16] Barium hydroxide and sulfuric acid solutions were mixed by different methods and the data collected were used to qualitatively explain relative rates of precipitate nucleation and growth.

Barium xenate was prepared and its properties were studied.[17]

A patent was issued for the production of barium hydroxide monohydrate.[18]

A patent was issued for barium zirconium borate and the pigments containing it.[19] The method of manufacture was also covered. Barium boride was produced by mixing the oxides of barium and boron with carbon and heating to about 2,300°F.[20] Vitreous barium borosilicate was studied by X-ray diffraction methods.[21]

Equilibrium constants of barium oxide were determined by studying resonance lines of the metal atoms in various kinds of flames.[22] Op-

[11] Bureau of Mines. Mineral Trade Notes. V. 57, No. 4, October 1963, p. 3.

[12] Bureau of Mines. Mineral Trade Notes. V. 57, No. 3, September 1963, p. 8.

[13] Bureau of Mines. Mineral Trade Notes. V. 57, No. 2, August 1963, p. 9.

[14] Marshall, J. E. F. Flotation Theory and Practice, Control and Automation. Mine and Quarry Eng. (London), v. 29, No. 12, December 1963, pp. 540–541.

[15] Schranz, H. (assigned to Klockner-Humboldt-Deutz A.G.). German Pat. 1,142,803, Jan. 31, 1963.

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[17] Kirschenbaum, A. D., and A. V. Grosse. Barium Xenate. Sci., v. 142, No. 3592, Nov. 1, 1963, pp. 580–581.

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[22] Veits, I. V., and L. V. Gurvich. (The Dissociation Energy of Magnesium, Calcium, Strontium and Barium Oxides.) Optika. Spektroskopiya (U.S.S.R.), v. 1, No. 1, 1956, pp. 22–33; Tech. Transl. (U.S. Dept. of Commerce, OTS), v. 9, No. 2, Jan. 20, 1963, p. 208.

tical absorption and photoemission characteristics of barium compounds were also studied,[23] as was the stabilization effect of barium oxide on portland cement clinker.[24]

Studies of the electrolytic dissociation of barium hydroxide showed that the $(BaOH)^+$ ions affect the solubility of barium silicate hydrate.[25]

Barium silicate of a special type was used as an inoculant to reduce chill in gray iron.[26] Since the barium silicide resists fading (loss of beneficial effect), production problems should be reduced and overall quality of products shoud be improved.

Barium titanate ($BaTiO_3$) was vapor-deposited by a grain-by-grain method which resulted in a highly insulating amorphous film about 1 micron thick.[27] When substrate temperature was below 400°C, the film had a dielectric constant of about 15; above 500°C, constants of 400 to 700 were achieved.

Experimental investigations of barium titanate dielectrics were conducted in an attempt to increase their operating life.[28]

Ferroelectic ceramics composed of barium zirconate and lead titanate were examined to determine crystalline symmetry and dielectric, ferroelectric, and piezoelectric properties.[29] Patents were issued for barium titanate ceramic compositions with special propeties.[30] Antimony,[31] samarium,[32] and yttrium [33] were used to dope barium titanate single crystals and ceramics.

Single-crystal studies [34] of barium titanate involved thermal and electrical properties and the determination of a complete set of elastic, piezoelectric, and dielectric constants at 25° C.

High-frequency excitation of $BaTiO_3$ caused electroluminescence,

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[23] Zollweg, R. J. Optical Absorption and Photoemission of Barium and Strontium Oxides, Sulfides, Selenides, and Tellurides. Phys. Rev., v. 111, No. 1, 1958, pp. 113–119.

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[26] Foundry. Barium Inoculants Resist. V. 91, No. 4, April 1963, pp. 66–68.

[27] Müller, E. K., B. J. Nicholson, and Maurice H. Francombe. The Vapor Deposition of $BaTiO_3$ by a Grain-by-Grain Evaporation Method. Electrochem. Technol., v. 1, Nos. 5–6, May–June 1963, pp. 158–163.

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Levinson, S. (assigned to Vitramon, Inc., Monroe, Conn.). Dielectric Ceramic Composition. U.S. Pat. 3,068,107, Dec. 11, 1962.

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[32] Goodman, G. Electrical Conduction Anomaly in Samarium-Doped Barium Titanate. J. Am. Ceram. Soc., v. 46, No. 1, January 1963, pp. 48–54.

[33] Ichikawa, Y., and W. G. Carlson. Yttrium-Doped Ferroelectric Solid Solutions With Positive Temperature Coefficients of Resistance. Am. Ceram. Soc. Bull., v. 42, No. 5, May 7. 1963. pp. 312–316.

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which was the result of a high-radio frequency field across a thin surface barrier.[35]

Research on cements containing barium compounds continued.[36] The studies covered chemistry, chemical reactions, and mineralogy.

Patents were issued for using barite in nuclear applications [37] and for producing barium material with electronic applications.[38]

Barium ferrite powder was added to raw materials to produce new products with magnetic properties.[39]

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Bauxite

By Lloyd R. Williams [1] and John W. Stamper [1]

WORLD production of bauxite was about 30 million tons, 2 percent less than in 1962, the record year. Over 50 percent of the world production was in the Western Hemisphere. Jamaica was the leading producer, followed by Surinam and British Guiana. The world reserves of bauxite in 1963 was more than 3.5 times higher than in 1950.

Production of bauxite in the United States increased 11 percent and was equivalent to 13 percent of the domestic supply of new bauxite. A record 5.1 million short tons of alumina and aluminum oxide products was produced from bauxite. Aluminum production accounted for 82 percent of the bauxite consumed. (Aluminum metal is discussed in the Aluminum chapter of this volume.)

TABLE 1.—Salient bauxite statistics

(Thousand long tons and thousand dollars)

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Production, crude ore (dry equivalent)	1,651	1,700	1,998	1,228	1,369	1,525
Value	$14,348	$17,725	$21,107	$13,937	$15,609	17,234
Imports for consumption [1]	6,111	8,149	8,739	9,206	[2] 10,575	9,170
Exports (as shipped)	24	17	29	151	259	203
Consumption (dry equivalent)	7,167	8,619	8,883	8,621	10,577	11,318
World: Production	19,060	[2] 22,690	[2] 27,020	[2] 28,890	[2] 30,535	29,835

[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.
[2] Revised figure.

DOMESTIC PRODUCTION

Output of crude bauxite in the United States was 1.5 million long tons, dry equivalent, valued at $17.2 million. Production increased 156,000 tons, or 11 percent, and shipments to consumers from mines and processing plants increased 11,000 tons, or less than 1 percent.

Arkansas produced 97 percent of the total U.S. output. The two leading producers in Arkansas were Aluminum Company of America (Alcoa) and Reynolds Metals Co., and each shipped crude ore to its own alumina plant. Dried ore was produced by Campbell Bauxite Co. and Stauffer Chemical Co. Activated bauxite was produced by these same two companies and by Porocel Corp. Calcined bauxite was produced by American Cyanamid Co. Norton Co. did not operate its mine in Saline County.

[1] Commodity specialist, Division of Minerals.

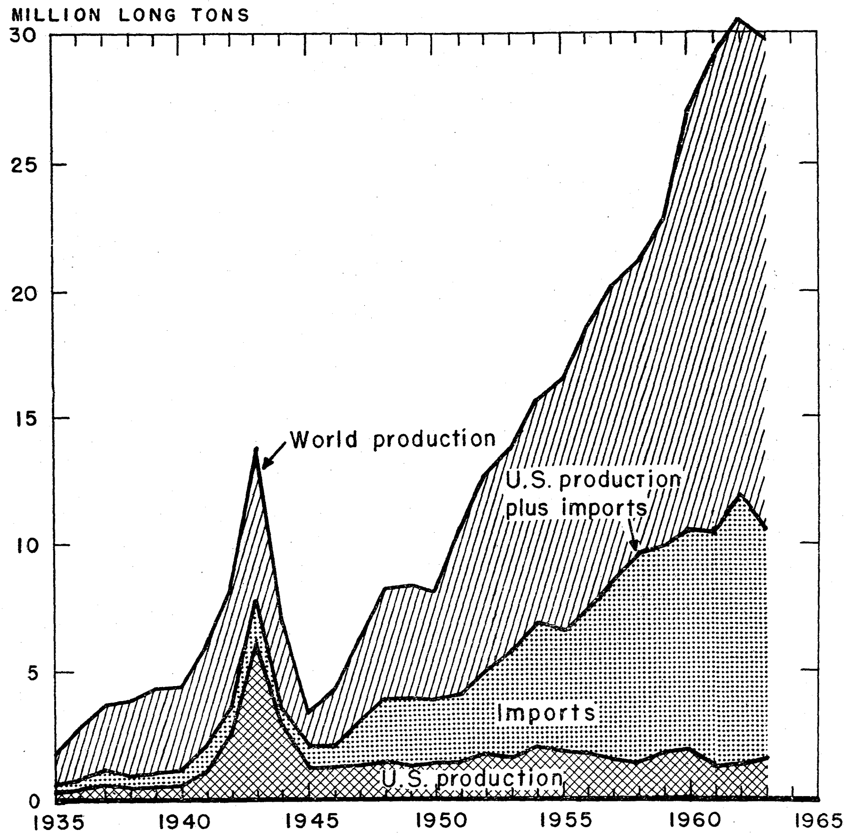

FIGURE 1.—U.S. supply and world production of bauxite, 1935–63.

Harbison-Walker Refractories Co., R. E. Wilson Mining Co., and Wilson-Snead Mining Co. operated bauxite mines in Barbour and Henry Counties, Ala., and American Cyanamid Co. mined in Floyd, Bartow, and Sumter Counties, Ga. Together they produced 47,000 long dry tons of ore, a 53-percent decrease from 1962 output. Crude ore was shipped to consumers by the Wilson-Snead Mining Co. and the American Cyanamid Co. American Cyanamid Co. and R. E. Wilson Mining Co. processed their crude ore and produced dried bauxite, and Harbison-Walker Refractories Co. produced calcined bauxite.

North American Coal Co. discontinued operation of its facility at Pawatan Point, Ohio, for the production of aluminum sulfate from coal mine waste shales and clays. The company started operations in 1962.

Reynolds Aluminum Co. purchased land south of Salem, Oreg., containing low-grade bauxite deposits.

The Nilo Barge Line Inc. was recently formed for the transportation of bulk commodities. The company stated that it hoped to acquire most of the Olin Mathieson Chemical Corp. barge fleet and participate in shipping Olin's alumina from Louisiana to Ohio.

Two 22,000-ton self-loading carriers began regular transport of alumina from Corpus Christi, Tex., to the Reynolds Metals Co. aluminum reduction plant at Longview, Wash.[2]

Stauffer Chemical Co. began production of aluminum sulfate at its new plant in Houston, Tex. The annual capacity of domestic plants for producing metallurgical-grade alumina increased almost 4 percent during 1962 as a result of completion of the third unit at the Point Comfort, Tex., plant of Alcoa.

Annual capacity of domestic companies to produce dried bauxite was 111,000 long tons. Domestic capacity to produce activated and calcined bauxite amounted to 292,000 tons, an increase of 30 percent.

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:						
1954-58 (average)	77	60	$530	67	62	$690
1959	89	69	677	63	61	678
1960	82	66	638	49	51	577
1961	60	49	475	40	43	498
1962	120	99	1,003	50	53	609
1963	60	47	533	54	62	747
Arkansas:						
1954-58 (average)	1,891	1,591	13,818	1,865	1,597	15,115
1959	1,940	1,631	17,048	1,827	1,580	17,960
1960	2,327	1,932	20,469	1,876	1,603	18,982
1961	1,419	1,179	13,462	1,244	1,080	13,220
1962	1,523	1,270	14,606	1,715	1,481	17,535
1963	1,771	1,478	16,701	1,725	1,483	17,543
Total United States:						
1954-58 (average)	1,968	1,651	14,348	1,932	1,659	15,805
1959	2,029	1,700	17,725	1,890	1,641	18,638
1960	2,409	1,998	21,107	1,925	1,654	19,559
1961	1,479	1,228	13,937	1,284	1,123	13,718
1962	1,643	1,369	15,609	1,765	1,534	18,144
1963	1,831	1,525	17,234	1,779	1,545	18,290

[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	Total: Dry equivalent
1954-58 (average)	192,735	115,136	24,651	139,786	151,343
1959	215,008	85,833	60,135	145,968	171,187
1960	186,094	46,015	58,373	104,388	147,079
1961	153,321	30,202	55,242	85,444	124,992
1962	172,262	37,776	57,232	95,008	141,969
1963	170,641	35,727	61,853	97,570	164,072

[2] Reynolds Metals Co. 36th Annual Report. 1963, p. 3.

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CONSUMPTION AND USES

Domestic consumption of bauxite increased 7 percent. Foreign sources supplied 85 percent of the total consumption. Jamaican-type ore (from Jamaica, Haiti, and the Dominican Republic) comprised 49 percent of the total consumption; Surinam-type ore (from Surinam and British Guiana) made up 36 percent. Domestic sources supplied the remainder.

Shipments of domestic ore (an index of the grade of ore consumed) containing less than 8 percent silica were 8 percent of the total, a decrease from the 12 percent shipped in 1962. The proportion of ore containing 8 to 15 percent silica decreased from 58 to 52 percent, and the proportion of the ore containing more than 15 percent silica increased to 40 percent, 10 percent more than in 1962.

The eight domestic alumina plants operated by the aluminum companies produced 4,987,000 short tons of calcined alumina and aluminum oxide products calculated on the basis of calcined equivalent. This was 9 percent more than in 1962. The gross weight of the calcined alumina and aluminum oxide products was 5,062,000

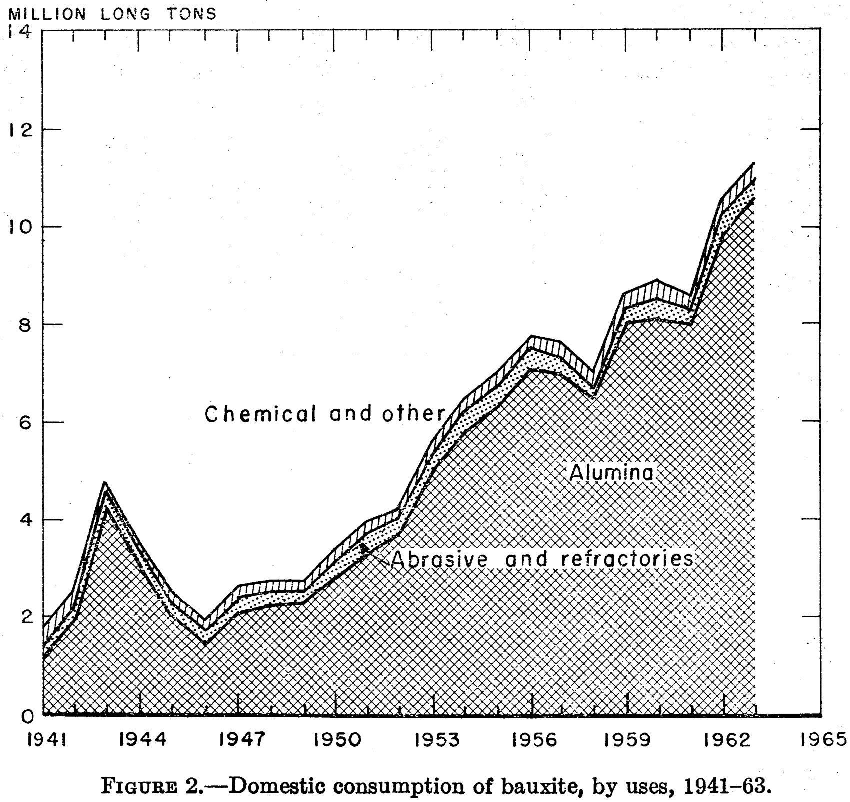

FIGURE 2.—Domestic consumption of bauxite, by uses, 1941–63.

tons, of which 4,799,000 tons was calcined alumina and 211,000 tons was trihydrate alumina. The remainder was activated or tabular alumina. Shipments of alumina and aluminum oxide products totaled 5,035,000 tons, of which 94 percent, or 4,752,000 tons went to the aluminum industry. The remaining 283,000 tons was shipped as commercial trihydrate or as activated, calcined, or tabular alumina for use chiefly by the chemical, abrasive, ceramic, and refractory industries.

Calcined alumina consumed at the 22 aluminum reduction plants in the United States totaled 4,276,000 short tons, 6 percent more than in 1962. An average of 2.125 long dry tons of bauxite was required to produce 1 short ton of alumina, and an average of 1.849 short tons of alumina was required to produce 1 short ton of aluminum metal. The overall ratio was 3.929 long dry tons of bauxite to 1 short ton of aluminum.

Western Gold and Platinum Co. established a shop called Wesgo-East at Newark, N.J., to machine, fire, grind, and inspect small quantities of high-aluminum ceramica for missile, space, and electronic applications.

TABLE 4.—Bauxite consumed in the United States, by industries

(Long tons, dry equivalent)

Year and industry	Domestic	Percent	Foreign	Percent	Total	Percent
1962:						
Alumina	1,447,258	91.6	8,431,167	93.7	9,878,425	93.4
Abrasive [1]			260,657	2.9	260,657	2.5
Chemical	88,680	5.6	155,143	1.7	243,823	2.3
Refractory	20,150	1.3	117,454	1.3	137,604	1.3
Other	23,624	1.5	32,850	.4	56,474	.5
Total [1]	1,579,712	100.0	8,997,271	100.0	10,576,983	100.0
Percent	14.9		85.1		100.0	
1963:						
Alumina	1,539,568	91.8	9,056,047	93.9	10,595,615	93.6
Abrasive [1]			230,045	2.4	230,045	2.0
Chemical	90,583	5.4	158,707	1.6	249,290	2.2
Refractory	26,259	1.6	152,381	1.6	178,640	1.6
Other	21,067	1.2	43,087	.5	64,154	.6
Total [1]	1,677,477	100.0	9,640,267	100.0	11,317,744	100.0
Percent	14.8		85.2		100.0	

[1] Includes consumption by Canadian abrasives industry.

TABLE 5.—Bauxite consumed in the United States in 1963, by grades

(Long tons, dry equivalent)

Grade	Domestic origin	Foreign origin	Total	Percent
Crude	1,558,056	183,133	1,741,189	15.4
Dried	24,789	9,081,891	9,106,680	80.5
Calcined	84,264	375,243	459,507	4.1
Activated	10,368		10,368	
Total	1,677,477	9,640,267	11,317,744	100.0
Percent	14.8	85.2	100.0	

TABLE 6.—Capacities of domestic alumina plants in operation and under construction

Company and plant	Capacity as of Dec. 31, 1963 (short tons per year)	
	Operating plants	Plants under construction
Aluminum Company of America:		
Mobile, Ala	985,500	
Bauxite, Ark	420,000	
Point Comfort, Tex	562,500	187,500
Total	1,968,000	187,500
Reynolds Metals Co.:		
Hurricane Creek, Ark	803,000	
La Quinta, Tex	876,000	
Total	1,679,000	
Kaiser Aluminum & Chemical Corp.:		
Baton Rouge, La	850,000	
Gramercy, La	430,000	
Total	1,280,000	
Ormet Corp.: Burnside, La	345,000	
Grand total	5,272,000	187,500

TABLE 7.—Production and shipments of selected aluminum salts in the United States in 1962

Type of salt	Number of plants producing	Production (short tons)	Total shipments including interplant transfers	
			Short tons	Value (thousands)
Aluminum Sulfate:				
Commercial (17 percent Al_2O_3)	57	917,341	908,269	$32,892
Municipal (17 percent Al_2O_3)	5	4,671		
Iron-free (17 percent Al_2O_3)	16	64,163	31,747	2,062
Aluminum chloride:				
Liquid (32° Be) } Crystal (32° Be) }	10	23,982	13,343	1,092
Anhydrous (100 percent $AlCl_3$)	6	24,966	24,694	6,387
Aluminum fluoride, technical	6	70,515	69,968	18,450
Aluminum hydroxide, trihydrate (100 percent $Al_2O_3 \cdot 3H_2O$)	9	228,900	194,862	13,230
Other inorganic aluminum compounds [1]				11,916
Total				86,029

[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 and Gases.

STOCKS

Bauxite stocks in the United States on December 31, 1963 were 241,000 long dry tons less than at year end 1962. By dry weight, consumers' inventories of crude and processed bauxite decreased 11 percent, and those at mines and processing plants increased 2 percent.

No withdrawals were made from the Government strategic or nonstrategic stockpiles. Jamaican, Surinam, and refractory types of bauxite remained on the group I list of strategic materials for the national stockpile.

During the year, 472,000 long dry tons of Jamaican-type ore and 135,000 tons of Surinam-types ore was acquired by barter, bringing the total Government inventories to 8,030,000 tons of Jamaican-type ore and 7,890,000 tons of Surinam-type ore. Details of the quantities and various types of bauxite and alumina stored in the three Government inventory accounts are shown in tables 8 and 9.

The decrease of 14,000 tons of crude fused aluminum oxide to 178,000 tons in the Government stockpile tabulations of alumina was due to adjusting for establishment of the category "abrasive grain aluminum oxide."

TABLE 8.—Stocks of bauxite in the United States [1]

(Long tons)

Year	Producers and processors		Consumers		Government	Total	
	Crude	Processed [2]	Crude	Processed [2]	Crude	Crude and processed [2]	Dry equivalent
1959	741,228	7,341	543,074	1,998,475	2,204,674	5,494,792	5,013,995
1960	1,225,569	10,242	530,646	1,974,890	2,204,674	5,946,021	5,388,767
1961	1,306,419	9,466	621,729	1,897,635	2,204,674	6,039,923	5,450,930
1962	1,121,705	9,960	542,539	1,920,051	2,204,674	5,798,929	5,246,349
1963	1,143,893	8,967	499,526	1,696,700	2,204,674	5,553,760	5,005,456

[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 bauxite shipped and delivered to domestic alumina plants was estimated at $17.15 per long ton, dry equivalent for imported ore.

Prices per long ton quoted in E&MJ Metal and Mineral Markets for imported bauxite at yearend in 1962 and 1963 were as follows:

	British Guiana f.o.b. port, Dec. 31, 1962	*Atlantic ports f.o.b. cars, Dec. 30, 1963*
Calcined, crushed (abrasive grade)	[1] $21.45	[2] $25.50–$27.50
Refractory grade	27.85	[3] 34.75
Dried bauxite, crushed, chemical grade (60 percent Al_2O_3, 6 percent silica, 1¼ percent iron)	[4] 7.25	13.95

[1] 86 percent minimum Al_2O_3.
[2] 87 percent minimum Al_2O_3.
[3] 88 percent minimum Al_2O_3.
[4] F.o.b. vessels.

TABLE 9.—Government inventories as of December 31, 1963

	Alumina		Bauxite		
	Short dry tons		Long tons		
	Crude fused	Abrasive grain	Metal grade, dried: Jamaican type	Metal grade, dried: Surinam type	Refractory grade calcined
Maximum objective	200,000		2,600,000	6,400,000	137,000
Government inventories:					
National (strategic) stockpile	200,000		880,000	4,963,000	299,000
DPA inventories			1,370,000		
CCC and supplemental stockpile	178,000	49,000	5,780,000	2,927,000	
Total	378,000	49,000	8,030,000	7,890,000	299,000

The average value of calcined alumina, as determined from producer reports, was $0.0326 per pound. The value of imported calcined alumina at the foreign port of shipment was $0.0268 per pound based on first 8 months of 1963. Beginning in September, imported alumina products were included with imported calcined alumina. The combined value for the full year was $0.0278 per pound.

TABLE 10.—Average value of domestic bauxite in the United States [1]

(Per long ton)

Type	Shipments f.o.b. mines or plants: 1962	Shipments f.o.b. mines or plants: 1963	Type	Shipments f.o.b. mines or plants: 1962	Shipments f.o.b. mines or plants: 1963
Crude (undried)	$9.53	$9.57	Calcined	(2)	(2)
Dried	12.26	12.15	Activated	$66.24	$60.58

[1] Calculated from reports to the Bureau of Mines by bauxite producers.
[2] Figure witheld to avoid disclosingi ndividual company confidential data.

TABLE 11.—Average value of U.S. imports and exports of bauxite

(Per long ton)

Type and country	Average value, port of shipment: 1962	Average value, port of shipment: 1963	Type and country	Average value, port of shipment: 1962	Average value, port of shipment: 1963
Imports:			Imports—Continued		
Crude and dried:			Calcined: [1]		
British Guiana	$9.16	$8.98	British Guiana	$23.38	$25.06
Canada	29.87		Greece	(2)	
Dominican Republic [3]	12.38	12.89	Surinam	32.38	27.34
Germany, West		7.28	Average	26.07	25.41
Greece	[4] 8.44	12.45			
Haiti [3]	[4] 9.38	9.59	Exports:		
Jamaica [3]	[4] 12.61	13.82	Bauxite and bauxite concentrate	76.86	77.24
Surinam	9.86	[5] 10.28			
Average	[4] 11.53	12.44			

[1] For refractory use.
[2] Revised to none.
[3] Dry equivalent tons as adjusted by Bureau of Mines used in computation.
[4] Revised figure.
[5] Surinam has been adjusted by the Bureau of Mines to include 73,333 long tons ($796,403) reported as Trinidad and Tobago by the Bureau of the Census.

Source: Bureau of the Census.

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 12.—Market quotations on alumina and aluminum compounds

Compound	Dec. 31, 1962	Dec. 27, 1963
Alumina, calcined, bags, carlots, works____pound__	$0.0530	$0.0530
Aluminum hydrate, heavy, bags, carlots, freight equalized____do____	.0370	.0370
Aluminum sulfate, commercial, ground, bulk, carlots, works, freight equalized__ton__	40.00	40.00
Aluminum sulfate, iron-free, bags, carlots, works, freight equalized_____100 pounds__	3.80	3.80

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE

Imports.—Imports of bauxite, including ores acquired by the U.S. Government, were 9.2 million long tons by dry weight, 13 percent less than in 1962. Imports from Jamaica, the principal source in recent years, were 13 percent less than in 1962 (the record year), and remained at 57 percent of the total. Imports from Surinam decreased 14 percent and remained at 27 percent of the total. The Dominican Republic, Haiti, and British Guiana accounted for most of the remaining imports.

By dry weight, 43 percent of the imports entered through the New Orleans, La., customs district; 34 percent through the Galveston, Tex., district; 21 percent through the Mobile, Ala., district; and 2 percent through other districts.

Imports of calcined alumina for producing aluminum during the first 8 months were 116,044 short tons; 55 percent came from Japan, almost 30 percent came from West Africa (probably Guinea), and 15 percent came from Jamaica. Other aluminum compounds imported into the United States during the same period were 1,766 short tons; 83 percent from Canada, and 16 percent from Austria, West Germany Italy, and France. Japan and the United Kingdom accounted for most of the remainder.

Effective September 1 imports of aluminum oxides and compounds were classified under one category, 417.12, Aluminum Hydroxides and Oxides (alumina). Material imported under this classification totaled 74,499 short tons during the remainder of the year.

Exports.—Exports of bauxite and bauxite concentrate decreased 21 percent. Canada received 60 percent of the exports; Australia, 16 percent; Mexico, 10 percent; and France, 9 percent.

Approximately 40 percent of the 17,576 short tons of aluminum sulfate exported was shipped to Venezuela, and 46 percent was shipped to Viet-Nam, Ecuador, the Dominican Republic, and Canada. Of the 228,076 short tons of other aluminum compounds exported, 51 percent was shipped to Norway and 42 percent was shipped to Japan and Australia. Small quantities were shipped to 64 countries.

Tariff.—The duties on crude bauxite, calcined bauxite, and alumina imported for making aluminum were suspended until July 16, 1964. Duties on aluminum hydroxide and alumina not used for aluminum production were 0.25 cent per pound.

TABLE 13.—U.S. imports for consumption of bauxite (crude and dried)[1] by countries

(Thousand long tons and thousand dollars)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	----------	----------	----------	----------	(2)	----------
Dominican Republic	----------	384	632	722	719	729
Haiti	127	307	341	289	[3] 437	328
Jamaica	3,008	4,220	4,175	4,933	[3] 5,986	5,239
Total	3,135	4,911	5,148	5,944	[3] 7,142	6,296
South America:						
British Guiana	260	160	330	319	560	335
Surinam	2,710	3,078	3,256	2,912	[3] 2,858	[4] 2,518
Other	----------	----------	----------	4	----------	----------
Total	2,970	3,238	3,586	3,235	[3] 3,418	2,853
Europe	(2)	----------	5	27	[3] 15	21
Africa	6	----------	----------	----------	----------	----------
Grand total:						
Quantity	6,111	8,149	8,739	9,206	[3] 10,575	9,170
Value	$49,679	$73,549	$78,024	$88,814	$121,888	$114,077

[1] Import figures for Jamaican, Haitian, and Dominican Republic bauxite adjusted by Bureau of Mines to dry equivalent by deducting 13.6 percent free moisture for Jamaican, 14.6 percent for Haitian bauxite in 1957 and 13.6 percent in 1958 and later, and 17.7 percent for Dominican Republic. Other imports, which are virtually all dried, are on an as-shipped basis. Includes bauxite imported for Government account.
[2] Less than 1,000 tons.
[3] Revised figure.
[4] Surinam has been adjusted by the Bureau of Mines to include 73,333 long tons ($796,403) reported by the Bureau of the Census as Trinidad and Tobago.
Source: Bureau of the Census.

TABLE 14.—U.S. exports of bauxite (including bauxite concentrates),[1] by countries

(Long tons)

Destination	1954–58 (average	1959	1960	1961	1962	1963
North America:						
Canada	21,886	13,377	24,879	108,104	160,811	121,044
Mexico	782	1,614	2,781	562	826	20,245
Other	174	92	406	109	239	79
Total	22,842	15.083	28,066	108,775	161,876	141,368
South America	67	346	92	559	655	455
Europe	368	1,082	577	39,859	62,721	24,362
Asia	308	835	542	1,327	22,861	4,059
Africa	30	57	33	10	51	33
Oceania	----------	----------	7	153	10,397	32,919
Grand total as reported	23,615	17,403	29,317	150,683	258,561	203,196
Dried bauxite equivalent [2]	36,603	29,975	45,441	233,559	400,770	314,954
Value ... thousands	$1,569	$1,825	$2,588	$12,189	$19,874	$15,696

[1] Classified as "Aluminum ores and concentrates" by the Bureau of the Census.
[2] Calculated by Bureau of Mines.
Source: Bureau of the Census.

WORLD REVIEW[3]

A 2-percent decrease in world bauxite production of 700,000 long tons was more than accounted for by a 1.1 million ton drop in production in Jamaica, the major producer (23 percent of the total) and British Guiana. The decline was partially offset by increased output of 381,000 tons in the United States. A tenfold increase in

[3] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

TABLE 15.—World production of bauxite by countries [1]

(Thousand long tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America (dried equivalent of crude ore):						
Dominican Republic	------	759	678	739	706	[2] 729
Haiti	[3] 272	255	268	263	370	327
Jamaica	3,630	5,125	5,745	6,663	7,495	6,903
United States	1,651	1,700	1,998	1,228	1,369	1,525
Total	5,553	7,839	8,689	8,893	9,940	9,484
South America:						
Brazil	54	95	119	110	188	[4] 125
British Guiana	2,203	1,674	2,471	2,374	[4] 2,690	[4] 2,210
Surinam	3,215	3,376	3,400	3,351	3,202	3,427
Total	5,472	5,145	5,990	5,835	6,080	5,762
Europe:						
Austria	21	24	26	18	17	18
France	1,528	1,729	2,035	2,190	2,124	1,971
Germany, West	4	4	4	4	5	[4] 4
Greece	638	904	870	1,100	1,300	[4] 1,280
Hungary	1,053	923	1,171	1,344	1,450	1,340
Italy	287	290	310	318	304	265
Rumania	50	70	87	68	30	[4] 30
Spain	7	8	3	6	6	[4] 6
U.S.S.R. [4]	2,180	3,000	3,500	4,000	4,200	4,300
Yugoslavia	783	802	1,009	1,213	1,311	1,265
Total [4]	6,551	7,754	9,015	10,261	10,747	10,479
Asia:						
China (diasporic) [4]	[5] 150	300	350	400	400	400
India	102	215	381	468	564	556
Indonesia	261	381	389	413	484	485
Malaya	248	382	452	410	349	444
Pakistan	[6] 2	2	1	------	------	------
Sarawak	[5] 136	207	285	253	225	155
Total	899	1,487	1,858	1,944	2,022	2,040
Africa:						
Ghana (exports)	162	148	224	196	287	207
Guinea, Republic of	412	296	1,171	1,739	[4] 1,420	[4] 1,475
Mozambique	4	4	5	5	6	[4] 6
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	------	------	------	------	1	2
Sierra Leone	------	------	------	------	------	30
Total	578	448	1,400	1,940	[4] 1,714	[4] 1,720
Oceania: Australia	8	15	69	16	30	350
World total (estimate)	19,060	22,690	27,020	28,890	30,535	29,835

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] U.S. imports.
[3] Average annual production 1957–58.
[4] Estimate.
[5] 1 year only as 1958 was the 1st year of commercial production.
[6] Average annual production 1955–58.

bauxite production in Australia foreshadows the future importance of that country in the aluminum industry.

World alumina capacity was reported at 14.2 million short tons and additional planned capacity at 1.6 million tons.[4] Although the United States has the largest productive capacity, Australia accounts for the largest portion of the planned increase.

[4] Metal Bulletin (Aluminum Issue). World Aluminum Directory, Alumina. December 1963, pp. 127–129.

A contract in which Nippon Light Metal Co. and Sumitomo Chemical Co. had supplied Harvey Aluminum Inc. with alumina since 1958 was extended for 1 year until June 1964 to furnish 100,000 tons of alumina. Harvey Aluminum Inc. plans to have sufficient alumina capacity by that time.

A review of world bauxite reserves was published, indicating 5.7 billion long tons of reserves and 8.7 billion tons of marginal rsources.[5]

It was reported that British Guiana expected to increase shipments of calcined bauxite to Japan by 11 percent.

TABLE 16.—Relationship of world production of bauxite and aluminum

(Million long tons)

Commodity	1954-58 (average)	1959	1960	[1] 1961	1962	1963
Bauxite	19.0	22.7	27.0	28.9	[1] 30.5	29.8
Aluminum	3.2	4.0	4.5	4.6	5.0	5.4
Tons of bauxite per ton of aluminum produced	5.9	5.7	6.0	6.3	[1] 6.1	5.5

[1] Revised figures.

NORTH AMERICA

Canada.—Aluminum Company of Canada, Ltd. (Alcan), planned to build a liquid aluminum sulfate plant in the Three Rivers area of Quebec. A local market for the product exists with the concentration of papermills in the area.

Jamaica.—The world's major producer of bauxite, Jamaica, accounted for 23 percent of the output. Exports to the United States amounted to 5 million tons, or 76 percent of Jamaica production. Alcan Jamaica Ltd. accounted for the remainder and produced 795,000 short tons of alumina, 13 percent more than in 1962.

By November the initial cargo of bauxite mined at Woodside by Alcoa Minerals of Jamaica, Inc. was shipped from the new port facilities at Rocky Point on the southern coast. The entire complex, including mining equipment, drying facilities, railroad, conveyor lines, storage shed, port facilities, etc., cost $14.5 million for a designed capacity of 300,000 long dry tons of bauxite per year.[6]

Kaiser Bauxite Co. commenced a 5-year program, estimated to cost $30 million, on the north side of the island, and planned to recover 1.5 million tons of bauxite per year. The program includes channel dredging and port facilities at Discovery Bay, a drying and storage plant, railroad facilities, and mining facilities.[7]

[5] Patterson, Sam H. Estimates of World Bauxite Reserves and Potential Resources. U.S. Geol. Survey Prof. Paper 475-B (art. 41), 1963, pp. B156-B158.

[6] Alcoa Prepares To Ship Jamaican Bauxite Next Month. Engineering and Mining Journal. V. 164, No. 10, p. 116. Mining Journal (London). Alcoa's Jamaican Plant. V. 261, No. 6683, Sept. 20, 1963, p. 265.

[7] Bureau of Mines. Mineral Trade Notes. V. 57, No. 3, September 1963, p. 10.

TABLE 17.—Production and trade of bauxite in 1962 by major countries

(Thousand long tons)

Country	Production	Exports by country of destination: 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	706	855		855									
Haiti	370	[2] 505		[2] 505									
Jamaica	7,495	5,987		5,987									
United States	1,369	259	161		51	1	(3)	(3)	10	1	(3)	(3)	35
South America:													
Brazil	188	2											2
British Guiana	[4] 2,690	[5] 1,869	[5] 1,123	[5] 560	[5] 32	[5] 37	[5] 18	[5] 8			[5] 11	[5] 52	[5] 28
Surinam	3,202	3,203	273	2,922						3	3		2
Europe:													
Austria	17	5				5							
France	2,124	262				151	5			101	1		4
Germany, West	5	(3)					(3)				(3)		(3)
Greece	1,300	887		16	43	374		31	304	62	37		20
Hungary	1,450	708				[5] 64			[5] 644				
Italy	304												
Rumania	30	15							15				
Spain	6												
U.S.S.R.	[4] 4,200	(6)											
Yugoslavia	1,311	899			3	668	181	1	45		1		
Asia:													
China (diasporic)	[4] 400	(6)											
India	564	175				29	74			(3)	(3)	72	
Indonesia	484	442										442	
Malaya	349	315										293	22
Sarawak	225	199										160	39
Africa:													
Ghana	[7] 287	287	12			[5] 29				246			
Guinea, Republic of	[4] 1,420	44	[5] 10			[5] 10			1				23
Mozambique	6	(6)											
Oceania: Australia	30	6				6							
World total	[8] 30,535	16,924	1,579	10,845	129	1,374	278	40	1,019	413	53	1,019	175

[1] U.S.S.R. and other Communist nations of East Europe.
[2] U.S. imports.
[3] Less than 500 tons.
[4] Estimate.
[5] Imports.
[6] Data not available.
[7] Exports.
[8] Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

SOUTH AMERICA

Brazil.—Alumina Minas Gerais and the Cia Brasileiro do Aluminio began exploration of bauxite deposits at Pocos de Caldas in Minas Gerais.[8]

British Guiana.—Bauxite and alumina production was adversely affected by a strike that started April 21 and lasted 11 weeks. Production of dried bauxite decreased 48 percent from 1962 production to 974,000 long tons. Reynolds Metals Co. accounted for 296,000 tons of this production, 37 percent less than in 1962. Demerara Bauxite Co., Ltd. produced 365,000 long tons of calcined bauxite and 222,000 long tons of alumina, 1 percent below 1962 production in both cases.[9]

Plans were made to dredge the Berbice River to facilitate transportation of bauxite from mines in the vicinity of Kwakani to a plant at Everton about 140 miles downstream. This will enable Reynolds Metals Co. to ship about 500,000 long tons of bauxite per year.[10]

A United Nations team of four experts initiated a survey of British Guiana's aluminum potential.[11] Aluminum Ltd., issued a fact sheet titled "Bauxite and Alumina From British Guiana," describing aspects of the bauxite industry from mining to manufacture of alumina.

Surinam.—Suriname Aluminum Co. (Suralco) has agreed with the Surinam Government to assume responsibility for a hydroelectric installation on the Suriname River and for the erection of a 60,000-ton aluminum smelter and an alumina plant of at least corresponding size, to be completed by 1965. After 75 years, ownership of the facilities converts to the Surinam Government.[12] The program includes processing at the Suralco alumina plant bauxite mined by N. V. Billiton Maatschappij.[13] Bauxite resource survey in the Bakhuys Mountains estimated 300 million to 400 million tons of ore, of which 200 million tons was first quality.

EUROPE

Austria.—The Unterlaussa bauxite mine, the only one in Austria, was closed owing to uneconomic operation.[14]

Czechoslovakia.—The Metals Research Institute of Panenske Brezany developed a process to produce alumina from domestic flue ash and clay. Although the Czechoslovakian aluminum industry is dependent on imported Hungarian bauxite, the Government has taken no action on a proposal to use the process by rebuilding an old facility.[15]

Greece.—Export bauxite quotas scheduled by the Greek Ministry of Commerce for 1963 were 480,000 tons to European Economic Community (EEC) countries, 450,000 to the U.S.S.R. under the Greek-Soviet trade agreement, and 100,000 tons to other countries

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[8] Light Metals. Expanding Production in Brazil. V. 26, No. 298, March 1963, p. 7.
[9] Bureau of Mines. Mineral Trade Notes. V. 58, No. 4, April 1964, p. 5.
[10] Metals Bulletin (London). Reynolds to Expand BG Bauxite Operations. No. 4817, July 30, 1963, p. 21.
[11] American Metal Market. Aluminum Survey Set for Guiana. V. 70, No. 237, Dec. 12, 1963, p. 10.
[12] Metal Bulletin (London). Suralco's $100 Million Responsibility. No. 4842, Oct. 29, 1963, p. 21.
[13] Mining Journal (London). Alumina Project in Surinam. V. 261, No. 6695, Dec. 13, 1963, p. 571.
[14] Light Metals. V. 26, No. 301, June 1963, p. 5.
[15] E&MJ Metal and Mineral Markets. Czech Plan To Produce Alumina From Clay Ash. V. 34, No. 51, Dec. 15, 1963, pp. 7, 11.

including the United States.[16] The bauxites of Helicon Mining Co. planned to mine 200,000 tons of bauxite per year for 2 years, and then to raise output to 500,000 tons per year.[17]

The Aluminum de Grece, organized and principally financed by the French producers Péchiney, Compagnie de Produits Chimiques et Electrométallurgiques, and Societé d'Electro-Chimie, d'Electro-Metallurgie et des Aciéries Electriques d'Ugine (Ugine), Reynolds Metal Co., the Greek Industrial Development Corp., and Stavros Niarchos, developed plans for a completely integrated aluminum industry on the Bay of Antikira below Mount Parnassus. The proposed plant location is adjacent to extensive bauxite deposits. The plans include modernizing mining operations and developing additional deposits to meet present commitments, increasing exports, and furnishing 450,000 tons of bauxite per year to the plant to produce 200,000 tons of alumina. The plans also specify that 120,000 tons of this production be used to produce 62,000 tons of aluminum. Construction of a hydroelectric plant has started on the Achelos River.[18]

Hungary.—Discovery of a 24- to 32-foot-thick bauxite deposit was reported near the Iskaszentgyörgy mine.[19]

Expansion and renovation started at Alumina Factory (Almasfuzitoi Timfoldgyar) to increase capacity 250 percent by 1970. A change from batch production to instrumented and automated continuous production was planned.[20]

Yugoslavia.—A 38-million-ton bauxite deposit was discovered near Split, Dalmatia.[21]

Six of the largest bauxite mines producing most of the Yugoslav bauxite, agreed to consolidate technical and business enterprises. The mines are located at Rovinj in Istria, Mostar in Hercegovina, Niksic in Montenegro, and Vlasenica, Jajce, and Bosanska Krupa in Bosnia.[22]

Bauxite mines in Drnis, Obrovac, and Sinj, with a 300,000-ton-per-year capacity, contracted sale of only 108,000 tons in 1963. The bauxite was low quality, and production and transportation costs were high.

ASIA

India.—The reserve of bauxite in India was estimated to be 250 million long tons, of which 63 million tons was high grade.[23]

Plans for an aluminum industrial complex at Salem, Madras, including mining a 7-million-ton bauxite deposit in nearby Sheveroy Hills.

A detailed investigation was authorized to explore a bauxite deposit in the Palami Hills in the vicinity of Madurai.[24] A geological survey

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[16] Metal Bulletin (London). Greek Bauxite Quotas. No. 4811, July 9, 1963, p. 10.
[17] Mining Journal (London). Bauxites of Helicon. V. 261, No. 6687, Oct. 18, 1963, p. 367.
[18] Engineering and Mining Journal. Construction Is Under Way on Greek Al Complex. V. 164, No. 10, October 1963, p. 136. Metal Bulletin (London). Parnassus Bauxite Developments. No. 4811, July 9, 1963, pp. 18–19.
[19] Mining Journal (London). New Bauxite Find in Hungary. V. 261, No. 6691, Nov. 15, 1963, p. 473.
[20] Muszaki Elet. Expansion of Alumina Plant. V. 18, No. 9, Apr. 25, 1963, p. 13.
[21] E&MJ Metal and Mineral Markets. Yugoslav Geologists Find 38-Million Tons of Bauxite. V. 35, No. 2, Dec. 13, 1964, p. 3.
[22] Engineering and Mining Journal. Six Yugoslavian Bauxite Mines Will Consolidate. V. 165, No. 1, January 1964, p. 185.
[23] Bureau of Mines. Mineral Trade Notes. V. 57, No. 6, December 1963, p. 12.
[24] American Metal Market. Indian Bauxite Find Explored. V. 70, No. 216, Nov. 8, 1963, p. 29.

resulted in an estimate of 3 million tons of bauxite in Maharashtra State, about 100 miles from Karwar. Baharat Reynolds drafted plans to erect an aluminum smelter.[25]

Approval was reported for a $46.2 million bauxite and aluminum project in Maharashtra, operated by a new company, Koyna Aluminium Corp. Ltd.

Indonesia.—Cost of delivery in Rotterdam of a 10,300-ton cargo of bauxite from Bintan Island, Indonesia, was estimated at $5.60 per ton f.o.b. and $6.30 per ton shipping costs.[26]

Japan.—Two Japanese firms—Sumitomo Chemical Co., Ltd. and Nikkel Kako—contracted to export 4,830 tons of aluminum sulfate to Egypt by September 1964. Previous to this contract New Zealand was the major destination of Japanese aluminum sulfate.[27]

Sumitomo Chemical expanded alumina production from 13,000 tons to 166,000 tons per year.[28]

A plant designed by Bowen Engineering Inc. to produce 15 tons per day of silica-alumina catalyst for the petroleum industry was put into operation by Chemical Industries Co. Ltd.[29]

AFRICA

Ghana.—Annual production of bauxite increased 29 percent in 1963 to 309,393 long tons, but exports decreased about 28 percent.

Bauxite reserves in Awaso, Kibi, Aya-Yenahin, Ejuanema, Nyinahin, and Bekinai were estimated to total from 200 million to 400 million long tons. British Aluminium Co., Ltd., which operated the only producing mine, is 51 percent owned by Tube Investments, Ltd. and 49 percent by Reynolds Metals Co. The bauxite averaged 50 percent aluminum trioxide and was mined from a deposit on Kanaiyeribo Hill near Awaso about 55 miles northwest of Dunkwa. After crushing to minus 3 inch and washing, the ore was transported by railroad to the port of Takoradi.

The bauxite ranges from 30 to 150 feet thick and was formed by redeposition of aluminum and iron hydroxides after removal of silica by acid leaching of lateritized schists and slates. The flat-topped hills on which the bauxite deposits occur were formed by dissection of an ancient peneplane surface.

Kaiser Engineers and Constructors, Inc., completed 50 percent of the Volta River hydroelectric project with a designed capacity of 512 megawatts. Future plans include an aluminum complex which will use a major portion of the power.[30]

Guinea, Republic of.—The Guinea Government canceled an agreement with Bauxites du Midi, a subsidiary of Aluminium, Ltd., to develop the Boké bauxite deposits on notification that the company could not meet the scheduled completion date. This was followed by a reported agreement with Harvey Aluminum Co. for a joint venture in which the Government received 65 percent of the profits and the company was responsible for mining bauxite and furnishing technical

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[25] Mining Journal (London). Indian Aluminium Project. V. 261, No. 6682, Sept. 13, 1963, p. 240.
[26] Metal Bulletin (London). Bintan Bauxite. No. 4813, July 16, 1963, p. 21.
[27] Chemical Trade Journal and Chemical Engineer (London). Aluminium Sulfate for Egypt. V. 153, No. 3991, Dec. 6, 1963, p. 867.
[28] Metal Bulletin (London). Sumitomo Alumina. No. 4780, Mar. 15, 1963, p. 21.
[29] European Chemical News (London). New Catalyst Plant in Japan. V. 3, No. 55, Feb. 1, 1963, p. 26.
[30] Kaiser Builder. March, 1964, pp. 2–15.

assistance. Three stages are programed in the agreement: mining, construction of an alumina refinery, and an aluminum smelter. Mining plans were reported to show a capability of 2 million tons of bauxite per year.[31]

Rhodesia and Nyasaland, Federation of.—A 60-million-ton bauxite deposit in the Mlanje Mountain was under investigation by the Nyasaland Geological Department.[32] It was reported that the ore could be up-graded by removing the free quartz.[33]

Sierra Leone.—Discovery of a bauxite deposit in the Kpaka Chiefdom of Pujehun' district was reported.[34] Aluminium-Industrie-Aktiengesellschaft reached an agreement to obtain 100,000 to 200,000 long tons of bauxite from Sierra Leone through its subsidiary, Sierra Leone Ore and Metal Co.[35] The company opened the Mokanji bauxite mine in southern Sierra Leone and in November exported the first shipment of 10,000 tons to an alumina plant in West Germany.[36]

OCEANIA

Australia.—A new company, Queensland Alumina, Ltd., was formed by Kaiser Aluminum and Chemical, Conzinc Rio Tinto of Australia Ltd., Aluminium Ltd. of Canada and Péchiney to increase the production of alumina in Australia. Plans were drafted to complete by 1967 a 600,000-long-ton-per-year, $112 million alumina plant at Gladstone on the east coast of Australia, 380 miles north of Brisbane. Arrangements were made to divide the output as follows: Kaiser 44 percent; Alcan 20 percent; Péchiney 20 percent; and 16 percent to Comalco (Commonwealth Aluminum Corp. Pty., Ltd., a partnership of Kaiser and Conzinc Rio Tinto). It was agreed to mine bauxite from the Weipa deposit about a thousand miles north of Gladstone on the west coast of Cape York Peninsula. Comalco leased the deposit and has spent $9 million and 6 years to prepare the deposit for mechanized production including mining and port facilities and a 7-mile dredged channel. However, additional development will be needed to meet additional requirements totaling 2 million tons per year.

On July 3, 1963, Nippon Light Metals Co. received 12,000 tons of Comalco bauxite, the first shipment of the 150,000 tons purchased by Japanese aluminum producers.[37]

Proved bauxite reserves at Weipa total more than 600 million tons. Additional exploration will probably increase this to several billion tons.[38]

Swiss Aluminium Ltd. (formerly Aluminium Industrie A.G., Zurich, Switzerland) applied for a 21-square-mile bauxite lease in Arnhem Land, northern Australia, recently forfeited by British Aluminium Co., Ltd. It is adjacent to a lease held by Péchiney and Swiss Al-

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31 Mining Journal (London). Bauxite. Harvey's Guinea Venture. IV, 261, No. 6686, Oct. 11, 1963, p. 329.
32 Engineering and Mining Journal. Regional Mapping by Nyasaland Geological Dept. Is Processeding. V. 164, No. 12, December 1963, p. 168.
33 South African Mining and Engineering Journal (Johannesburg). Bauxite in Nyasaland. V. 74, pt 2, No. 3685, Sept. 20, 1963, p. 860.
34 Mining Engineering. Sierra Leone Reports Bauxite. V. 15, No. 8, August 1963, p. 9.
35 Bureau of Mines. Mineral Trade Notes. V. 58, No. 6, June 1964, p. 5.
36 Bureau of Mines. Mineral Trade Notes. V. 58, No. 2, February 1964, p. 6.
37 Metal Bulletin (London). Australian Bauxite to Japan. No. 4813, July 16, 1963, p. 21.
38 Mining World. V. 25, No. 9, August 1963, p. 41.

uminium. Both these firms tentatively planned 500,000-ton alumina plants with necessary facilities.[39]

Alcoa of Australia started shipments of alumina from the new 210,000-ton plant on the west coast at Kwinana, Australia, to the Point Henry reduction plant in Victoria. Bauxite was supplied from the Jarrahdale deposits in the Darling Range about 30 miles from the plant. About 90,000 tons of alumina per year was scheduled for Point Henry and the balance is for Mitsubishi Chemical Industries, Ltd. of Japan.[40]

TECHNOLOGY

Continued interest in development of processes for extracting alumina from low-grade and nonbauxitic materials was illustrated by the large number of technical reports published during the year.

Processes on the economics of various experimental methods for extracting alumina from nonbauxite ores were reviewed.[41] None were in commercial operation at the end of the year.

During part of the year, the North American Coal Corp. produced a high-grade aluminum sulfate from coal shale at Powhatan, Ohio. A pure aluminum sulfate was crystallized from a sulfuric acid solution by careful control of concentration and temperature. The Kretzchmar process at Dresden, West Germany, also used sulfuric acid and depended on a vacuum crystallization technique to separate aluminum sulfate from iron in solution.

In the Commonwealth Scientific and Industrial Research Organization process, hydrolysis was used to form a basic aluminum sulfate. Olin Mathieson developed a continuous process for producing large, coarse sandlike crystals from the aluminum sulfate solution. The Anaconda process used hydrochloric acid to produce iron and aluminum chlorides which were roasted to oxides. The aluminum chlorides which were roasted to oxides. The aluminum oxides were separated from iron oxides by dissolving in a caustic solution. In a sulfurous acid process silica was precipitated from a 20-percent sulfurous acid solution. Iron sulfite was decomposed to iron oxide under pressure from 230° to 320° F, and the aluminum hydrate was purified by a modified Bayer process. The Pedersen process was used experimentally to produce pig iron and calcium aluminate slag from high silica aluminum ore in an electric furnace. The Péchiney process used a 10w-stack blast furnace, and the alumina and aluminum sulfide slag were hydrolized. An alkaline treatment was applied to the slag to produce pure alumina.

In the potassium process aluminum sulfate was converted to potassium alum. Purification of alum was by a two-step crystallization or two-step liquid-liquid extraction. An ammonium sulfate process was suggested for diaspore clays, whereby ammonium sulfate alum is crystallized after leaching with sulfuric acid. Iron content is reduced by a single-step recrystallization and a two-step liquid-liquid extraction with amines.

[39] Metal Bulletin (London). Alusuisse Wants Gove Bauxite. No. 4831, Sept. 20, 1963, p. 23.
[40] American Metal Market. Alcoa Makes Its First Shipment From Australian Alumina Plant. V. 71, No. 37, Feb. 24, 1964, p. 15.
[41] Sulphur (London). Acid Leaching Processes for Extraction of Alumina From Mineral Ores. No. 45, April 1963, pp. 21–30.

Various aspects in the commercial production of alumina from bauxite were discussed in detail.[42] Practices and methods used in the United States, Great Britian, and various European countrie. were compared. The influence of silica content, calcination, materials of construction, heat transfer methods, extraction process equipment, and problems in design of thickeners was discusseds

Anorthosite containing 27 to 29 percent Al_2O_3 was tested for alumina recovery by the lime soda sinter process.[43] More than 88 percent of the alumina was extracted by using a mole ratio of CaO to SiO_2 of 1.94 and Na_2O to Al_2O_3 of 1.19.

Studies indicated that adding Fe_2O_3 to an anorthosite-soda sinter improved recovery of alumina. However, adding coke in excess of 1.3 percent reduced the recovery of alumina.[44] Poor blending and sintering resulted in an incomplete reaction, leaving excess free CaO which apparently formed an insoluble calcium aluminate, thus causing a loss of alumina.[45]

In the recovery of alumina from monocalcium aluminate in sinters, laboratory studies showed that with a Na_2CO_3 solution containing 10 to 12 percent NaOH about 98 percent of the alumina was extracted.[46]

Alumina was extracted from bauxite containing 15 percent SiO_2, 35 percent Al_2O_3, and 30 percent Fe_2O_3 by calcining the ore at 1,050° C and leaching the silicates with dilute NaOH.[47] The NaOH was recovered from this leach solution by adding CaO and precipitating calcium silicates. The alumina residue (containing Fe_2O_3) from the first leach was then treated by the Bayer process with strong caustic. Results of the tests demonstrated 80-percent recovery of the alumina.

Anaconda continued to operate a 5-ton-per-day pilot plant at Anaconda, Mont., for the production of alumina from high-alumina clay.[48]

The Bureau of Mines released two publications in a series of reports on cost evaluation of processes for the production of metallurgical-grade alumina from low-grade aluminous materials.[49] Relative processing costs, based upon previously published pilot plant and laboratory studies, were estimated from $81.35 to $86.17 per ton of alumina for the sulfuric acid processes and $96.15 for a potassium alum process for a plant producing 1,000 tons a day using clay at $1 per ton.

The Reynolds Metals Co. Sherwin alumina plant near Corpus Christi, Tex., has a rated capacity of 2,400 tons of alumina per day.[50]

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42 Chemical Trade Journal and Chemical Engineer (London). Alumina Production From Bauxite Recent Developments in Bayer Process. (Extracts from paper by A. R. Carr, symposium on Chemical Engineering in the Metallurgical Industries, Edinburgh.) V. 153, No. 3981, Sept. 27, 1963, pp. 456-458.

43 Lundquist, R. V. Recovery of Alumina From Anorthosite, San Gabriel Mountains, California, Using the Lime Soda Sinter Process. BuMines Report of Inv. 6288, 1963, 12 pp.

44 Lundquist, R. V., and E. L. Singleton. Some characteristics of Iron in the Lime Soda Sinter Process for Recovering Alumina From Anorthosite. BuMines Rept. of Inv. 6090, 1962, 13 pp.

45 Lundquist, R. V., and H. Leitch. Two Hydrate Calcium Aluminates Encountered in the Lime Soda Sinter Process. BuMines Rept. of Inv. 6335, 1963, 9 pp.

46 Lundquist, R. V., and H. Leitch. Solubility Characteristics of Monocalcium Aluminate. BuMines Rept. of Inv. 6294, 1963, 9 pp.

47 Holbrook, W. F., and L. A. Yerkes. Extraction of Alumina From Ferruginous Bauxite by a Double-Leach Process. BuMines Rept. of Inv. 6280, 1963, 20 pp.

48 American Metal Market. Alumina-Bearing Clay Breakthrough Indicated. V. 70, No. 94, May 16, 1963, pp. 1-2.

49 Peters, F. A., P. W. Johnson, and R. C. Kirby. Methods for Producing Alumina From Clay. An Evaluation of Three Sulfuric Acid Processes. BuMines Rept. of Inv. 6229, 1963, 57 pp.

———. Methods for Producing Alumina From Clay. An Evaluation of a Potassium Alum Process. BuMines Rept. of Inv. 6290, 1963, 27 pp.

50 Minerals Processing. Seven Rotary Kilns Provide 2,400 Tons-Per-Day Capacity at Reynolds Sherwin Alumina Plant. V. 4, No. 10, 1963, pp. 20-23.

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Bauxite from Jamaica and Haiti was wet-ground in rodmills with a spent sodium aluminate liquor to 98 percent minus 20 mesh. The slurry was pumped to digesters containing strong caustic and heated to approximately 390° F at 200 pounds per square inch. The resulting slurry of sodium aluminate solution containing about 4 percent solids (red mud) was pumped through heat recovery vessels to mud settlers. The underflow containing 20 percent solids was pumped to thickeners, and the overflow with 20 to 55 parts per million solids was pumped to filters. More than 93 percent of the sodium aluminate solution was precipitated by seeding and recovered in settling tanks. The spent liquor was recirculated. Free moisture and water of crystallization was removed in seven calcining rotary kilns operating at 2,000° to 2,300° F. The calcined alumina was cooled to 160° to 200° F and transported to storage silos. An eighth kiln was used to eliminate tramp sodium-organic salts from plant liquor and reclaim sodium hydroxide from sodium carbonate. The Sherwin plant also was described in an earlier article.[51]

Electronic conveyor scales were installed at the Ormet Corp. alumina plant at Burnside, La.[52] The scales were used for both process regulation and inventory.

A paper describing the two-step theory of the origin of Guiana bauxite was published.[53] The first step was weathering of metamorphic and igneous rocks bordering the peneplane and transportation of the weathered products over the low land areas, with a predominance of kaolin near the coast. The second step was presumed to start with a slight uplift of the coastal plain, permitting bauxitization to occur through the leaching action of surface waters on the kaolin. Assuming that the bauxite was formed at considerable distance above the basement rocks, the configuration of the basement had little effect on the formation of the bauxite.

A discussion of the paper questioned the occurrence of only one period of bauxitization (Pleistocene, high- and medium-level bauxites); it was suggested that low-level and plateau-type bauxites might have been formed during Tertiary and pre-Tertiary time and that a determination of the configuration of the basement rock would be useful for exploration of the two latter types of bauxite.[54]

Another discussion of the paper suggests that there may be bauxite in those parts of the coastal plain that overlie basement highs, as well as plateau-type bauxite, such as that in the Bakhuis Mountains where 300 million to 400 million tons of 45 percent available alumina is inferred.[55]

A paper describing the formation of Jamaica bauxite from weathering of Oligocene and Miocene limestone was published.[56] In tropical and subtropical climates solutions of oxygenated water and carbonic

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[51] Engineering and Mining Journal. Reynolds Expands Alumina Production. V. 160, No. 5, May 1959, pp. 98–101.

[52] Canadian Mining Journal. Burnside Alumina Plant. V. 84, No. 1, January 1963, pp. 64–66.

[53] Moses, J. H., and W. D. Michell. Bauxite Deposits of British Guiana and Surinam in Relation to Underlying Unconsolidated Sediments Suggesting Two-Step Origin. Econ. Geol., v. 58, No. 2, March–April 1963, pp. 250–262.

[54] de Vletter, D. R. Genesis of Bauxite Deposits in Surinam and British Guiana. Econ. Geol., v. 58, No. 6, September–October 1963, pp. 1002–1008.

[55] Doeve, G., and W. O. J. G. Meijer. Bauxite Deposits of British Guiana and Surinam in Relation to Underlying Unconsolidated Sediments Suggesting Two-Step Origin, Econ. Geol., v. 58, No. 7, November 1963, pp. 1160–1162.

[56] Economic Geology. Jamaica Type Bauxites Developed on Limestones. v. 58, No. 1, January–February 1963, pp. 62–69.

acid reacted with the sodium and calcium aluminum silicates in the rocks to produce gibbsitic bauxite in Jamaica as a residual lateritic deposit. The boehmitic and diasporic deposits in France and Greece were residual deposits formed on top of the older Lower Cretaceous limestones.

Jamaican bauxites are soft, earthy or shaly, uniformly porous, and generally dark red or yellow and occasionally white (less than 7 percent Fe_2O_3). Composition ranges from 47 to 59 percent Al_2O_3, 6 to 23 percent Fe_2O_3, 2.0 to 3.5 percent TiO_2, 0.1 to 5.0 percent SiO_2, 25 to 31 percent H_2O, and 0.5 to 8.6 others. The boehmitic and diasporic bauxites in the Mediterranean area are higher in Al_2O_3 and lower in Fe_2O_3 and H_2O.

Berylium

By Donald E. Eilertsen [1]

DOMESTIC cobbed beryl production declined from 218 tons in 1962 to only 1 ton in 1963. Other figures for cobbed beryl in 1963 were: Consumption, 7,934 tons; imports, 6,243 tons; and world production, 7,400 tons, which includes 750 tons of beryllium ore. New uses for beryllium continued to develop.

LEGISLATION AND GOVERNMENT PROGRAMS

No beryl or beryllium-copper master alloy was acquired in 1963 for stockpiling under the Strategic and Critical Materials Stockpiling Act of 1946 (Public Law 520, 79th Cong.).

Under the Agricultural Trade Development and Assistance Act of 1954 surplus agricultural commodities could be bartered with certain countries for strategic materials including beryl, beryllium-copper master alloy, and beryllium for the supplemental stockpile. During 1963, 900 tons of beryl and 76 tons of beryllium were acquired under this program, 4 additional tons of beryllium remained on order for delivery in 1964. A total of 108 tons of beryllium was transferred from CCC stocks to the supplemental stockpile.

TABLE 1.—Salient beryl statistics

	1954–1958 (average)	1959	1960	1961	1962	1963
United States:						
Beryl, approximately 11 percent BeO unless otherwise stated:						
Domestic beryl shipped from mines short tons	520	328	244	317	218	1
Value, delivered	$263,315	$170,523	$121,105	(1)	(1)	(1)
Other domestic low-grade beryllium materials short tons	(2)	97	265	805	760	750
Value, delivered	(2)	$8,622	$41,250	(1)	(1)	(1)
Imports short tons	7,223	8,038	8,943	8,516	8,552	6,243
Consumption do	4,092	8,173	9,692	9,392	7,758	7,934
Price, approximate, per unit Beo, domestic, cobbed beryl, delivered	$46	$47	$45	(1)	(1)	(1)
Price, approximate, per unit BeO, domestic, low-grade beryllium materials, delivered	(2)	$20	$31	(1)	(1)	(1)
Price, approximate, per unit BeO, imported, cobbed beryl at port of exportation	$34	$27	$29	$30	$31	$24
World: Production short tons	9,800	11,200	12,300	12,900	10,900	7,400

[1] Figure withheld to avoid disclosing individual company confidential data.
[2] Material first available in 1958; figures for that year were 42 tons, valued at $5,000.

[1] Commodity specialist, Division of Minerals.

The Office of Minerals Exploration, U.S. Department of the Interior, offered financial assistance up to 50 percent of approved costs to explore for all types of beryllium ore. No new contract for beryllium exploration was made in 1963.

DOMESTIC PRODUCTION

Mine Production.—Production (mine shipments) of beryllium source materials from four States totaled 751 tons. This consisted of slightly more than 1 ton of cobbed beryl from Colorado, South Dakota, Utah, and Wyoming and 750 tons of beryl-bertrandite-euclase ore containing 3 percent BeO from Colorado.

Mineral Concentrates and Chemical Co., Inc., produced a small quantity of flotation concentrate from beryl-bertrandite-euclase ore in its Tarryall flotation plant near Lake George, Colo.

TABLE 2.—Cobbed beryl and beryllium ore shipped from mines in the United States by States

State	1962				1963			
	Cobbed beryl (short tons)	Units BeO	Beryllium ore (short tons)	Units BeO	Cobbed beryl (short tons)	Units BeO	Beryllium ore (short tons)	Units BeO
Colorado	22	277	760	2,320			750	2,250
New Hampshire	7	79						
New Mexico	34	380						
South Dakota	144	1,557						
Other States [1]	11	110			1	16		
Total	218	2,403	760	2,320	1	16	750	2,250

[1] 1962—Arizona, Connecticut, Maine, and Wyoming; 1963—Colorado, South Dakota, Utah, and Wyoming.

Refinery Production.—The Beryllium Corp. of Reading and Hazleton, Pa., and The Brush Beryllium Co. of Elmore, Ohio, were the only firms in the United States that processed hand-sorted beryl into beryllium metal, alloys, and compounds; output was mostly beryllium metal and beryllium-copper master alloy. Production data are company confidential.

Beryllium Metals & Chemicals Corp., Bessemer City, N.C., a subsidiary of Lithium Corporation of America, Inc., produced a small quantity of electrorefined beryllium.

Mineral Concentrates and Chemical Co., Inc., Loveland, Colo., produced small quantities of various beryllium compounds.

The Brush Beryllium Co. secured beryllium ore deposits in the Topaz Mountain area, Utah, from Vitro Corporation of America and the Rochester & Pittsburgh Coal Co., in addition to deposits acquired from Beryllium Resources, Inc., in October 1962. Studies got under way to determine what intermediate product would be produced in Utah for conversion to beryllium at the Elmore, Ohio, plant.

The Anaconda Company announced that beryllium fabrication facilities of General Astrometals Corp., Yonkers, N.Y. (80-percent owned by Anaconda), moved into production. The company also reported that a pilot plant would be completed at Anaconda, Mont., to develop methods for extracting beryllium from Anaconda's beryllium mineral concentrate and also to recover beryllium from scrap.

CONSUMPTION AND USES

Almost all of the cobbed beryl consumption of 7,934 tons was processed into beryllium metal and its alloys and compounds.

Sales of The Beryllium Corp. were $28.2 million, compared with $27.1 million in 1962. The Brush Beryllium Co. sales were $24.3 million, compared with $22.6 million in 1962.

Other consumers of cobbed beryl were Lapp Insulator Co., LeRoy, N.Y., which used ground beryl in making high-voltage electrical porcelain; and the Ceramic Division, Champion Spark Plug Co., Detroit, Mich., which used beryl as a minor constituent in special ceramic compositions, principally spark plugs.

In addition to Government stockpile acquisitions, large quantities of beryllium metal were utilized in nuclear energy and in special applications for aircraft, missiles, and space exploration vehicles as well as in research and development in these fields. Beryllium was used as a neutron reflector and/or moderator material and sometimes as a shield in certain nuclear reactors. Quantities of beryllium used in individual reactors vary from a few pounds as in Systems for Nuclear Auxiliary Power (SNAP) devices to 3,500 pounds as in the Advanced Test Reactor. Beryllium was used in inertial guidance hardware, and was of special interest for application as a structural material in the aerospace industry. The Minuteman missile, capable of delivering a warhead 6,300 miles away, was reported to contain a beryllium spacer to join the guidance and control compartment with its re-entry vehicle. Use of beryllium in jet engine compressor blades and as a rocket fuel were under study. New high-strength hot-pressed beryllium block, having fine-grain structure and high beryllium oxide content, was available.

Heat treatable beryllium copper alloys, well known for their outstanding high strength and high thermal and electrical conductivity in a wide variety of uses, continued to be a principal support of the beryllium industry. Some uses for this alloy were in business machines, electronic devices, automobile and aircraft products, household appliances, and housings to protect undersea telephone systems. Individual beryllium-copper parts ranged in size from smaller than a match head to pieces weighing a hundred or more pounds.

Heat-treatable beryllium-nickel alloys were used in many applications demanding high strength, hardness, and toughness.

Beryllium was used as an alloying constituent to improve the processing and properties of light metals. New beryllium-aluminum alloys containing mostly beryllium were available and attracted attention.

Beryllium oxide was used in nuclear reactors and in a wide variety of commercial applications, especially for ceramic parts. The oxide also was used in resistor cores and began to have a place in household switches and rheostats.

STOCKS

Consumers stocks of cobbed beryl at the end of the year totaled 8,686 tons. Producers yearend stocks of beryllium metal and beryllium-copper master alloy were larger than in 1962.

As of December 31, 1963, the national (strategic) stockpile contained an equivalent of 23,230 tons of beryl which also included the beryllium content of 1,075 tons of beryllium-copper master alloy.

Additional Government stocks of beryllium bearing materials on hand at yearend were as follows: Supplemental stockpile, 108 tons of beryllium metal and 11,321 tons of beryl (the beryl included the beryllium content of 6,312 tons of beryllium-copper master alloy); CCC stocks, 37 tons of beryllium and 900 tons of beryl; and Defense Production Act stocks, 2,087 tons of domestically produced stockpile-grade beryl and 456 tons of domestically produced nonstockpile grade beryl.

PRICES AND SPECIFICATIONS

Prices for domestic cobbed beryl were on a buyer and seller basis and were not published. Imported beryl, per short ton unit of BeO, based on 10 to 12 percent BeO, c.i.f. U.S. ports, was quoted at $29 to $32 on spot contracts.[2]

The price of beryllium metal, 97 percent pure, lump or beads, f.o.b. Reading, Pa., and Cleveland, Ohio, was quoted at $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. Beryllium-copper master alloy was quoted f.o.b. Reading, Pa., Detroit, Mich., and Elmore, Ohio, at $43 per pound of contained beryllium with copper paid for at the market price on date of shipment. Beryllium-copper strip, rod, bar, and wire were quoted at $2.01 per pound. Beryllium-aluminum was quoted at $65 per pound of contained beryllium with aluminum paid for at the market price. Beryllium-magnesium-aluminum was quoted at $60 per pound of contained beryllium with magnesium and aluminum paid for at the market price.[3]

The Brush Beryllium Co., quoted the following prices per pound of beryllia: GC regular grade, $15; GC high-fired grade, $16; and UOX grade: Minus 20 mesh (dry screened), $20; minus 100 mesh (wet screened), $23; and minus 200 mesh (wet screened), $26.

FOREIGN TRADE

Imports.—Imports of cobbed beryl decreased 27 percent compared with that of 1962. Imports of beryllium oxide or carbonate were 200 pounds, valued at $2,524, from France; and a fraction of a pound, valued at $501, from the United Kingdom. Some beryllium metal not separately reported from other commodities may have been imported before September 1. Since September 1, imports of unwrought, waste, and scrap beryllium were 1,650 pounds, valued at $94,995, from

[2] E&MJ Metal and Mineral Markets. V. 34, Nos. 1–52, January–December 1963.
[3] American Metal Market. V. 70, Nos. 1–249, January–December 1963.

France; 2,426 pounds, valued at $1,261, from the Netherlands; 25,240 pounds, valued at $13,027, from West Germany; and 2,572 pounds, valued at $1,519, from the United Kingdom. Other imports reported only since September 1 were 13 pounds of wrought beryllium, valued at $3,359, from France and 2,110 pounds of other beryllium compounds, valued at $3,299, also from France.

TABLE 3.—U.S. imports for consumption of beryl, by countries

(Short tons)

Country	1962	1963
South America:		
Argentina	997	718
Bolivia	------	33
Brazil	3, 715	2, 280
Total	4, 712	3, 031
Europe:		
Portugal	48	------
Sweden	26	------
Total	74	------
Asia:		
India	150	------
Japan	(1)	------
Total	150	------
Africa:		
British East Africa and Tanganyika (principally Uganda)	1, 043	664
British West Africa, n.e.c	37	------
Congo, Republic of the, and Ruanda-Urundi	485	510
Malagasy Republic	293	324
Mozambique	678	850
Rhodesia and Nyasaland, Federation of	322	347
South Africa, Republic of (includes South-West Africa)	519	394
Total	3, 377	3, 089
Oceania: Australia	239	123
Grand total: Short tons	8, 552	6, 243
Aalue	$2, 897, 495	$1, 671, 590

1 Less than 1 ton.

Source: Bureau of the Census.

Exports.—One-quarter ton of beryllium ore concentrate, valued at $3,150, was exported to France. Other exports are shown in table 4.

WORLD REVIEW

World production of beryl totaling 7,400 tons, consisted of 6,650 tons of hand-sorted beryl containing approximately 11 percent BeO and 750 tons of beryl-bertrandite-euclase ore containing 3 percent BeO.

France.—Production totals of 8.9 tons of beryllium metal valued at approximately US$1,147,000 and 230 tons of beryllium-copper alloy valued at about US$634,000 were reported for 1962.

Japan.—A total of 275 tons of beryllium-copper master alloy was produced in 1962. Monthly production of Nippon Gaishi Kaisha, Ltd., Tokyo, was 17.6 tons per month while that of Yokozawa Kagaku Kogyo, Tokyo, was 5.5 tons. Both of these firms also produced small experimental quantities of beryllium. In addition, Santoku Kinzoku

TABLE 4.—U.S. exports of beryllium products, in 1963, by countries

Destination	Beryllium and beryllium alloy (except beryllium copper) metal powders		Beryllium metal and alloys (except beryllium copper) in crude form and scrap		Beryllium and beryllium alloys in semifabricated forms, n.e.c.	
	Pounds	Value	Pounds	Value	Pounds	Value
Argentina					1	$520
Australia			3,493	$12,440		
Canada	4,042	$12,074	12,210	29,857	19	7,305
Canal Zone			5	268		
Denmark					3	902
France					588	60,820
Germany, West	41	1,564	34,062	102,636	39	8,478
India	8	716	550	1,771	3	1,265
Italy			7,762	25,618		
Japan			2,640	31,044		
Mexico	1,800	1,376	2,200	7,526	23	8,660
Netherlands					6	1,964
Norway			6,604	21,623		
Spain			2,112	7,107		
Sweden	4	326				
Switzerland			1,762	5,920	12	4,738
United Kingdom	120	7,493	16,884	52,112	80	28,577
Yugoslavia			2,750	9,133		
Total	6,015	23,549	93,034	307,055	774	123,229

Source: Bureau of the Census.

Kogyo, Nagoya, reportedly produced a limited quantity of beryllium-aluminum alloy. Japanese imports of beryl are mostly from South America and Africa and average about 500 tons per year. Beryllium oxide imports for the first 6 months of 1963 were valued at about US$131.[4]

Malagasy Republic.—A comprehensive report describing beryllium and many other mineral resources of the Malagasy Republic was published.[5]

TECHNOLOGY

Research continued on recovery, preparation, and utilization of beryllium for civilian, military, nuclear, and space applications. The magnitude of research in progress was much smaller in 1963 than in either 1962 or 1961.

Principal features of the Bureau of Mines program on beryllium were the continuation of the widespread study of potential domestic beryllium resources and the extensive research on developing milling methods to recover disseminated beryl and other beryllium minerals from submarginal deposits; extracting beryllium oxide from various mineral concentrate and ores; preparing high-purity beryllium from its chloride and oxide; electrorefining beryllium metal; and casting beryllium shapes. Some results of California and Nevada beryllium resource investigations were published.[6] The occurrence of beryllium and many other elements in coals was summarized.[7] A mobile laboratory was developed and used in connection with beryllium resource

[4] Bureau of Mines. Mineral Trade Notes. Vol. 57, No. 4, October 1963, p. 5.
[5] Murdock, Thomas G. Mineral Resources of the Malagasy Republic. BuMines Inf. Circ. 8196, 1963, 147 pp.
[6] Holmes, George H., Jr. Beryllium Investigations in California and Nevada, 1959–62. BuMines Inf. Circ. 8158, 1963, 19 pp.
[7] Abernethy, R. F., and F. H. Gibson. Rare elements in Coal. BuMines Inf. Circ. 8163, 1963, 69 pp.

TABLE 5.—World production of beryl by countries [1]

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America: United States (mine shipments):						
Cobbed beryl	528	328	244	317	218	1
Other lower grade beryllium ore	----------	97	265	805	760	750
Total	528	425	509	1,122	978	751
South America:						
Argentina	1,299	[2] 3,336	[2] 1,157	[2] 1,488	[3] 996	[3] 718
Brazil (exports)	1,861	2,927	3,827	3,503	3,319	2,169
Total	3,160	6,263	4,984	4,991	4,315	2,887
Europe:						
Norway (U.S. imports)	1	4	----------	----------	----------	----------
Portugal	238	41	32	39	19	1
Sweden (U.S. imports)	----------	41	----------	----------	----------	----------
U.S.S.R. [4] [5]	150	550	750	900	1,000	1,100
Total [4]	390	640	780	940	1,020	1,100
Asia:						
Afghanistan	21	----------	11	----------	----------	----------
India (U.S. imports)	1,291	----------	1,000	885	150	----------
Korea, Republic of	[3] 2	----------	----------	6	----------	----------
Total	1,314	----------	1,011	891	150	----------
Africa:						
Congo, Republic of the	960	280	369	184	304	[3] 510
Kenya	2	2	1	1	----------	----------
Malagasy Republic	323	474	701	836	743	[2] 239
Morocco	3	----------	----------	----------	----------	----------
Mozambique	1,187	1,559	1,649	1,073	627	[4] 600
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	11	2	2	----------	----------	----------
Southern Rhodesia	710	440	539	396	559	249
Ruanda-Urundi	80	187	310	525	394	(6)
South Africa, Republic of	330	203	326	192	360	425
South-West Africa	424	170	413	252	159	61
Swaziland	----------	2	6	7	----------	2
Uganda	90	235	470	1,136	1,015	381
Total	4,120	3,554	4,786	4,602	4,161	2,467
Oceania: Australia	294	355	213	343	250	[4] 150
World total (estimate) [1]	9,800	11,200	12,300	12,900	10,900	7,400

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Exports.
[3] United States imports.
[4] Estimate.
[5] Cobbed concentrates at about 11 percent BeO.
[6] Ruanda-Urundi included in Republic of the Congo in 1963.

studies in the northwestern United States.[8] A flotation method to separate phenacite, bertrandite, and also beryl if present, from low-grade ores was patented.[9] Fluosilicate sintering, sulfuric acid leaching, and solvent extraction appeared to be feasible phases in extracting beryllium from Spor Mountain, Utah, ores.[10] The fluosilicate sinter-

[8] Pattee, E. C., and R. D. Weldin. A Mobile Spectroscopic Laboratory for Reconnaissance and Exploration. BuMines Rept. of Inv. 6208, 1963, 22 pp.
[9] Havens, Richard (assigned to the U.S. Department of the Interior). Flotation Process for Concentration of Phenacite and Bertrandite. U.S. Pat. 3,078,997, Feb. 26, 1963.
[10] Crocker, Laird, R. O. Dannenberg, and D. W. Bridges. Acid Leaching of Beryllium Ore From Spor Mountain, Utah. BuMines Rept. of Inv. 6322, 1963, 16 pp.
Crocker, Laird, R. O. Dannenberg, D. W. Bridges, and J. B. Rosenbaum. Recovery of Beryllium From Spor Mountain, Utah, Ore by Solvent Extraction and Caustic Stripping. BuMines Rept. of Inv. 6173, 1963, 27 pp.
Dannenberg, R. O., D. W. Bridges, and J. B. Rosenbaum. Recovery of Beryllium From Utah Ore by the Fluosilicate Process. BuMines Rept. of Inv. 6156, 1963, 12 pp.

water leach process appeared to have good potential as a phase in extracting beryllium from 10 to 30 percent beryl (1.4 to 4.2 percent BeO) concentrate products which were obtained from spodumene-mill tailing in connection with studies on recovering the vast supply of disseminated beryl in pegmatites of the tin-spodumene belt of North Carolina.[11] Heat capacity and enthalpy values for beryllium sulfate through the ranges of 10° to 300° K were determined.[12]

The Geological Survey published a number of beryllium reports. Beryllium deposits in the Lost River area of Seward Peninsula, Alaska, were found to consist of replacement veins, pipes, and stringer lodes in limestone in an area of 14 to 21 square miles and to contain up to 10 percent chrysoberyl and small quantities of other beryllium minerals.[13] Geological reports on Spor Mountain, Utah, beryllium deposits were made,[14] and the association of beryllium with fluorine in this and other deposits was discussed.[15] The Helen Beryl, Elkhorn, and Tin Mountain pegmatites in Custer County, South Dakota, and tin deposits in Virginia were investigated for beryllium.[16]

The U.S. Atomic Energy Commission (AEC) reduced its beryllium research to a minimum. The major work was on purification and its effect on the mechanical behavior of beryllium single crystals. Plans were under way to continue this work until a clear picture of the effects of purification on the mechanical properties of beryllium is established.

U.S. Armed Forces research on beryllium was concerned with developing better analytical techniques for the high-purity metal, obtaining a better understanding of the physical and chemical properties, and developing larger strategic uses for the metal.

Studies on the structural aspect of beryllium utilization were revealed.[17]

The status of the technological development of beryllium and of beryllium utilization were briefly summarized.[18]

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[11] Dannenberg, R. O., D. W. Bridges, and J. B. Rosenbaum. Treating Beryl-Spodumene Concentrates Containing 10 to 30 Percent Beryl by the Fluosilicate Process. BuMines Rept. of Inv. 6153, 1963, 18 pp.

[12] Taylor, A. R., Jr., T. Estelle Gardner, and D. F. Smith. Thermodynamic Properties of Beryllium Sulfate from 0° to 900° K. BuMines Rept. of Inv. 6240, 1963, 8 pp.

[13] Sainsbury, C. L. Beryllium Deposits of the Western Seward Peninsula, Alaska. Geol. Survey Circ. 479, 1963, 18 pp.

[14] Staatz, Mortimer H. Geology of the Beryllium Deposits in the Thomas Range Juab County, Utah. Geol. Survey Bull. 1142–M, 1963, M1–M36 pp.

[15] Griffitts, Wallace R., and Howard A. Powers. Beryllium and Fluorine Content of Some Silicic Volcanic Glasses From Western United States. Geol. Survey Research 1963, Prof. Paper 475–B, Art. 5, pp. B18–B19.

Griffitts, Wallace R., and L. F. Rader, Jr. Beryllium and Fluorine in Mineralized Tuff. Spor Mountain, Juab County, Utah. Geol. Survey Research 1963, Prof. Paper 475–B, Art. 4, pp. B16–B17.

[16] Lesure, F. G., T. H. Kiilsgaard, C. E. Brown, and M. E. Mrose. Beryllium in the Tin Deposits of Irish Creek, Virginia. Geol. Survey Research 1963, Prof. Paper 475–B, Art. 3, pp. B12–B15.

Staatz, Mortimer H., Lincoln R. Page, James J. Norton, and Verl R. Wilmarth. Exploration for Beryllium at the Helen Beryl, Elkhorn, and Tin Mountain Pegmatites Custer County, S. Dak. Geol. Survey Prof. Paper 297–C, 1963, pp. 129–197.

[17] Materials Advisory Board. Beryllium in Aerospace Structures. Nat. Acad. Sci. Nat. Res. Council, MAB–193–M. July 1, 1963, 20 pp.

[18] Hodge, Webster. The Current Status and 1970 Potential of Selected Defense Metals (section on beryllium). Defense Metals Inf. Center, Battelle Memorial Inst., DMIC Memorandum 183, Oct. 31, 1963, 37 pp.

Numerous patents on beryllium technology were issued.[19]

Seventy papers presented at the International Conference on Metallurgy of Beryllium held in London in 1961 together with summaries of discussions were published.[20]

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[19] Cook, Charles C. (assigned to Vitro Corp. of America). Process for Concentrating Beryllium Minerals. U.S. Pat. 3,112,260, Nov. 26, 1963.

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Kirpatrich, William J., and Earl S. Funston (assigned to General Electric Co.). Method of Making High Purity, Substantially Spherical Discrete Particles of Beryllium Hydroxide or Oxide. U.S. Pat. 3,099,532, July 30, 1963.

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Ramsden, Hugh E. (assigned to Metals & Thermite Corp.). Reaction Products of Boron Hydrides With Vinyl Containing Aluminum Silicon, Aluminum or Beryllium Compounds. U.S. Pat. 3,072,699, Jan. 8, 1963.

Richmond, John L., and Charles E. Wells (assigned to Atomic Energy Commission). Neutron Source. U.S. Pat. 3,073,768, Jan. 15, 1963.

Sturm, Bernard J. (assigned to U.S. Atomic Energy Commission). Method of Preparation of Sinterable Beryllium Oxide. U.S. Pat. 3,100,686, Aug. 13, 1963.

[20] Institute of Metals (London). The Metallurgy of Beryllium. Monograph and Report Series No. 28, 1963, 879 pp. (obtainable also from Am. Soc. Metals).

Bismuth

By Donald E. Moulds [1]

THE DOMESTIC bismuth industry reported an increase in consumption and a decrease in production of refined bismuth in 1963. Imports were increased but did not fully compensate for the decrease in domestic production and consumer stocks declined slightly. The government did not purchase any bismuth during the year although a small amount delivered in 1962 was added to the stockpile and all Commodity Credit Corporation (CCC) stocks were transferred to the supplemental stockpile.

World production during 1963 was estimated at 6.5 million pounds, approximately 3 percent below the 1962 output. The quoted market price of bismuth metal in New York remained unchanged at $2.25 per pound in 1-ton lots.

TABLE 1.—Salient bismuth statistics

(Pounds)

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Consumption	1,471,600	1,598,000	1,527,300	1,478,400	1,909,500	2,175,000
Imports, general	728,639	457,163	1,167,019	798,518	816,190	1,123,466
Exports	220,665	179,744	156,636	167,166	118,056	32,293
Price: New York, ton lots	$2.25	$2.25	$2.25	$2.25	$2.25	$2.25
Stocks Dec. 31: Consumer and dealer	327,500	472,000	362,800	323,000	447,800	428,100
World: Production	4,600,000	5,000,000	5,300,000	5,100,000	6,700,000	6,500,000

DOMESTIC PRODUCTION

Domestic bismuth, derived from foreign and domestic base-metal ore and segregated in the smelting and refining of these ores, is ultimately recovered as a byproduct of lead refineries. An additional source is alloy scrap reclamation. Companies reporting production to the Bureau of Mines were American Smelting and Refining Company, The Anaconda Company, United States Smelting Lead Refinery Inc., and United Refining & Smelting Co. Production from primary sources declined 28 percent from the abnormally high level of 1962 and recovery of secondary material increased slightly.

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[1] Commodity specialist, Division of Minerals.

CONSUMPTION AND USES

Consumption of refined bismuth metal reached 2.2 million pounds, 14 percent above the 1962 consumption and 45 percent above the average annual quantity for the period 1954–61. The leading use of bismuth in 1963 was in the major classification of pharmaceuticals, including industrial and laboratory chemicals. The 25-percent increase in comparison with 1962 resulted from a substantial advance in production of industrial chemicals. Consumption in the form of fusible alloys decreased slightly while use in other types of alloys, principally as an additive to improve machinability of aluminum and malleable iron, increased about 30 percent over that of 1962. A significant feature of the 1963 consumption was the substantial increase in dissipative uses of bismuth as minor additive in alloys and in industrial chemicals in comparison with the nondissipative recycling of most of the bismuth used in manufacturing fusible alloys.

TABLE 2.—Bismuth metal consumed in the United States, by uses

(Pounds)

Use	1962	1963	Use	1962	1963
Fusible alloys	[1] 795,588	763,862	Experimental uses	5,212	6,433
Other alloys	442,040	572,543	Other uses	21,559	23,817
Pharmaceuticals [2]	645,149	808,383			
			Total	1,909,548	2,175,038

[1] Includes 159,188 pounds of bismuth contained in bismuth-lead bullion used directly in the production o an end product in 1962 and 168,137 pounds in 1963.
[2] Includes industrial and laboratory chemicals.

STOCKS

Consumer and dealer stocks of refined bismuth decreased from 448,000 pounds at the beginning of the year to 428,000 pounds at yearend, as reported to the Bureau of Mines. Additional stocks of bismuth in the form of bismuth-lead bullion and other intermediate smelter products were held by refineries.

Government stockpiles contained 3,835,000 pounds of bismuth metal; this quantity remained essentially unchanged during the year. Of this total, the national stockpile held 1,305,800 pounds; the supplemental stockpile, 2,506,500 pounds; and the Defense Production Act stockpile, 22,900 pounds. The surplus held above the objective amounted to 835,000 pounds. An additional 36,600 pounds of nonstockpile grade bismuth was in government holdings.

PRICES

The price of refined bismuth as quoted by the E&MJ Metal and Mineral Market (New York) and the Metal Bulletin (London) continued unchanged during the year. The last price change occurred on September 5, 1950, when the New York price advanced from $2.00 to $2.25 per pound. The Metal Bulletin quotation for bismuth ores also continued unchanged with 65 percent bismuth at about $1.19 per pound of contained bismuth and lower grade ores at related prices.

FOREIGN TRADE

General imports of refined bismuth amounted to 1,123,500 pounds, an increase of 38 percent over the 1962 imports. Imports from Canada and Peru increased substantially while those from Mexico decreased. Yugoslavia and the Netherlands were the other significant sources of imported metal.

In addition to the imports of refined bismuth metal, the domestic supply was augmented by imports of bismuth contained in base-metal concentrates, base-metal bullion, and intermediate smelter products for processing in refineries and marketing as refined bismuth. Approximately 168,000 pounds of bismuth base-bullion was imported and consumed in end items without further refining.

Exports of bismuth metal and alloys amounted to 32,300 pounds, a substantial decrease from the 118,100 pounds reported in 1962. The Netherlands received 55 percent of the exports, and the United Kingdom, Canada, Belgium-Luxembourg, and Japan were the other significant importers.

TABLE 3.—U.S. imports [1] of metallic bismuth, by countries

(Pounds)

Country	1962	1963	Country	1962	1963
North America:			Europe:		
Canada	35,239	152,408	Netherlands	175	18,513
Mexico	180,166	166,322	United Kingdom		3
			Yugoslavia	26,456	57,311
Total	215,405	318,730			
South America: Peru	573,651	728,909	Total	26,631	75,827
			Asia: Korea, Republic of	503	
			Grand total	816,190	1,123,466

[1] Data are general imports; that is, they include bismuth imported for immediate consumption plus material entering country under bond.

Source: Bureau of the Census.

TABLE 4.—U.S. exports of bismuth metal and alloys

Year	Gross weight (pounds)	Value	Year	Gross weight (pounds)	Value
1954–58 (average)	220,665	$342,004	1961	167,166	$267,775
1959	179,744	261,367	1962	118,056	176,163
1960	156,636	275,540	1963	32,293	42,271

Source: Bureau of the Census.

WORLD REVIEW

The estimated world production of 6.5 million pounds of bismuth indicates a 3-percent decrease in relation to the revised estimate of 6.7 million pounds for 1962. The major producers were: Bolivia, Canada, Japan, Mexico, Peru, Republic of Korea, Sweden, United States, and Yugoslavia. Significant increase in production occurred in Peru, Mexico, and Japan whereas the output of Bolivia, Canada, and Yugoslavia declined in comparison to 1962.

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Bolivia.—Production of bismuth, recovered, as a coproduct of tin mining and recorded in terms of content of concentrate and bullion exported, decreased as activity in tin mining declined.

Canada.—Approximately 60 percent of the bismuth was derived from the refining of British Columbia lead-zinc ores; 27 percent, from the molybdenite ores of Quebec; and the remaining 13 percent, from cobalt-silver ores of Ontario and copper refining in the Gaspé Peninsula. Production as refined metal declined 10 percent over that of 1962.

Japan.—Production of bismuth metal derived in the smelting and refining of base-metal concentrates, largely imported, has steadily increased to place Japan in fourth position as a metal producer in the free world. Output in 1963 is estimated to be 15 percent above that reported for 1962.

TABLE 5.—World production of bismuth, by countries [1] [2]

(Pounds)

Country [1]	1954-58 (average)	1959	1960	1961	1962	1963
North America:						
Canada (metal) [3]	308,633	334,736	423,827	478,118	425,102	380,285
Mexico [3]	831,800	527,600	599,400	[4] 140,000	780,000	[5] 948,000
South America:						
Argentina (in ore)	[5] 28,200	[5] 40,000	[5] 14,900	[5] 8,600	7,100	[5] 7,100
Bolivia [6]	124,910	487,400	403,700	465,300	652,300	[5] 504,600
Peru [3]	743,510	737,617	908,438	1,031,795	1,084,227	1,243,000
Europe:						
France (in ore)	83,600	101,400	112,400	116,800	[5] 116,800	[5] 110,000
Spain (metal)	91,914	53,168	29,875	21,427	18,799	[5] 18,700
Sweden [5]	115,100	66,000	79,000	79,000	154,000	155,000
Yugoslavia (metal)	221,174	200,026	231,582	216,348	199,765	[5] 194,657
Asia:						
China (in ore)	[5] 313,000	(7)	(7)	(7)	(7)	(7)
Japan (metal)	146,280	223,187	261,089	422,326	572,841	[5] 660,000
Korea, Republic of (in ore)	275,100	227,000	317,000	333,000	353,000	[5] 350,000
Africa:						
Mozambique	3,254	22,900	30,000	38,800	13,900	13,900
South Africa, Republic of (in ore)	767	527	511	168	130	[5] 770
South-West Africa (in ore)	1,300	530	310	485	155	[5] 5,100
Uganda	4,380	19,140	3,640	1,430	110	[5] 110
Oceania: Australia (in ore)	2,600	925	265	900	97	----------
World total (estimate) [1] [2]	4,600,000	5,000,000	5,300,000	5,100,000	6,700,000	6,500,000

[1] U.S. figure withheld to avoid disclosing individual company confidential data; included in world total. Bismuth is believed to be produced in Brazil, East and West Germany, and U.S.S.R. Production figures are not available for these countries, but estimates are included in the world total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Bismuth content of refined metal and bullion plus recoverable content of concentrates exported.
[4] In addition, approximately 2,000,000 pounds of bismuth in impure bars are excluded from the world total to avoid duplication.
[5] Estimate.
[6] Content in ore and bullion exported, excluding that in tin concentrates.
[7] Data not available; estimate included in world total.

Korea, Republic of.—The bismuth refinery of Korea Tungsten Mining Co. continued production of refined metal derived from tungsten-ore concentration and output was at essentially the 1962 level.

Mexico.—Production of bismuth in refined metal, and other bismuth bearing base-metal products was about 22 percent above the 1962 output. Refined metal is produced by Metalurgic Mexicana Peñoles, S.A., and bismuth is recovered in base-bullion, impure bismuth bars, and other intermediate smelter products, most of which are refined in the United States.

Peru.—The La Oroya refinery of the Cerro de Pasco Corp. produces all of the refined metal and bismuth lead alloy originating in Peru. Improvement of operating technique and expansion of plant facilities at La Oroya resulted in new production records for copper, lead, zinc and base-metal byproducts. The increase in bismuth output was about 15 percent above that of 1962.

Yugoslavia.—Bismuth is derived as a byproduct of lead-zinc refining at the Zvecan Lead Smelter & Refinery. Output declined again.

TECHNOLOGY

Bismuth metal continued to gain acceptance as a minor additive to molten steel, aluminum, and malleable iron to improve machinability of these materials without undue sacrifice of strength, toughness, and corrosion resistance.

Reports on investigative studies were published on analytical methods,[2] preparation of materials for examination,[3] and characteristics of bismuth alloys at high temperatures.[4]

A U.S. patent was issued relating to preparation of bismuth alkyl compounds.[5]

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[2] Connadi, G., and M. Kopanica. Polarographic Determination of Bismuth in Battery Materials, Refined Lead, and Bismuth Ores. Chemist-Analyst, January 1963, pp. 11–12.

[3] Coons, William C. Preparing Bismuth and Antimony for Metallographic Examination. Metal Prog., v. 84, No. 6, December 1963, pp. 120–123.

Glatz, Alfred C., and Virginia F. Meikleham. The Preparation and Electric Properties of Bismuth Trisulfide. J. Electrochem. Soc., v. 110, No. 12, December 1963, pp. 1231–1234.

[4] Ofte, Donald, and L. J. Wittenberg. Viscosity of Bismuth, Lead, and Zinc to 1,000° C. Trans. AIME (Met. Soc.), v. 227, No. 3, June 1963, pp. 706–711.

Verhoeven, John D., and Edward E. Hucke. Electrotransport and Resistivity in the Molten Bismuth-Tin System. Trans. AIME (Met. Soc.), v. 227, No. 5, October 1963, pp. 1156–1166.

[5] Jenkner, Herbert (assigned to Kali-Chemie Aktiengesellschaft, Hanover-Wulfel, West Germany). Preparation of Alkyl Compounds of Boron, Mercury, and Bismuth. U.S. Pat. 3,103,526, Sept. 10, 1963.

Boron

By William C. Miller [1]

NEW mining operations, plant expansion, more efficient processes, and new terminal facilities for export shipments contributed to an upward trend in domestic production and export sales of boron materials. Prices of boron compounds remained firm, with the exception of a slight increase in the technical and U.S. Pharmacopoeia (USP) grades of crystalline boric acid.

Consumption of boron materials increased significantly, both as a result of wider usage of known compounds and the development of new or modified compounds. Research and development on organoboron compounds, corrosion inhibitors, and boron fibers effected noteworthy accomplishments.

TABLE 1.—Salient boron minerals and compounds statistics in the United States

	1954–58 (average)	1959	1960	1961	1962	1963
Sold or used by producers:						
Short tons:						
Gross weight [1]	585,269	619,946	640,591	602,613	646,613	700,183
Boron oxide	255,891	314,286	323,955	313,104	339,060	369,302
Value ....thousands..	$33,321	$46,150	$47,550	$46,936	$49,336	$54,981
Imports for consumption:						
Short tons	[2] 1,066	91	74	15	15	17
Value ....thousands..	$148	$174	$202	$52	$51	$58
Exports:						
Short tons	224,402	253,674	300,606	269,271	292,264	338,912
Value ....thousands..	$15,660	$21,047	$25,576	$23,212	$24,736	$27,519
Consumption, apparent:						
Short tons	361,933	366,363	340,059	333,357	354,364	361,288

[1] In 1954 gross weight reported included a higher proportion of crude ore to finished products than in 1955–63.
[2] Imports for 1957 include a higher proportion of crude ore to refined products.

DOMESTIC PRODUCTION

Production of boron minerals and compounds (as measured by sales) increased 8 percent in quantity and 11 percent in value compared with 1962. An increase in sales was recorded for each primary boron product except colemanite, which decreased slightly.

Boron minerals and compounds were produced from the brine of Searles Lake by American Potash & Chemical Corp., Trona, Calif., and West End Chemical Division of Stauffer Chemical Co., Westend,

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Calif. Pacific Coast Borax Division of United States Borax & Chemical Corp. mined borax and kernite from a deposit in the Kramer district near Boron, Calif., and colemanite and ulexite in Inyo County, Calif. Kern County Land Co. mined colemanite in Inyo County, Calif.

United States Borax & Chemical Corp. designed, built, and put into operation a large mobile service station to reduce operating cost of pit equipment at its boron mine. The expansion program at the Trona, Calif., operations of American Potash & Chemical Corp., completed in 1962, was supplemented by the installation of additional heat exchangers to raise the original design capacity. The first shipload of bulk borate products in the history of the borax industry was made from the recently constructed facilities for loading oceangoing ships at the U.S. Borax & Chemical Corp. plant at Wilmington, Calif., on the Los Angeles Harbor.

CONSUMPTION AND USES

Boron minerals and compounds were used in a wide variety of industries. The largest quantity of boron compounds was consumed by the fiberglass, borosilicate glass, ceramic, and porcelain enamel industries. Producers of cleaning materials, antifreeze, and wood cellulose continued to increase their consumption of boron compounds. Boron and its derivatives were used in herbicides, plant foods, steel, pharmaceuticals, cosmetics, glues, tanning leather, sterilizing materials, photographic chemicals, liquid fuels, hydraulic fluid, plastic materials, fungus control, insulation, fire-resistant and firefighting materials, electrolytic condensers, nonferrous metal refining, soldering, and welding, and paints.

Boron was consumed in the 282,949 short tons of alloy steel (other than stainless steel) ingots produced in 1962, compared with 279,710 tons in 1961.[2]

The boron-fuels plant at Muskogee, Okla., was placed on a "caretaker" status in an agreement reached with the Callery Chemical Co., operator of the plant. Metal Hydrides, Inc., Beverly, Mass., was scheduled to resume full operation of its multimillion-pounds-per-year sodium borohydride plant at Danvers, Mass.

Several new applications for boron compounds were reported in 1963. An organoboron was developed for controlling the growth of micro-organisms in diesel fuels. A super purity boron-titanium in three different cast shapes was offered as an additive for molten aluminum. Boronated graphite was used at an atomic powerplant as an effective neutron shielding material. The U.S. Air Force awarded a contract for the manufacture of a boron filament material to replace other metals and glass for wound structural components in aerospace and missile use. An experimental instrument platform off the coast of California was supported by hollow balls of borosilicate glass. A new hard-facing alloy that produces a dense, corrosion-resistant coat was made available for nickel-chromium-boron coatings. Boron nitride fabricated shapes were manufactured in larger sizes than in

[2] American Iron and Steel Institute. Annual Statistical Report. New York, 1962, p. 56.

the past. A new series of boron nitride coatings, which could be applied by spray, brush, or dip to metallic and nonmetallic parts was made available. Two new compounds, tetraethylammonium borohydride (TEAB) and tetramethylammoniumborohydride (TMAB), were soluble and stable in a wide range of hydroxylic solvents. A nickel boride anode catalyst was found to be a very significant factor for the long-range development of hydrogen-oxygen fuel cells.

PRICES

The price of technical grade boric acid crystals, 99.9 percent, in bags, at works, in carlots, was increased on April 1, 1963, from $163.50 to $168.50 per ton; drums, at works, in carlots, from $188.50 to $193.50 per ton. Boric acid, USP grade, in bags, was $25 per ton higher than technical grade.

FOREIGN TRADE

Boric acid imported from the United Kingdom totaled 8 pounds valued at $1,554 compared with 9 pounds valued $1,495 in 1962. Boron, barium, strotium, and vanadium metal imports from Canada, United Kingdom, and West Germany were not reported separately and totaled 556 pounds valued at $10,514. Imports of boron carbide from Canada, West Germany, and France were 13,468 pounds valued at $39,398 compared with 9,124 pounds valued at $33,601 in 1962. Ferroboron imports from the United Kingdom and West Germany, for the first 8 months of 1963, totaled 21,213 pounds valued at $17,194. Effective September 1, 1963, this class of imports was no longer separately classified. No refined borate or borate of soda was imported.

Exports of boric acid, borates, and compounds increased 16 percent in quantity and 11 percent in value over exports in 1962.

Exports increased slightly over the shipments during 1962, except to South America where they decreased. Continued expansion of the enamel and ceramic industries and the manufacture of perborate was responsible for the increased consumption of boron products.

On August 31, 1963, the Tariff Schedules of the United States (TSUS) went into effect. These revised schedules replaced those established by the Tariff Act of 1930 as amended. According to the new tariff the rates of duty on boron products are as follows:

Product:	*TSUS number*	*Rate of duty Aug. 31, 1963*
Boric acid	416. 10	5 cents per pound.
Calcium borate, crude	418. 12	Free.
Manganese borate	419. 40	10 percent ad valorem.
Sodium borate, crude	420. 76	Free.
Sodium borate, other	420. 78	0.125 cent.
Boron carbide	422. 90	6.25 percent ad valorem.
Ferroboron	607. 80	10 percent ad valorem.

TABLE 2.—U.S. exports of boric acid, borates, and compounds [1]

Destination	1962		1963	
	Short tons	Value	Short tons	Value
North America:				
Canada	16,344	$1,875,163	19,224	$1,991,711
Costa Rica	361	30,705	705	68,737
Dominican Republic	122	13,557	80	23,218
Mexico	5,690	555,674	7,834	763,503
Nicaragua	14	4,792	28	6,630
Other	88	11,066	87	14,616
Total	22,619	2,490,957	27,958	2,868,415
South America:				
Argentina	10	1,182	5	1,606
Brazil	6,203	576,890	4,822	512,997
Colombia	849	86,070	1,442	152,888
Peru	324	27,561	490	43,665
Uruguay	255	27,614	260	27,683
Venezuela	254	33,800	207	22,440
Other	22	2,461	11	695
Total	7,917	755,578	7,237	761,974
Europe:				
Austria	4,453	237,910	3,938	206,073
Belgium-Luxembourg	4,910	481,933	5,875	573,611
Denmark	733	64,465	1,122	79,459
Finland	1,688	154,869	2,329	184,196
France	34,975	2,797,882	42,878	3,395,257
Germany, West	56,363	4,053,173	64,125	4,259,049
Greece	253	14,613	159	14,967
Ireland	1,259	83,014	1,390	84,934
Italy	9,597	763,155	9,828	812,046
Netherlands	16,303	1,431,681	35,183	2,561,863
Norway	2,760	234,044	2,775	215,269
Portugal	756	60,312	1,145	85,288
Spain	6,502	297,951	4,096	158,625
Sweden	4,061	350,722	3,960	334,828
Switzerland	3,525	312,024	3,315	290,538
United Kingdom	46,227	3,908,502	50,117	3,943,554
Yugoslavia	3,082	308,882	1,197	113,653
Other	44	3,884	(2)	274
Total	197,491	15,559,016	233,432	17,313,484
Asia:				
Ceylon	272	$18,749	235	$18,338
Hong Kong	3,900	346,602	3,990	356,071
India	5,465	427,414	7,153	585,290
Indonesia	176	13,957	582	38,068
Iran	189	14,130	268	24,513
Israel	841	78,561	669	71,053
Japan	30,415	2,793,043	34,707	3,179,189
Korea, Republic of	1,062	85,512	627	51,054
Malaya, Federation of	162	14,505	332	27,250
Pakistan	942	73,166	645	52,355
Philippines	908	73,138	1,258	119,990
Singapore	159	11,359	385	28,121
Syrian Arab Republic	33	3,350	42	4,000
Taiwan	1,295	85,086	1,252	79,845
Thailand	805	74,879	652	65,002
Viet-Nam	296	31,088	682	132,473
Other	68	4,682	105	20,648
Total	46,988	4,149,221	53,584	4,853,260
Africa:				
Rhodesia and Nyasaland, Federation of	227	18,666	509	40,191
South Africa, Republic of	2,688	293,325	2,409	255,512
United Arab Republic (Egypt)	208	24,121	252	21,199
Other	355	37,544	370	59,335
Total	3,478	373,656	3,540	376,237
Oceania:				
Australia	9,598	953,883	8,870	831,607
New Zealand	4,173	453,900	4,208	502,154
Other			83	11,671
Total	13,771	1,407,783	13,161	1,345,432
Grand total	292,264	24,736,211	338,912	27,518,802

[1] Classified by the Bureau of the Census as boric acid and borates, crude, refined, and compounds (including borate esters and other boron compounds) not elsewhere classified. [2] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW

Argentina.—Mineral production in Argentina declined sharply in 1962; however, the production of boron increased from 7,535 short tons in 1961 to 15,983 tons in 1962. Exports of borates totaled 3,937 tons valued at US$300,265.

Germany, West.—Boron minerals or compounds produced during calendar year 1962 totaled 75,568 short tons. A new sales company for boron products, Deutsche Borax-Gesellschaft m.b.H., was formed jointly by Borax (Holdings) Ltd., London, and Metallgesellschaft A.G., Frankfurt-am-Main.[3]

Italy.—Boric acid production by the ammonia-carbonate process was begun by the Italian company Larderello-S.p.A at their acid works. Production of borax anhydride was started by the use of a proven process. This production was for home market consumption. Previously the supply of borax anhydride was dependent on imports.[4]

Turkey.—The Tulu mine of Rasih ve Ihsan Mining Co., near Bigadic, was purchased by a new company formed by American Potash & Chemical Corp. and Fethiye Mining Co. Colemanite ore produced from the mine was used as a partial source of supply for the new boric acid of Société Européenne du Bore (SUBOR) in France.[5]

TECHNOLOGY

A waterproofing agent was developed that contained boron and silicon esters in an aqueous base.[6] When applied to wet or damp concrete, the boron ester acts as a bonding agent to attach the silicon ester to the calcium compounds in the concrete and impart a water repelling characteristic. The tensile strength and modulus of elasticity of titanium alloys was increased by the addition of boron, without much loss of ductility and impact strength.[7]

To achieve a high-thermal stabilization of polyvinyl chloride (PVC), laboratory and industrial investigations were conducted with stabilizers based on the synergic compounds of boron.[8] Products with high-thermal properties and easy processing ability were obtained by using synergic boron compounds with lead and calcium in PVC mixtures.

Experiments were conducted to determine whether the oxidation product of boron afforded protection from further oxidation. When anodized under similar conditions in alkaline solution, boron differed markedly in anodic behavior from that of aluminum, tantalum, and other valve metals.[9]

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[3] Chemical Trade Journal and Chemical Engineer (London). New Company for Borax in Germany. V. 153, No. 3981, Sept. 27, 1963, p. 463.
[4] Chemical Age (London). Larderello to Use New Boric Acid Process. V. 89, No. 2293, June 22, 1963, p. 911.
[5] Bureau of Mines. Mineral Trade Notes. V. 58, No. 2, February 1964, p. 6.
[6] Chemical Engineering. New Chemicals. V. 70, No. 1, Jan. 7, 1963, p. 50.
[7] Brown, A. R. G., H. Brooks, K. S. Jepson, and G. I. Lewis. High-Modulus Titanium Alloys Containing Boron and Aluminum. J. Inst. Metals (London), v. 91, pt. 5, January 1963, pp. 161–166.
[8] Velea, I. T. Wexler, and D. Cornilescu. A New Class of Stabilizers for Vinyl Polymers on the Basis of Boron Compounds. Rev. Chim., v. 14, No. 1, 1963, pp. 13–16.
[9] Chen, Cheng Leung, and R. E. Salomon. The Anodix Oxidation of Boron. J. Electrochem. Soc., v. 110, No. 2, February 1963, pp. 173–174.

In the conversion of hexagonal boron nitride (BN) to cubic BN (borazon), effective catalysts were alkaki and alkaline earth metals and their nitrides.[10] The synthesis required high pressure and temperatures. Optimum pressure was 45,000 atmospheres and pressure was 1,500° C.

A study was started to determine the permanence of boron compounds used as flame-resisting agents in fabrics.[11] A flame-resisting process that will not alter the characteristics of the fabrics, and will be permanent and inexpensive, was the ultimate objective of the project.

The use of a sodium borohydride-based compound was reported by textile mills to improve stability, lower costs, and provide greater control of dyeing operations in vat coloring.[12] The excellent stability to air oxidation was the key to the benefits derived. It also reduced the amount of hydrosulfite and caustic soda needed for reduction, and produced brighter and cleaner dyeings.

The effect of boron applications on the response of cotton yields was investigated in Arkansas during 1962.[13] Yields were increased as much as 1,000 pounds per acre when boron was added to fertilizers of nitrogen and potassium.

A process for producing high-purity boron used boron tribromide that was reduced with hydrogen on a substrate of zone-refined boron.[14] No impurities in the boron produced by the technique employed were detectable by the analytical procedures available at that time. The need for a crucible was eliminated in the growth of the material into crystalline bars.

Because of its unusually high resistance to heat, the new product, epoxy-boroxine foam, is expected to be of commercial importance.[15] It remained rigid at a temperature of 572° F. No additional heat was required to produce the polymer system, which consisted of a liquid epoxy resin, a primary polyamine, and trialkoxyboroxine. A built-in foaming agent, methanol, was formed and vaporized when the boroxine reacted with the amine. As the foamed plastic was self-extinguishing and adhered well to materials, it could be used as high-temperature insulation or lightweight reinforcing material.

A compilation of background information for future research concerning boride materials was published.[16] The review showed the need for development of scientific information on borides.

Papers presented at an International Symposium on Boron-Nitrogen Chemistry held at Duke University, Durham, N.C., described new boron compounds.[17] Procedures, reactions, and bonding were discussed.

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[10] Journal of American Ceramic Society. V. 46, No. 2, February 1963, p. 54.

[11] Chemical Trade Journal and Chemical Engineer (London). V. 152, No. 3953, Mar. 15, 1963, p. 417.

[12] Chemical & Engineering News. See Lower Dyeing Costs With Sodium Borohydride. V. 41, No. 11, Mar. 18, 1963, p. 9.

[13] Miley, Woody, N. Glenn W. Hardy, and B. A. Waddle. Missing Link in Cotton Production. Farm Chem., v. 126, No. 3, March 1963, pp. 28, 62, 64.

[14] Starks, R. J., and J. T. Buford. The Preparation of Ultrahigh-Purity Boron. Electrochem. Tech., v. 1, No. 3–4, March–April 1963, pp. 108–111.

[15] Chemical Engineering. Today's Exotic New Products Can Be Tomorrow's Commercial Chemicals. V. 7, No. 9, Apr. 29, 1963, p. 52.

[16] Emrich, Barry R. Literature Survey on Synthesis, Properties, and Applications of Selected Boride Compounds. Wright-Patterson Air Force Base, Ohio, Rept. ASD TDR62–873, December 1962, 122 pp.; abs. in U.S. Dept. of Commerce, v. 38, No. 9, May 5, 1963, p. 10.

[17] Chemical & Engineering News. V. 41, No. 18, May 6, 1963, pp. 39–41, 44.

A sodium borate-sodium chlorate mixture was marketed as a granulated herbicide.[18] It could be applied dry or as a spray and was useful for control of weedy grasses.

The applications of boron nitride, as a refractory ceramic, were broadened by the production of large sizes.[19] The diameter of cylinders was increased 5 inches and the length 4 inches over the previously available largest size.

Boron-containing fuel soluble additives prevented contamination of furnace oils caused by bacteria and fungi.[20] These boron biocides also protected, at small cost, diesel and jet turbine fuels from contamination.

Adding boron and increasing the percentage of molybdenum to a wrought martensitic steel, Type 422, improved its high temperature strength.[21] Resistance to softening was provided by stable borides.

An atomic powerplant in Michigan used plain and boronated graphite for reactive shielding.[22] Fast neutrons were slowed down in the plain graphite portion of the shield and were captured in the boronated portion.

A Russian researcher reported that the addition of interstitial atoms, such as boron nitrogen and carbon, increased the high-temperature strength and healed vacancies in chromum-nickel-manganese steels.[23] The addition of boron was especially effective.

A study of the mechanism and kinetics of the reaction at elevated temperatures of boron carbide powder with water vapor and/or air was initiated.[24] Temperatures at which reactions occur, oxidation, and oxidation rate were significant findings.

Advantages in curing epoxy resins were reported for two boron compounds.[25] An aromatic borate prepared from a mixture of m- and p-cresols was used with peracid derived epoxies for consistent quality epoxy formers and room temperature cures. A boric acid ester was used to control the reaction and extend the pot-life by a retarding influence.

One feature of a new process was the use of a chelating agent in a large-scale industrial extraction to produce boric acid from weak brines.[26] The chelating agent was a new aliphatic polyol which was very soluble in kerosine.

A new series of boron nitride coatings that could be applied by spraying, brushing, or dipping to organic or inorganic surfaces was made available.[27] The coatings had temperature and corrosion resistance and high thermal conductivity. They were also used as high-temperature lubricants and for electrical insulation.

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[18] Agricultural Chemicals. V. 18, No. 5, May 1963, p. 58.
[19] Materials in Design Engineering. Boron Nitride Made in Large Sizes. V. 57, No. 5, May 1963, p. 91.
[20] Chemical Trade Journal and Chemical Engineer (London). Boron Biocides in Prevention of Corrosion. V. 152, No. 3965, June 7, 1963, p. 917.
[21] Bedell, Edward L., Thad J. Rick, and Donald J. Beernstsen. A stainless Steel for High Temperature Service. Metal Prog., v. 84, No. 1, July 1963, pp. 96–99.
[22] Materials in Design Engineering. V. 58, No. 2, August 1963, p. 11.
[23] Page 13 of work cited in footnote 22.
[24] Litz, Lawrence M., and R. A. Mercuri. Oxidation of Boron Carbide by Air, Water, and Air-Water Mixtures at Elevated Temperatures. J. Electrochem. Soc., v. 110, No. 8, August 1963, pp. 921–925.
[25] Industrial and Engineering Chemistry. V. 55, No. 9, September 1963, p. 110.
[26] Chemical & Engineering News, Chelating Agent Used To Extract Boric Acid. V. 41, No. 40, Oct. 7, 1963, pp. 44–45.
[27] Chemical Week. V. 93, No. 18, Nov. 2, 1963, p. 83.

Harmful amounts of poisonous boron were detected by a new device.[28] A safety level of 10 parts per-billion-parts of air were measured by the device.

Following fundamental research in bromite and carbonhydrate chemistry, a new oxidative desizing agent, sodium boromite, was developed in France.[29] Claims made by the discoverers of the agent were being investigated. For certain applications the bromite was superior to enzymes. Desizing and scouring of some cotton fabrics, using the same solution as the agent in an alkaline medium, were effective at room temperatures.

The research stage in a new field of boron-organic chemistry was completed.[30] A number of carbon-based organic compounds modified by reaction with decaborane, identified as "carboranes," were made in the laboratory. Research programs for the study of applications were started.

The reaction of decaborane with a substituted acetylene yielded a substituted carborane and hydrogen.[31] A regular polyhedron with 12 boron and carbon atoms joined through delocalized bonding was thought to be the structure of the new carborane ($C_2B_{10}H_{10}$) group. By varying the substituents on the starting acetylenic compound and by conventional organic chemical treatment of the product, many types of carboranes were produced.

Two new quaternary ammonium borohydrides (cetyl trimethyl ammonium borohydride and tricapryl methyl ammonium borohydride) were made available in laboratory quantities.[32] These chemicals were used as catalysts, pneumatogens, scavenging agents for carbonyl and peroxide groups, biocidal agents, and antioxidants.

A boron tribromide of purity exceeding 99.990 percent was made available.[33] An emission spectograph determined that the product contained less than 3 parts per million of silicon and had no other detectable impurities.

The results of a study of high-temperature energy relations in some alkaline-earth and lead borate compounds and glasses were reported.[34] Data contained in the report included: X-ray diffraction, heats of solution, and heat contents.

The oxygen content of boron nitride was reduced by five times by researchers at the Parma Research Center of Union Carbide Corp.[35] New high temperature and high power uses for the material were made available by this reduction.

A process was patented for preparing and applying boron nitride to the surfaces of a container for confining molten aluminum.[36]

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[28] Missiles and Rockets. V. 13, No. 21, Nov. 18, 1963, p. 21.

[29] Chemical Trade Journal and Chemical Engineer (London). Chemicals for Textile Finishing: Research Association's Recent Work. V. 153, No. 3989, Nov. 22, 1963, p. 782.

[30] Chemical Week. Boron: New Polymer Upgrader. V. 93, No. 21, Nov. 23, 1963, pp. 145–146.

[31] Chemical Week. What's a Carborane? V. 93, No. 21, Nov. 23, 1963, p. 146.

[32] Chemical Week. V. 93, No. 22, Nov. 30, 1963, p. 45.

[33] Chemical Trade Journal and Chemical Engineer (London). V. 153, No. 3991, Dec. 6, 1963, p. 878.

[34] Steward, Daniel R., and Guy E. Rindone. High-Temperature Energy Relations in Borates: Alkaline-Earth and Lead Borate Compounds and Their Glasses. J. Am. Ceram. Soc., v. 46, No. 12, Dec. 21, 1963, pp. 593–596.

[35] Metalworking News. Union Carbide Researchers Cut O Content of B Nitride. V. 4, No. 174, Dec. 23, 1963, p. 9.

[36] Baer, Charles A., Phillip J. Clough, and Robert W. Steeves (assigned to National Research Corp., Cambridge, Mass.). Process of Coating a Refractory Body With Boron Nitride and Then Reacting With Aluminum. U.S. Pat. 3,084,060, Apr. 2, 1963.

A patent was issued for a method of preparing a corrosion inhibitor for hydraulic brake fluids.[37]

An abrasion and corrosion resistant turbine bucket coated with boron phosphide for use in high-temperature combustion engines was patented.[38]

A method was devised to treat calcium borate ores to recover useful boron compounds.[39]

British Patent 926,292 was granted for preparing a self-bonding, water-insoluble borate gel by reacting borax with a soluble salt of lead, calcium, barium, magnesium, cadmium, or zinc.[40]

A process was patented for producing high-purity elemental boron.[41]

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[37] Jordan, Charles B. (assigned to the Secretary of the Army). Soluble Borax Inhibitor. U.S. Pat. 3,087,959, Apr. 30, 1963.

[38] Gruber, Bernard A., Robert A. Ruehrwein, and Forrest V. Williams (assigned to Monsanto Chemical Co., St. Louis, Mo.). Boron Phosphide Articles and Coatings. U.S. Pat. 3,090,703, May 21, 1963.

[39] Dwyer, Thiel E. (assigned to Tholand, Inc., Sperryville, Va.). Recovery of Boron Compounds From Boron-Containing Ores. U.S. Pat. 3,103,412, Sept. 10, 1963.

[40] Chemical Trade Journal and Chemical Engineer (London). Patent Abstracts. V. 153, No. 3981, Sept. 27, 1963, p. 478.

[41] Robb, Walter L. (assigned to General Electric Co.). Process for Boron Production. U.S. Pat. 3,115,393, Dec. 24, 1963.

Bromine

By William C. Miller [1]

DOMESTIC sales of bromine and bromine compounds continued to increase at a slower rate than in 1962. Exports also increased, in contrast with a decrease in the previous year. Bromine production started at two new plants in the United States and at a plant in Israel which is one of the largest of its kind in the world.

DOMESTIC PRODUCTION

Sales of bromine and bromine compounds (bromine content) increased 6 percent over the sales reported by primary producers in 1962. The larger volume of sales resulted from increased production of elemental bromine and all bromine compounds except potassium and sodium bromides which decreased slightly.

TABLE 1.—Sales of bromine and bromine compounds by primary producers in the United States

(Thousand pounds and thousand dollars)

Year	Quantity		Value
	Gross weight	Bromine content	
1954-58 (average)	220,505	187,390	$44,666
1959	231,438	195,483	51,508
1960	206,948	175,010	44,637
1961	212,497	180,798	44,517
1962	223,972	190,747	46,617
1963	238,583	203,333	48,558

In California, bromine was recovered from sea water bitterns by the FMC Corp. at Newark and from dry lake brines by the American Potash & Chemical Corp. at Trona. At Freeport, Tex., the Ethyl-Dow Chemical Co. extracted bromine from sea water. Arkansas Chemicals, Inc., and Michigan Chemical Corp. recovered bromine from oil-well brines near El Dorado, Ark.

Bromine was recovered from well brines in Michigan at the St. Louis and Manistee plants of the Michigan Chemical Corp., the Filer City plant of Great Lakes Chemical Corp., the Manistee plant of the Morton Chemical Co., and the Ludington and Midland plants of the Dow Chemical Co.

[1] Commodity specialist, Division of Minerals.

Construction started of office and research facilities in Lafayette, Ind., by the Great Lakes Chemical Corp. Pilot-plant units and conventional laboratory facilities are planned for developmental production of various bromine and bromine-phosphorus compounds. The company also expanded the capacity of its Filer City plant to produce 1 million tons per year of 48 percent or 62 percent hydrobromic acid for use in various medical preparations.

The Dow Chemical Co. started construction on a plant at Midland, Mich., to produce ethyl bromide using ethylene and hydrogen bromide in the presence of radiation from a cobalt-60 source. A brick tower, in which the Dow Chemical Co. blowing-out process for bromine has operated since 1926, was torn down. A new process was begun in 1962 for purifying bromine from steaming-out towers. Yields of at least 99.98 percent pure bromine are obtained from the process in contrast to the previous purity of 99.8 percent.

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	
1962:			
Elemental bromine	23,106	23,106	$4,267
Methyl bromide	9,963	8,386	4,316
Other, including ethylene dibromide, sodium bromide, ammonium bromide, and potassium bromide	190,903	159,255	38,034
Total	223,972	190,747	46,617
1963:			
Elemental bromine	26,248	26,248	4,443
Methyl bromide	13,490	11,357	5,020
Other, including ethylene dibromide, sodium bromide, ammonium bromide, and potassium bromide	198,845	165,728	39,095
Total	238,583	203,333	48,558

CONSUMPTION AND USES

Production of high-purity bromine and greater utilization of bromine compounds in treating swimming pool water, flameproofing wood products, flameretarding foam and synthetic fibers, and as intermediates for various drugs supported the growth of the bromine industry.

Ethylene dibromide and methyl bromide comprised about 90 percent of the bromine compounds manufactured and consumed approximately 80 percent of the total bromine produced. Ethylene dibromide, used chiefly as an additive to tetraethyl or tetramethyl lead antiknock fluid, consumed the greatest percentage of the bromine output; sales increased for the third consecutive year. Increased amounts of ethylene dibromide were used in fumigation mixtures for treating soil and seeds and for intermediates in the synthesis of dyes and pharmaceuticals. Consumption of methyl bromide, used principally in fumigating mixtures and fire-extinguishing fluids also increased.

Elemental bromine consumption increased for the second consecutive year. Bromine was used for swimming pool sanitizors, bleaching and disinfecting agents, laboratory reagents, and in many organic and inorganic compounds.

Consumption of potassium and sodium bromides decreased slightly. These compounds were used in medicinal and pharmaceutical preparations, photographic emulsions, and laboratory reagents.

Two new products were a bromoacetyl bromide for use as an organic intermediate and an organobromine for use as a microorganism-control chemical.

PRICES

Prices of bromine in truckload or carload quantities were reduced in June from 31 to 28 cents per pound. The price of shipments of fewer than 10 drums was 33 cents per pound. The following prices were quoted by Oil, Paint and Drug Reporter:

	Cents per pound	
	June 10	*June 17*
Bromine, purified, cases, carlots, ton lots, delivered east of Rocky Mountains	32	32
Drums, carlots, ton lots, delivered east of Rocky Mountains	31	28
Tanks, carlots, same basis	21.5	21.5
Ammonium bromide, National Formulary (N.F.) granular, drums, carlots, ton lots, freight equalized	44	44
Bromochloromethane, drums, carlots, freight equalized	48	48
Tanks, same basis	47	47
Ethylene dibromide, drums, carlots, freight equalized	30.5	30.5
Tanks, freight equalized	28.5	28.5
Potassium bromate, 200-pound drums, carlots, freight allowed	49	49
Potassium bromide, U.S.P., granular, barrels, kegs	39–40	39–40
Sodium bromide, U.S.P., granular, barrels, drums, works	40	40

FOREIGN TRADE

Imports of bromine and bromine compounds totaled 374,012 pounds valued at $167,615, compared with 461,108 pounds valued at $245,007 in 1962. The Netherlands supplied 80 percent of the imports.

Exports of bromine, bromides, and bromates increased 23 percent in quantity and 6 percent in value. Exports were 3 percent less than the record of 11.1 million pounds established in 1961. The largest increase in shipments was to Africa, and exports to South America decreased most.

WORLD REVIEW [2]

France.—Production of liquid bromine in 1962 declined to 1,786 short tons valued at $647,609, compared with 2,019 short tons valued at $751,558 in 1961.

Germany, West.—A plant for the production of hydrogen bromide was put in operation by Chemische Fabrik Kalk G.m.b.H. The parent company, Salzdetfurth A–G, will supply the bromide used in the process.[3]

[2] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[3] Chemical Trade Journal and Chemical Engineer (London). V. 153, No. 3981, Sept. 27, 1963, p. 472.

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TABLE 3.—U.S. exports of bromine, bromides, and bromates, by countries

Destination	1962		1963	
	Pounds	Value	Pounds	Value
North America:				
Canada	6,656,806	$1,200,928	8,481,459	$1,465,195
El Salvador	37,365	14,100	12,845	3,612
Guatemala	15,908	5,858	32,508	14,324
Mexico	363,358	194,473	399,169	196,529
Panama	21,851	6,429	1,800	849
Other	5,541	3,765	19,232	13,299
Total	7,100,829	1,425,553	8,947,013	1,693,808
South America:				
Argentina	15,640	8,963	19,937	10,448
Brazil	229,571	98,339	16,098	8,691
Colombia	12,200	6,938	8,770	6,251
Paraguay	5,000	1,515	5,000	2,037
Peru	4,132	2,842	248	720
Uruguay	5,450	3,698		
Venezuela	66,664	25,172	36,594	18,267
Other	3,051	1,555		
Total	341,708	149,022	86,647	46,414
Europe:				
Austria	6,400	3,552	6,704	3,774
Belgium-Luxembourg	10,173	8,607	33,189	11,856
Denmark	1,100	956	2,388	1,251
France	61,054	17,725	97,661	60,019
Germany, West	62,304	39,265	43,030	46,580
Hungary			44,800	33,510
Italy	283,821	82,287	688,830	112,860
Netherlands	112,470	57,325	49,790	26,999
Spain	44,000	7,399	4,900	11,627
Sweden	6,098	1,967	1,904	772
Switzerland	186,790	181,989	90,851	32,392
U.S.S.R.	132,400	74,000		
United Kingdom	104,781	44,281	56,395	38,009
Other	1,980	697	13,600	5,740
Total	1,013,371	520,050	1,134,042	385,389
Asia:				
Burma	7,953	4,943	3,600	2,586
India	27,022	11,032	42,506	20,966
Iran	5,580	4,106	1,600	888
Japan	20,238	26,087	40,801	17,868
Korea, Republic of	2,732	2,097		
Pakistan			6,000	6,900
Philippines	7,636	3,498	12,738	8,385
Thailand	5,692	2,813	30,608	12,959
Viet-Nam	12,817	5,683	18,633	6,665
Other	7,409	2,968	13,476	7,730
Total	97,079	63,227	169,962	84,947
Africa:				
Nigeria	1,200	642	49,880	13,986
Rhodesia and Nyasaland, Federation of	69,984	30,156	108,120	38,618
South Africa, Republic of	3,600	1,920	229,358	44,287
Total	74,784	32,718	387,358	96,891
Oceania:				
Australia	165,240	33,294	113,338	44,340
New Zealand	7,340	4,081	1,600	888
Total	172,580	37,375	114,938	45,228
Grand total	8,800,351	2,227,945	10,839,960	2,352,677

Source: Bureau of the Census.

Israel.—A bromine plant with an annual capacity of 4,450 short tons was dedicated on January 25, 1963. An initial production of 2,200 tons per year of bromine products was planned. The plant cost $670,000 and was a joint venture of the Dead Sea Works, Ltd., and U.S. and British interests. Production of bromide during the period January–September increased by 50 percent compared with the same period of 1962.[4]

Japan.—Manufacture of bromine and bromine compounds increased during calendar year 1962. Production of elemental bromine totaled 3,182 short tons, compared with 3,061 tons (revised figure) in 1961. The output of potassium bromide was 418 tons, compared with 377 tons (revised figure) in 1961.

TECHNOLOGY

Vinyl bromide, a new chemical for use as an intermediate or monomer, was produced in laboratory and small pilot lots.[5]

Ammonium bromide was one of the catalysts in a new process for converting benzene to fumaric acid.[6] The effluent from the absorbing step that removes most of the impurities of the maleic acid was catalytically isomerized in the presence of ammonium bromide plus ammonium persulfate to yield pure, white, fumaric acid crystals.

An improved zinc bromide-filled shielding window for hot cell use was designed, constructed, and tested.[7] Bare steel surfaces under an argon atmosphere contained zinc bromide solution satisfactorily. This was an improvement over the painted surfaces in an air atmosphere previously used, because no corrosion or deterioration of optical properties occurred in the window.

Addition of methyl bromide to a methane-air mixture inhibited its velocity of burning.[8] The flame speed was reduced further when larger quantities of methyl bromide were added.

Bromine dissolved in methanol was used as a chemical etchant to produce a high polish on crystals of gallium arsenide.[9] The etchant was fed at a rate of 15 to 20 cubic centimeters per minute between the cystals and a Pellon polishing cloth which was attached to a disk that rotated at 72 revolutions per minute. A surface relief of less than 25 angstroms was attained.

Bromoacetyl bromide (98+ percent purity) was made available in semicommercial quantities.[10] It was intended as an organic intermediate with some derivatives known to have insecticidal and biocidal properties.

The developers of a new micro-organism-control chemical, an organobromine, claimed that this water soluble compound was the first of its type to become available commercially.[11] Reports attributed good performance as a mocro-organism-control chemical to the compound.

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[4] Chemical Age (London). Israel Increase Potash Bromide Production. V. 90, No. 2314, Nov. 16, 1963, p. 776.

[5] Chemical Week. Vinyl Bromide. V. 92, No. 4, Jan. 26, 1963, p. 91.

[6] Chemical Engineering. Catalysts Systems Hold Key to Direct Route From Benzene to Fumaric Acid. V. 70, No. 30, Feb. 4, 1963, pp. 29, 31.

[7] Lane, W. B., and M. J. Nuckolls. An Improved Zinc Bromide Shielding Window. Naval Radiological Defense Lab., San Francisco, Calif., Rept. No. NRDL-TR-594, Oct. 2, 1962, 11 pp.; abs. in U.S. Dept. of Commerce, v. 38, No. 6, Mar. 20, 1963, p. 35.

[8] National Bureau of Standards. Effect of Methyl Bromide on Flame Speed of Methane. Tech. News Bull., v. 47, No. 5, May 1963, pp. 73–74.

[9] Sullivan, M. V., and G. A. Kolb. The Chemical Polishing of Gallium Arsenide in Bromine-Methanol. J. Electrochem. Soc., v. 110, No. 6, June 1963, pp. 585–587.

[10] Chemical Week. Organic Bromine Compound. V. 92, No. 25, June 22, 1963, p. 73.

[11] European Chemical News (London). V. 4, No. 81, Aug. 2, 1963, p. 30.

Physical properties, toxicity, methods of handling, some basic chemical reactions, and engineering materials were published.[12]

Bromine was recovered from an aqueous solution by absorption on an anion-exchange resin by a countercurrent fluidized-bed process.[13]

Dispersing a solid clathrate compound of methyl bromide and hydroquinone through soil fumigated the soil.[14]

Bromine was recovered from dilute bromine containing chlorine brine wherein the chlorine-to-bromine ratio was within the range 20:1 to 500:1.[15]

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[12] Electrochemical Technology. V. 1, Nos. 11–12, November–December 1963, p. 380.

[13] Schoenbeck, Leland Clarence (assigned to E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.). Continuous Fluid Bed Adsorption of Bromine on Anion Exchange Resin. U.S. Pat. 3,075,830, Jan. 29, 1963.

[14] Bryant, Burl E. (assigned to the Dow Chemical Co., Midland, Mich.). Clathrate Compound of Methyl Bromide. U.S. Pat. 3,076,742, Feb. 5, 1963.

[15] Gradishar, Fredrick John, and Frank Hein Rowland (assigned to E. I. du Pont de Nemours & Co. Inc., Wilmington, Del.). Recovery of Bromine From Solutions Thereof. U.S. Pat. 3,098,716, July 23, 1963.

Cadmium

By H. J. Schroeder[1]

THE DOMESTIC cadmium industry in 1963 experienced lower metal production and consumption compared to the record high quantities achieved in 1962. Imports of metal declined 10 percent while exports increased to the highest level since 1960. Sales of 2.0 million pounds of cadmium were made from the Government stockpile from April through September. Combined producer and distributor stocks of metal increased during the year from 1.3 to 1.4 million pounds. The price of cadmium advanced from $1.70 to 1.80 per pound in ton lots at the beginning of the year to $3.00 by yearend.

TABLE 1.—Salient cadmium statistics

(Thousand pounds)

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Production [1]	10,053	[2] 8,710	[2] 10,445	[2] 10,466	[2] 11,137	9,990
Shipments by producers [3]	9,648	[2] 11,012	[2] 11,982	[2] 10,222	[2] 12,057	10,124
Value .... thousands	$13,850	[2] $12,225	[2] $14,721	[2] $14,218	[2] $18,481	$21,880
Imports for consumption, metal	1,407	1,638	942	1,079	1,117	991
Exports	990	900	2,448	702	717	1,313
Consumption	(4)	[2] 11,589	[2] 10,337	[2] 10,640	[2] 12,579	11,560
Price: Average [5] .... per pound	$1.67	$1.36	$1.52	$1.68	$1.72	$2.26
World: Production	19,400	[2] 22,500	[2] 25,300	[2] 25,900	[2] 27,100	26,300

[1] Primary and secondary cadmium metal. Includes equivalent metal content of cadmium sponge used directly in production of compounds.
[2] Revised figure.
[3] Includes metal consumed at producer plants.
[4] Estimated consumption of primary and secondary metal not available before 1956.
[5] Average quoted price for cadmium sticks and bars in lots of 1 to 5 tons.

LEGISLATION AND GOVERNMENT PROGRAMS

Public law 88-8, signed by President Kennedy on April 9, authorized release of 2 million pounds of cadmium from the Government stockpile. In accord with this authorization, General Services Administration (GSA) sold by bids the following quantities: April 30—150,000 pounds; May 7—150,000 pounds; July 8—624,000 pounds; and September 6—1,075,400 pounds. A bill (H.R. 7278 of June 26, 1963) to authorize the release of 5 million pounds of cadmium from the Government stockpile was referred to the House Armed Services Committee for consideration, but no further action was taken on the bill.

The U.S. Department of Agriculture, Commodity Credit Corpora- (CCC) acquired 63,174 pounds of cadmium that was delivered under barter contracts negotiated prior to 1963. Cadmium was removed

[1] Commodity specialist, Division of Minerals.

late in 1962 from the list of foreign-produced commodities to be considered for barter of surplus agricultural products.

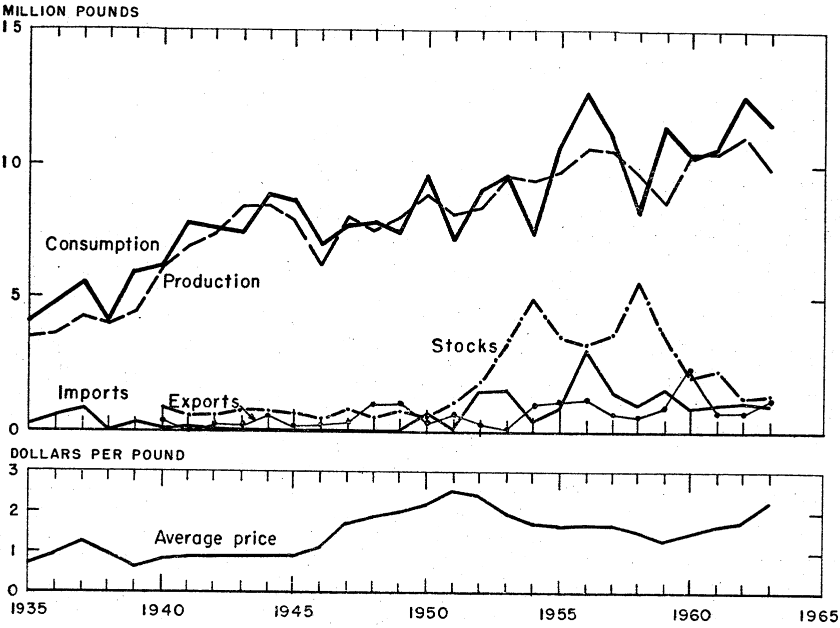

FIGURE 1.—Trends in production, consumption, yearend stocks, imports, exports, and average price of cadmium metal in United States, 1935–63.

DOMESTIC PRODUCTION

The 10 million pound production of cadmium metal from primary and secondary sources represented a decrease of 10 percent from the record high output in 1962 and the lowest level since 1959.

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 the foreign source estimated to be the largest item. The main source of zinc concentrates were Mexico, Canada and Peru. Secondary cadmium was recovered mainly from scrap alloys.

The Whitestone, New York secondary cadmium plant of Neo-Smelting & Refining, Inc., was closed in 1963. There were no other changes in the list of producers of cadmium shown in the 1960 Minerals Yearbook.

Production of cadmium sulfide, cadmium lithopone and cadmium sulfoselenide totaled 1.5 million pounds of contained cadmium, an increase of 16 percent over that of 1962 and a record quantity. The Bureau of Mines is not at liberty to publish the 1963 output of cadmium oxide (1.5 million pounds in 1962). Cadmium compounds are prepared from the metal or from intermediate compounds.

TABLE 2.—Cadmium oxide and cadmium sulfide produced in the United States

(Thousand pounds)

Year	Oxide		Sulfide [1]	
	Gross weight	Cadmium content	Gross weight	Cadmium content
1954-58 (average)	(2)	(2)	3,536	1,135
1959	(2)	(2)	3,701	1,243
1960	1,275	1,124	3,484	1,084
1961	1,229	1,075	3,355	1,115
1962	1,694	1,481	4,250	1,329
1963	(2)	(2)	4,560	1,542

[1] Includes cadmium lithopone and cadmium sulfoselenide.
[2] Figure withheld to avoid disclosing individual company confidential data.

CONSUMPTION AND USES

Consumption of cadmium metal—calculated as production, plus sales of cadmium from the Government stockpile, and plus or minus net foreign trade and net stock changes of producers, compound manufacturers, and distributors—was 11.6 million pounds. This quantity compared with 12.6 million pounds in 1962 and an average of 10.4 million pounds for the years 1958 through 1962.

Plating continued to be the largest use for cadmium, and was estimated to have consumed 55 to 60 percent of the total compared with an indicated 70 percent in 1960. The decrease is attributed to difficulties platers have had in obtaining adequate supplies of cadmium; also to substitution of competitive materials as the price of cadmium increased. Applications for cadmium plating include parts for automobiles, household appliances, aircraft, industrial machines, radio and television sets, and electrical and electronic equipment; also hardware fittings, instruments, and numerous fastening items (nuts, bolts, screws, etc.).

Pigments, the second largest use, accounted for an estimated 15 percent of total consumption. The cadmium compounds employed for high-quality industrial yellow and red colors are the sulfide, sulfoselenide and lithopones. Cadmium compounds used for other than colors represent about 15 to 20 percent of total consumption. Large and growing applications in this classification are the stearate for vinyl plastics, the nitrate for nickel-cadmium batteries and phosphors for television tubes.

Cadmium is used as a component of solders, low-melting point fusible alloys, and for other alloys amounting in the aggregate to an estimated 7 to 10 percent of total use.

STOCKS

Stocks of cadmium metal at producers, compound manufacturers, and distributors that were 1.3 million pounds at the beginning of 1963, decreased to approximately 1.0 million pounds by midyear and then rose to 1.4 million pounds by yearend. Government stockpile sales, which began in July, were undoubtedly a large factor in reversing the generally downward trend that began in 1959. Stocks of cadmium contained in compounds decreased 3 percent to 755,000 pounds during the year.

Government stockpiles were reduced by 2.0 million pounds during 1963 to 15.2 million, of which 7.8 million pounds was in the strategic stockpile and 7.4 million in the supplemental stockpile. At yearend there was a surplus of 8.7 million pounds of cadmium above the maximum stockpile objective of 6.5 million pounds.

TABLE 3.—Industry stocks, December 31
(Thousand pounds)

	1962 [1]		1963	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	880	(2)	755	(2)
Compound manufacturers	234	700	488	700
Distributors	143	75	122	55
Total	1,257	775	1,365	755
Consumers	[3] 600	(4)	(4)	(4)

[1] Figures partly revised.
[2] Included with stocks of cadmium contained in compounds at compound manufacturers in order to avoid disclosing individual company confidential data.
[3] Estimate.
[4] Data not available.

PRICES

Producer to consumer quoted prices for cadmium metal in one-ton lots advanced from $1.70 to $1.80 per pound at the beginning of the year to $3.00 by yearend. Details of price changes during the year for the several quotation bases are shown in table 4.

TABLE 4.—Cadmium quoted prices in the United States in 1963
(Per pound)

Date	Producer to consumer		Distributor to consumer
	One-ton lots	Less than ton lots	
January 1	$1.70-$1.80	$1.75-$1.85	(1)
January 2	1.70- 1.85	1.75- 1.85	(1)
January 14	1.85	1.90	(1)
February 4	1.85	1.90	$1.90-$2.10
May 1	2.35	2.40	2.40- 2.60
September 23	2.50- 2.65	2.55- 2.70	2.95- 3.10
November 18	2.50- 2.65	2.55- 2.70	[2] 3.50
December 18	3.00	3.05	[2] 3.50

[1] Published quotations began February 4, 1963.
[2] An approximate figure.

Cadmium on the London market was quoted at the beginning of the year at 14s. ($1.96 on the basis of $2.80 per pound sterling). Price quotations advanced four times during the year as follows: January 25–15s. ($2.10); May 10–18s. ($2.52); August 30–20s. ($2.80); and December 6–24s. ($3.36).

In Italy the quoted price was 3,200 lire per kilogram at the beginning of the year, or about $2.34 per pound on the basis of $0.001611 per lire. Many price changes during the year increased the quoted price to 4,000 lire ($2.92) by midyear and to 5,700 lire ($4.16) by yearend.

The French quotation for metal began the year at 22 francs or $2.04 per pound. A number of increases brought the price to 30 francs ($2.78) by the middle of June and to 39 francs ($3.61) by yearend.

FOREIGN TRADE

Imports.—General imports of cadmium metal were 1.0 million pounds, 10 percent less than in 1962; Canada, Peru, and Australia supplied 79 percent of the total. Imports of cadmium in flue dust, all from Mexico, decreased 9 percent to 1.2 million pounds.

Exports.—Exports of cadmium as metal and in alloys, dross, flue dust, residues and scrap increased 83 percent to 1.3 million pounds, the largest quantity since 1960. The United Kingdom, Netherlands, France, West Germany, Belgium-Luxembourg and Sweden received 96 percent of total exports.

Tariff.—The import duty on cadmium metal remained at 3.75 cents per pound in 1963—the rate effective January 1, 1948, as established at the Geneva Trade Conference in 1947. Cadmium contained in flue dust remained duty free.

WORLD REVIEW

World production of cadmium metal decreased 3 percent to 26.3 million pounds. Five countries—United States, U.S.S.R., Canada, Japan and Belgium—accounted for about 81 percent of the total. Countries with substantial decreases included Canada, Republic of the Congo and the United States; those with substantial increases included Japan, Peru, Northern Rhodesia, and the U.S.S.R.

Australia.—Construction work in the electrolytic zinc plant of EZ Industries, Ltd., at Risdon includes improvement in facilities for the recovery of cadmium.

Bulgaria.—Recent expansions in zinc plants reportedly includes facilities for recovery of cadmium. No quantitative report of output or capacity was available.

Canada.—Canadian Electrolytic Zinc's, Ltd. new electrolytic zinc plant, built near Montreal, includes facilities for recovery of byproduct cadmium.

South-West Africa.—A byproduct cadmium plant in conjunction with the recently constructed copper and lead smelter facilities at Tsumeb was projected to be in operation in 1964.

United Kingdom.—According to a bulletin published by the British Bureau of Nonferrous Metal Statistics, cadmium consumption was 2.9 million pounds and was used for the following purposes (in thousand pounds): Plating anodes, 1,124; plating salts, 321; cadmium-copper alloys, 114; other alloys, 73; alkaline batteries, 167; dry batteries, 9; solder, 163; colors, 828; and miscellaneous, 63. Imports of metal were 3.1 million pounds.

TABLE 5.—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]			
	1962		1963		1962		1963	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
CADMIUM METAL								
North America:								
Canada	812	$1,194	623	$1,370	812	$1,194	623	$1,370
Mexico			17	39			17	39
Total	812	1,194	640	1,409	812	1,194	640	1,409
South America:								
Argentina			41	98			22	56
Chile			11	16			11	16
Peru	130	176	119	168	130	176	119	168
Total	130	176	171	282	130	176	152	240
Europe:								
Belgium-Luxembourg	33	57	35	77	33	57	31	66
Germany, West			10	18			10	18
Italy	24	37			23	35	1	2
Netherlands	1	2	40	82	1	2	40	82
Poland and Danzig	(3)	(4)	1	4	(3)	(4)	1	4
United Kingdom	4	7			4	7		
Total	62	103	86	181	61	101	83	172
Asia: Japan	48	76	51	90	43	69	53	94
Africa:								
Angola	44	63			44	63		
Congo, Republic of the and Ruanda-Urundi	22	29	2	4	22	29	2	4
Total	66	92	2	4	66	92	2	4
Oceania: Australia	5	8	61	145	5	8	61	145
Total cadmium metal	1,123	1,649	1,011	2,111	1,117	1,640	991	2,064
FLUE DUST (CADMIUM CONTENT)								
North America: Mexico	1,273	$674	1,154	$845	1,570	$850	1,069	$795
Total flue dust	1,273	674	1,154	845	1,570	850	1,069	795
Grand total	2,396	2,323	[5] 2,165	[5] 2,956	2,687	2,490	2,060	2,859

[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.
[3] Less than 1,000 pounds.
[4] Less than $1,000.
[5] Excludes 6,144 pounds, valued at $5,714 credited to Honduras by the Bureau of the Census.

Source: Bureau of the Census.

TABLE 6.—U.S. exports of cadmium metal and cadmium in alloys, dross flue dust, residues, and scrap

(Thousand pounds and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1954-58 (average)	990	$1,425	1961	702	$983
1959	900	1,024	1962	717	1,139
1960	2,448	3,014	1963	1,313	3,070

Source: Bureau of the Census.

TABLE 7.—World production of cadmium metal, by countries [1] [2]

(Thousand pounds)

Country	1954-58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	1,894	2,160	2,357	1,358	2,605	2,431
Mexico (refined metal) [3]	[4] 14	[5] 133	[5] 179	[5] 104	[5] 63	[6] 17
United States (primary and secondary metal)	10,053	8,710	10,445	10,466	11,137	9,990
South America: Peru (refined metal) [3]	51	141	185	232	235	[7] 400
Europe:						
Austria	[6] 18	43	32	42	49	[7] 50
Belgium	1,367	[5] 1,512	[5] 1,583	[5] 1,988	[5] 1,854	[5] [7] 2,000
France	345	539	560	560	540	573
Germany, West	657	926	902	952	560	492
Italy	482	552	648	765	546	514
Netherlands [7]	51	88	88	88	88	88
Norway	239	284	243	231	254	243
Poland [9]	545	860	860	880	880	930
Spain	20	14	26	76	133	[7] 130
U.S.S.R. [7]	1,100	3,310	3,750	4,410	4,410	4,850
United Kingdom [10]	282	310	236	217	237	249
Yugoslavia	26	72	84	[7] 88	[7] 88	[7] 88
Asia: Japan	818	1,082	1,252	1,596	1,940	[7] 2,185
Africa:						
Congo, Republic of the (formerly Belgian)	621	1,047	1,113	1,168	650	[7] 220
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	[8] 94	----------	58	43	37	[7] 40
Oceania: Australia	722	764	672	676	791	818
World total (estimate) [1] [2]	19,400	22,500	25,300	25,900	27,100	26,300
The following data are not included in the above figures: [3]						
Guatemala (exports) [3] [11]	[8] 81	----------	123	94	[7] 27	[7] 16
Mexico (exports) [3]	1,909	2,074	1,201	2,557	2,422	[7] 2,425
Peru (exports) [3]	70	29	56	57	47	[7] 46
South-West Africa (sales and exports) [3]	2,175	1,294	1,732	1,747	1,219	1,058

[1] Data derived in part from bulletins of the World Nonferrous Metal Statistics and annual issues of Metal Statistics (Metallgesellschaft).

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail. No estimate included for Bulgaria, but it is reported to be producing cadmium.

[3] To avoid duplicating figures, data on cadmium exported in zinc concentrates, flue dusts, etc., are not included in the world total, but are shown separately at end of table.

[4] Exports for 1958 only.

[5] Exports.

[6] United States imports.

[7] Estimate.

[8] Average for 1956-58.

[9] Data revised in accordance with more recent information.

[10] Including secondary.

[11] Recoverable.

TECHNOLOGY

A vacuum method to remove and separate cadmium and zinc from molten lead containing the metals was patented.[2]

Articles [3] described results of research to produce high-purity cadmium compounds used in manufacture of photosensitive devices. Patents were granted for a method to prepare large single crystals of cadmium sulfide [4] and a method to produce cadmium phosphate glass.[5]

Hydrogen embrittlement in cadmium plating was reduced by electroplating with a dimethylformamide and cadmium iodide solution [6] or by selecting a steel with a lower embrittlement susceptibility and using the normal plating bath.[7] Patents were granted on methods to deposit cadmium on other metals by chemical reduction from a fused-salt solution [8] and to electroplate a corrosion resistant cadmium-titanium alloy.[9]

Research on characteristics of cadmium compounds for use as transistors, photoconductors and other functional components in electronics equipment was described.[10] A patent was granted for a method of manufacturing a cadmium sulfide photo-cell.[11]

The ductility of cadmium and cadmium-magnesium alloys from room to cryogenic temperatures was investigated.[12] An article described the structure of cadmium sulfide films as a function of substrate deposition temperature.[13] Another study related the electrical resistance of cadmium compounds under high pressure to crystallographic transformations.[14]

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[2] Woods, Stephen Esslemont, and Thomas Ronald Albert Davey (assigned to Metallurgical Processes Ltd., and The National Smelting Co.). Removal of Cadmium From Zinc. U.S. Pat. 3,080,227, Mar. 5, 1963.

[3] Fahrig, R. H. The Synthesis and Crystallization of High-Purity Cadmium Sulfide. Electrochem. Tech., v. 1, No. 11-12, November-December 1963, pp. 362-367.
Lorenz, M. R., and R. E. Halsted. High-Purity CdTe by Sealed-Ingot Zone Refining. J. Electrochem. Soc., v. 110, No. 4, April 1963, pp. 343-344.

[4] Fahrig, Richard H., and William E. Medcalf (assigned to The Eagle-Picher Co.). Process for Preparation of Cadmium Sulfide Crystals. U.S. Pat. 3,087,799, Apr. 30, 1963.

[5] Carpenter, Harry W., and Peter D. Johnson (assigned to the U.S. Atomic Energy Commission). U.S. Pat. 3,084,055, Apr. 2, 1963.

[6] Micillo, Carl. Cadmium Plating Without Embrittlement. Mat. Design Eng., v. 57, No. 6, June 1963, pp. 86-87.

[7] Beck, Walter, and Edward Jankowsky. Delayed Brittle Failure in Cadmium Plated Steels. Metal Prog., v. 84, No. 2, August 1963, pp. 92-95.

[8] Couch, Dwight E. (assigned to the U.S. Navy). Deposition of Cadmium By Chemical Reduction. U.S. Pat. 2,790,733, Apr. 30, 1957.

[9] Takada, Koji (assigned to Toyo Kinzokukagaku Kabushikikaisha). Process for the Electro-plating of Cadmium-Titanium Alloy. U.S. Pat. 3,083,150, Mar. 26, 1963.

[10] Dreeben, Arthur B., and Richard H. Bube. Photo-conductivity Performance in Large Single Crystals of Cadmium Sulfide. J. Electrochem. Soc., v. 110. No. 5, May 1963, pp. 456-460.
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Borkan, Harold, and Paul K. Weimer. An analysis of The Characteristics of Insulated-Gate Thin-Film Transistors. RCA Review, v. 24, No. 2, June 1963, pp. 153-165.

[11] Stanley, Howard E. (assigned to International Rectifier Corp.). Cadmium Sulfide Photo-Cell. U.S. Pat. 3,108,021, Oct. 22, 1963.

[12] Stoloff, N. S., and M. Gensamer. Deformation and Fracture of Polycrystalline Cadmium. AIME, (Met. Soc.) v. 227, No. 1, February 1963, pp. 70-80.

[13] Behringer, Arthur J., and Lester Corrsin. X-ray Diffraction Study of Evaporated CdS Films. J. Electrochem. Soc., v. 110, No. 10, October 1963, pp. 1083-1085.

[14] Science. High Pressure Phases of Some Compounds of Groups II-VI. V. 142, No. 3593, Nov. 8, 1963, pp. 672-673.

Calcium and Calcium Compounds

By Clarence O. Babcock [1]

PRODUCERS' supply of calcium chloride was short at yearend and a tight market and increased capacity were expected. While liquid calcium chloride for dust control on roads was the largest outlet, the use of solid calcium chloride for ice control was growing at a faster rate.

According to the sole domestic producer demand for calcium was expected to grow substantially in the next few years.

DOMESTIC PRODUCTION

Production of calcium averaged about 200,000 pounds per year for the last few years. The only commercial production of calcium in the United States was in a Federal Government-owned magnesium and calcium reduction plant and calcium redistillation plant at Canaan, Conn. Nelco Metals, Inc., a subsidiary of Chas. Pfizer & Co., Inc., has been operating the facility under contract with the Atomic Energy Commission. Operation was on a cost plus fee basis of 2.5 cents per pound of calcium delivered to the Commission. The company was permitted to operate the plants on its own behalf in the commercial market. Production of calcium was by the thermal reduction of quick lime briquetted with aluminum powder in horizontal, high-temperature, vacuum retorts in electric furnaces. Distillation which followed the reduction was followed by redistillation in a separate plant to increase the purity. The reduction plant could be used to produce 7.2 million pounds of calcium per year from 20 furnaces. The redistillation plant capacity was 600,000 pounds per year of calcium metal when operated 5 days a week.

Vanadium Corporation of America, New York, N.Y., produced a calcium-bearing inoculant for the improvement of mechanical properties of gray iron. This alloy contained calcium, 1.5 to 3 percent; silicon, 60 to 65 percent; manganese, 9 to 12 percent; barium, 4 to 6 percent; aluminum, 1 to 1.5 percent; and iron, the remainder.

Another calcium-silicon alloy was produced by Vanadium Corporation of America. It contained 12 to 16 percent calcium and was said to sink deeper into the melt than regular calcium-silicon alloys because of a 28 percent greater density.

Total production of natural and synthetic solid calcium chloride (73 to 75 percent $CaCl_2$) and flake calcium chloride (77 to 80 percent $CaCl_2$) was 672,000 short tons in 1962, an increase of 20 percent over

[1] Commodity specialist, Division of Minerals

that of 1961. Production of calcium chloride brine (40 percent $CaCl_2$) was 248,000 tons or 6 percent above a revised tonnage of 234,000 tons for 1961, excluding all brine that went into the production of solid and flake calcium chloride. Shipments of natural and synthetic solid and flake calcium chloride in 1962 totaled 658,000 tons valued at $19 million ($28.88 per ton) f.o.b. plant, an increase of 18 and 20 percent, respectively, from that of 1961. Brine shipments weighed 246,000 tons, 6 percent greater than the revised figure of 231,000 tons for 1961. Value was $2.3 million ($9.35 per ton) f.o.b. plant.[2]

Reported domestic production of natural calcium chloride and calcium-magnesium chloride, all forms, reduced to a 75-percent-chloride and 25-percent-water basis averaged 437,467 tons per year during the period 1959–63. Value averaged $8.32 million ($19.01 per ton) for the same 5-year period. Production was 8 percent less than the record high of 1962, but greater than any other previous year. However, value increased 7 percent.

Natural calcium chloride and natural calcium-magnesium chloride were produced by eight plants: Two in California, five in Michigan, and one in West Virginia. Michigan produced 95 percent; California, 4 percent; and West Virginia, 1 percent. Sources of supply were the Bristol Dry Lake in California and underground mines in Michigan and West Virginia. Domestic production on a calcium chloride content basis was 74 percent flake, 26 percent brine, and less than 1 percent solid.

Synthetic calcium chloride for sale on the open market was manufactured by Allied Chemical Corp., Solvay Process Division; by Pittsburgh Plate Glass Co., Chemical Division; and by Shell Chemical Co.

A new multimillion-dollar calcium chloride flake and granular plant planned by the Wyandotte Chemical Corp. was expected to be completed at Wyandotte, Mich., in mid-1964.[3]

Hot brine solutions from about 1 mile underground in the Salton Sea area of southern California contained calcium and other chemicals. The brine in O'Neill's Sportsman No. 1 well contained 34,470 parts per million calcium.[4]

CONSUMPTION AND USES

Use of commercial-grade calcium was expected to increase much faster than the higher grade now widely used. Lower grade calcium with its lower cost could be used as a reducing and deoxidizing agent for a wide range of metals. Calcium's unusual affinity for oxygen, nitrogen, sulfur, chlorine, and the other halides made it ideal for the reduction of impurities from metals. Industrial uses included calcium in making high-strength steels and in experimental calcium-aluminum alloys.[5]

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[2] U.S. Department of Commerce, Bureau of the Census, Industry Division. Inorganic Chemicals and Gases, 1962. Current Ind. Rept. Ser. M28A(62)-13, Dec. 5, 1963, p. 11.

[3] Chemical Engineering. Semiannual Inventory of New Plants and Facilities. V. 70, No. 22, Oct. 28, 1963, p. 130.

[4] Chemical Week. Harnessing Hot Brine. V. 93, No. 23, Dec. 7, 1963, p. 43.

[5] Starin, F. J. Calcium Is Built Up as a Reducing Agent. Iron Age, v. 192, No. 26, Dec. 26, 1963, p. 30

The quantity of solid calcium chloride used for winter maintenance of hard surface roads was reported to have increased from 90,000 tons in 1957 to 150,000 tons in 1961. Calcium chloride also was used in concrete highway construction to decrease the setting time at low temperature. Replacement of country dirt roads with asphalt paving reduced the need for liquid calcium chloride to settle dust. End uses of solid calcium chloride were as follows: Deicing of roads, 30 percent; dust control, 25 percent; concrete treatment, 13 percent; industrial uses, 10 percent; brine refrigeration, 5 percent; and miscellaneous, 17 percent.[6]

PRICES AND SPECIFICATIONS

Nelco Metals, Inc., supplied the following prices and specifications. Reportedly the prices had been stable since November 15, 1958. A typical composition for commercial-grade calcium, in percent, was calcium, over 99; magnesium, 0.50; aluminum, 0.30; nitrogen, 0.08; iron, 0.008; and manganese, 0.01. A typical composition for redistilled grade calcium expressed in percent, was calcium, over 99; magnesium, 0.50; nitrogen, less than 0.02; aluminum, less than 0.0010; iron, less than 0.0010; manganese, less than 0.0020; cobalt, less than 0.0002; lithium, less than 0.0001; beryllium, less than 0.0001; chromium, less than 0.0002; and boron, less than 0.0001. All prices given in table 1 were f.o.b. Canaan, Conn.

TABLE 1.—Nelco Metals, Inc., calcium metal price list
(Per pound)

Grade and form	Less than 100 pounds	100 to 1,999 pounds	2,000 pounds and over	6,000 pounds and over
Commercial:				
Full crowns	$2.00	$1.25	$0.95	
Broken crowns (5 inches and less)	2.10	1.50	1.05	
Nodules, 6 mesh	2.50	1.70	1.15	
Turnings	3.00	2.80	2.50	
Ingots or waffles	2.80	1.70	1.30	
80 percent Ca—20 percent Mg (ingots or waffles)	2.80	1.30	1.30	
Redistilled:				
Broken crowns (8 inches and less)	3.75	2.60	1.70	$1.50
Nodules:				
6 mesh	4.00	2.80	1.80	1.60
⅛ inch	5.00	3.80	2.50	2.50

The following posted prices of calcium chloride chemicals remained constant for 1963. Concentrated flake or pellet calcium chloride, 94 to 97 percent $CaCl_2$ (paperbags, carlots, at works, freight equalized), was $41.70 per ton. Regular flake calcium chloride, 77 to 80 percent $CaCl_2$ (paper bags, carlots, at works, freight equalized), was $34 per ton. Powdered calcium chloride, 77 percent minimum $CaCl_2$ (paper bags, carlots, at works, freight equalized), was $40 per ton. Solid calcium chloride, 73 to 75 percent $CaCl_2$ (carlots, freight equalized), was $32.50 per ton. Calcium chloride liquor or brine, about 40 per-

[6] Oil, Paint and Drug Reporter. Calcium Chloride Producers Turning Thoughts to Expansion as Use in Ice Control Gains. V. 184, No. 27, Dec. 30, 1963, p. 7.

cent $CaCl_2$, a supersaturated solution shipped in heated tank cars (tank cars, freight equalized), was $14 per ton.[7]

FOREIGN TRADE

Imports.—Calcium imports were all from Canada. Calcium-silicon alloy (calcium silicide) imports were from France, 76 percent; West Germany, 20 percent; and Norway, 4 percent. Calcium chloride imports were from Belgium-Luxembourg, 39 percent; Canada, 33 percent; United Kingdom, 17 percent; and West Germany, 11 percent.

Exports.—Calcium and calcium-silicon were not exported. Calcium chloride exports were received by Canada, 85 percent; Mexico, 7 percent; and 48 other countries, 8 percent. These other market areas in decreasing order of size, were South America, Europe, Asia, West Indies, Central America, and Oceania.

TABLE 2.—U.S. imports for consumption of calcium, calcium-silicon, and calcium chloride and exports of calcium chloride

Year	Imports						Exports	
	Calcium		Calcium-silicon		Calcium chloride		Calcium chloride	
	Pounds	Value	Pounds	Value	Short tons	Value	Short tons	Value
1954–58 (average)	286,700	$327,343	338,344	$53,760	1,694	$58,360	29,970	$998,375
1959	7,425	7,506	918,556	138,188	1,756	66,499	39,929	1,376,854
1960	12,618	15,276	352,765	50,899	1,570	61,938	26,792	1,067,909
1961	17,266	22,892	558,009	82,561	3,022	102,680	22,047	1,090,583
1962	43,962	51,669	1,370,048	200,163	1,896	59,753	43,830	1,686,819
1963	26,343	31,648	(1)	(1)	2,234	67,119	36,984	1,527,243

[1] No longer separately classified effective Sept. 1, 1963; January through August 1,119,308 pounds, value $159,575.

Source: Bureau of the Census.

WORLD REVIEW

Canada.—Calcium production was 123,511 pounds valued at Can$124,412 (Can$1.007 per pound) in 1962, compared with 72,597 pounds, valued at Can$76,359 (Can$1.05 per pound) in 1961. Preliminary estimates for 1963 were 79,429 pounds valued at Can$97,698 (Can$1.23 per pound).[8]

Calcium shipments totaled 104,850 pounds valued at Can$102,438 (Can$0.98 per pound) in 1962, compared with 99,355 pounds, valued at Can$100,881 (Can$1.015 per pound) in 1961. Dominion Magnesium, Ltd., Haley, Ontario, was the only producer. Production was at the company magnesium smelter. Commercial-grade calcium was produced by reduction of minus 200-mesh powdered lime by minus 20-mesh commercial-purity aluminum in briquets in a horizontal retort of chrome-nickel iron alloy. Reduction occurred in a vacuum at temperatures of about 1,170° C and the calcium vapor was condensed in crystalline form at temperatures of 680° to 740° C. Further refining produced

[7] Oil, Paint and Drug Reporter. V. 183, Nos. 1–26; v. 184, Nos. 1–27; Jan. 7–Dec. 30, 1963.
[8] Dominion Bureau of Statistics (Canada). Preliminary Estimate of Canada's Mineral Production. Catalogue No. 26, 202 Annual, December 1963, p. 3.

higher purity. The four grades produced ranged in purity from the 98-percent commercial grade to the nominal 99.9 percent of the chemical standard grade. Maximum impurities in the commercial grade were 0.5 to 1.5 percent magnesium, 1.0 percent nitrogen, and 0.35 percent aluminum. Chemical standard grade was available as granules (4 to 80 mesh), and other grades were available as granules, crystalline lumps, ingots, billets, and extruded shapes. Only a few hundred pounds was consumed in Canada and the remainder was exported to the following countries: United States, 36 percent; Great Britain, 23 percent; West Germany, 16 percent; India, 12 percent; Belgium-Luxembourg, 7 percent; Republic of South Africa, 4 percent; and other countries, 2 percent. The prices quoted by Dominion Magnesium, Ltd. for 1962 ranged from 80 cents per pound for commercial grade to Can$3.50 per pound for chemical standard grade, f.o.b. Haley. The U.S. tariff on imported Canadian calcium was 15.5 percent ad valorem. The Canadian most-favored-nation tariff on calcium metal, pure, in lumps, ingot, and powder was 15 percent ad valorem, and on calcium-metal alloys, or metal in rods, sheets, or semiprocessed form was 20 percent ad valorem.[9]

Viet-Nam.—New industrial projects for which funds were being sought would produce calcium chloride and calcium carbide at Cam Ranh Bay when the electric line from Da Nhim was finished.

TECHNOLOGY

A quantitative micromethod for determining calcium or strontium cations, especially in biological fluids, was reported.[10]

A new calcium indicator, hydroxy napthol blue A.R., marketed by Mallinckrodt Chemical Works, St. Louis, Mo., was specific for calcium and was unaffected by magnesium and other ions that commonly interfered with volumetric calcium determinations. The color change during titration was pronounced.[11]

Calcium was produced by a continuous electrolysis process under development by the British Atomic Energy Commission. Electrolysis of fused calcium chloride and calcium sulfide between a cathode of molten calcium-copper alloy and an anode of graphite produced a calcium enriched molten cathode. Part of the cathode was removed, calcium was distilled off, and the distillate residue, rich in copper, was recycled to the electrolysis cell.[12]

A report on theoretical and practical information of significance for the operation of a electrolytic cell for the preparation of calcium from calcium chloride and sodium was published.[13]

A new radioactivity standard for calcium-45 was made available from the National Bureau of Standards (NBS). Calcium-45 (NBS Standard Sample No. 4942, 3-milliliter ampoule, price $38) was issued

[9] Jackson, W. H. Calcium 1962. Canada Dept. Mines and Tech. Surveys, Min. Res. Div., Ottawa, April 1963, 3 pp.
[10] Science. Microdetermination of Calcium by Aequorin Luminescence. V. 140, No. 3573, June 21, 1963, pp. 1339–1340.
[11] Chemical & Engineering News. V. 41, No. 23, June 10, 1963, p. 57.
[12] Chemical Engineering. Inventory of New Processes and Technology. V. 70, No. 2, Jan. 21, 1963, p. 110.
[13] Deutsche Gold- und Silberscheideanstalt (Frankfurt am Main, n.d., Germany). (The Possibility of Obtaining Calcium from Calcium Chloride and Sodium.) Abs. Tech. Transl. U.S. Dept. of Commerce, OTS, v. 10, No. 6, Sept. 30, 1963, p. 658.

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as a solution of calcium chloride in hydrochloric acid, with a nominal activity of 8 by 10^4 disintegrations per second per milliliter.[14]

The rate at which various calcium alloys absorbed nitrogen was studied. Pure calcium reacted extremely slowly with nitrogen, and sodium had a strong activating effect as reported earlier by others. When added to calcium barium alone, barium with lithium, and potassium alone were ineffective as activators. Barium added to calcium-sodium alloy had an intense activating effect. This combination burned in nitrogen with a free flame.[15]

Adding 4 pounds of calcium-manganese-silicon and 4 pounds of ferrotitanium per ton to acid open-hearth steel, or 4 pounds calcium-manganese-silicon and 3 pounds of aluminum per ton of acid-electric steel, gave improved fluidity, ductility, and low-temperature impact strength to steel castings.[16]

A Canadian patent (660,063) was issued for a process to produce an iron-calcium base alloy for addition to steel melts. The alloy was comprised of 15 to 40 percent calcium, 0.5 to 55 percent aluminum, 5 to 25 percent silicon and the remainder was iron.[17]

A study of the effect of calcium chloride on the durability of pre-tensioned wire in prestressed concrete was reported. The additional corrosion caused by the use of less than 2 percent by weight $CaCl_2$ (flake) in a dense normally cured portland cement concrete was thought to have no structural significance. The assumption also was made that the materials, mix design, and depth of cover were satisfactory.[18]

Calcium chloride was found to be one of several common deicing salts that will not damage asphalt pavements. Asphalt Institute research engineers conducted the laboratory study. Calcium chloride did not damage good quality, air-entrained concrete pavements in tests by the Portland Cement Association.[19]

Frequently asked questions about the use of chemicals for ice and snow control were answered. Graphs related the melting properties of calcium chloride and sodium chloride. These included the amount of ice melted in time up to 2 hours for each chemical alone; depth of ice melted in 2 hours with temperatures ranging from minus 30 to plus 30 degrees for each chemical alone and with a mixture of 25 percent calcium chloride and 75 percent sodium chloride.[20]

Ice removal and outdoor storage characteristics of calcium chloride, sodium chloride, and mixtures of the two were studied by the Minnesota Department of Highways in cooperation with the Bureau of Public Roads. They recommended that a mixture of one-third calcium chloride to two-thirds sodium chloride be used for best storage, ice removal, and economy.[21]

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[14] National Bureau of Standards Technical News Bulletin. Standard Materials. V. 47, No. 5, May 1963, pp. 78–79.

[15] I. G. Farbenindustrie (Griesheim, n.d., Germany). (Comparative Experiments on the Velocity With Which Various Calcium Alloys Take Up Nitrogen.) Abs. in Tech. Transl., U.S. Department of Commerce, OTS, v. 10, No. 6, Sept. 30, 1963, p. 702.

[16] Canadian Mining and Metallurgical Bulletin (Canada). Steel Casting Quality Improved. V. 56, No. 616, August 1963, p. 8.

[17] Iron Age. Iron-Calcium Alloy. V. 192, No. 5, Aug. 1, 1963, p. 68.

[18] Building Science Abstracts (London). Effect of Calcium Chloride on Durability of Pre-tensioned Wire in Prestressed Concrete. V. 34, No. 5, May 1963, pp. 138–139.

[19] Calcium Chloride Institute News. Calcium Chloride Acclaimed Best De-Icer for Variety of Surfaces. First Quarter 1963, p. 10.

[20] Calcium Chloride Institute News. V. 13, No. 4, Fourth Quarter 1963, pp. 6–7.

[21] Calcium Chloride Institute News. Calcium Chloride Stands Out in Minnesota Storage Tests. Special Winter Issue, Third Quarter 1963, p. 12.

Cement

By William R. Barton [1]

PRODUCTION and shipments of cement, under the stimuli of building and road construction demands, achieved record highs in 1963. Production and shipments were both 5 percent higher than in 1962, and compared to the previous record year, 1959, production and shipments each increased about 3 percent.

Portland cement plant capacity at yearend was reported to be 477.6 million 376-pound barrels as facility expansions and modernizations proceeded at a brisk pace. Increased plant automation and improvements in product distribution continued to characterize this mineral based industry during 1963. The competitive pressures generated by these developments resulted in sharp price decreases in some parts of the country causing cost-price relationships unsatisfactory to cement producers. In determining priority for constructing new distribution centers and production facilities, many firms made increasing use of Bureau of Mines data compilations for market research studies enabling optimum site selection.

TABLE 1.—Salient cement statistics

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Production thousand 376-pound barrels	[1] 310,927	350,419	328,715	332,558	345,567	361,235
Capacity used at portland cement mills Percent	85.6	80.5	73.5	73.1	71.5	73.4
Shipments from mills thousand 376-pound barrels	[1] 306,254	346,675	321,646	329,443	340,770	358,024
Value [2] thousands	[1] $936,575	$1,144,867	$1,089,134	$1,105,537	$1,129,387	$1,156,890
Average value per barrel	$3.06	$3.30	$3.39	$3.36	$3.31	$3.23
Stocks Dec. 31: At mills thousand 376-pound barrels	23,176	31,437	35,660	36,415	[3] 39,003	39,417
Imports for consumption do	3,589	5,265	4,108	3,621	[3] 5,633	4,030
Exports do	1,521	277	187	286	380	460
Consumption, apparent [4] do	308,322	351,663	325,567	332,778	[3] 346,023	361,594
World: Production do	1,356,056	[3] 1,726,233	[3] 1,855,952	[3] 1,954,987	[3] 2,098,128	2,201,159

[1] Portland cement, 1954–58; and masonry and natural cement 1955–58.
[2] Value received f.o.b. mill, excluding cost of containers.
[3] Revised figure.
[4] Quantity shipped plus imports minus exports.

LEGISLATION AND GOVERNMENT PROGRAMS

Following investigations by the Treasury Department, it was ruled that cement imported from Italy, Yugoslavia, and Poland was being sold at fair prices under the regulations of the Anti-Dumping Act. Martin Marietta Corp. consented, without admission of impropriety,

[1] Commodity specialist, Division of Minerals.

to a Federal Trade Commission order requiring it to sell 75 properties acquired in 29 States since 1954. The Federal Trade Commission also had instituted divestiture actions against six other firms charging their acquisitions might substantially lessen competition or tend to create a monopoly.

PORTLAND CEMENT

PRODUCTION AND SHIPMENTS

Production of portland cement increased to 352.5 million barrels, 5 percent above the 336.5 million barrels produced in 1962. In 1963 all except 5 of the 26 producer districts had greater output than in 1962.

Five new portland cement plants began production in 1963 at Atlanta, Ga. (Martin-Marietta Corp.); Joppa, Ill. (Missouri Portland Cement Co.); Castle Hayne, N.C. (Ideal Cement Co.); York, Pa. (Medusa Portland Cement Co., replacement of obsolete plant); and Montana City, Mont. (Permanente Cement Co.). A new plant was under construction at Catskill, N.Y., adjacent to existing facilities (Alpha Portland Cement Co.) and at Bushland, Texas (Southwestern Portland Cement Co.). Plants were expanded or modernized at Colton, Calif. (California Portland Cement Co.); Cushenbury, Calif. (Permanente Cement Co.); Linwood, Iowa (Dewey Portland Cement Co.); Hannibal, Mo. (Universal Atlas Cement Co.); and Kingston, N.Y. (Colonial Sand and Stone Co., Inc.). Plans were announced to build new plants at Cantwell, Alaska (Alaska Portland Cement, Ltd., of San Francisco); Festus, Mo. (Mississippi River Fuel Corp.); Bellefonte, Pa. (National Gypsum Co.); and Fernley, Nev. (Nevada Cement Co.). Closed or dismantled were the old York, Pa., grey cement plant of Medusa Portland Cement Co., the Dewey Portland Cement Co. plant at Dewey, Okla., and the Oglesby, Ill., plant of Lehigh Portland Cement Co.

The general trend continued toward larger capacity plants and plant components and increased automation to achieve production efficiencies and, concomitantly, reduced production costs. Descriptions were published of new or expanded cement plants at Crestmore, Calif.,[2] Cushenbury, Calif.,[3] Logansport, Ind.,[4] Montana City, Mont.,[5] Ravena, N.Y.,[6] Castle Hayne, N.C.,[7] Superior, Ohio,[8] York, Pa.,[9] and Houston, Tex.[10] The California cement production facilities

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[2] Rock Products. Riverside Takes Giant Step. V. 66, No. 7, July 1963, pp. 60–62, 64.

[3] Bergstrom, J. H. Permanente Doubles Capacity at Cushenbury. Rock Products, v. 66, No. 5, May 1963, pp. 69–74.

[4] Levine, Sid. Laboratory Control Console Regulates Materials Proportioning at Louisville Cement's Automated Logansport Plant. Minerals Processing, v. 4, No. 7, July 1963, pp. 24–29.
Herod, B. C. Louisville Cement's New Logansport Mill. Pit and Quarry. V. 56, No. 1, July 1963, pp. 142–150, 151.

[5] Pit and Quarry. Permanente Begins Production at New Montana Cement Plant. V. 55, No. 11, May 1963, pp. 175, 177.

[6] Trauffer, W. E. New Production-Distribution Complex of Atlantic Cement. Pit and Quarry. V. 56, No. 1, July 1963, pp. 114–123, 128–133, 136, 141.

[7] Minerals Processing. Dedication of Ideal's 18th Cement Plant. V. 5, No. 2, February 1964, pp. 14–16.

[8] Bergstrom, J. H. Space Age Technology Highlights Ohio Cement Plant. Rock Products, V. 66, No. 4, April 1963, pp. 65–72.

[9] Levine, Sid. Medusa's Modernized White Cement Plant On-Stream at York, Pa. Minerals Processing, v. 4, No. 8, August 1963, pp. 14–18.

[10] Levine, Sid. Dock Facilities Speed Materials to Gulf Coast Portland Cement. Minerals Processing, v. 4, No. 6, June 1963, pp. 21–24.

were discussed.[11] The number of portland cement plants in the United States (including Puerto Rico) in 1963, by size groups, was:

Estimated annual capacity:	*Number of plants*	*Percent of total capacity*
Less than 1	8	1.3
1 to 2	55	17.3
2 to 3	64	32.3
3 to 4	31	21.2
4 to 5	12	10.5
5 and over	11	17.4
Total	181	100.0

TYPES OF PORTLAND CEMENT

General-use and moderate-heat cements (types I and II) were produced at 180 of 181 operating plants and comprise 93 percent of all portland cement made. High-early-strength cement (type III) was produced at 145 plants—4 plants more than in 1962.

Eight plants reported production of portland-slag or portland-pozzolan cement. These plants also produced other types of portland cement.

CAPACITY OF PLANTS

Estimated annual capacity of all portland cement plants on December 31, as reported to the Bureau of Mines by producers, was 2 percent greater than on December 31, 1962. The capacity increase of 8.6 million barrels resulted mainly from new plants and expansions at existing plants.

CLINKER PRODUCTION

Production of portland clinker was 354.2 million barrels—5 percent higher than in 1962. Monthly output reached a high at 33.9 million barrels in July. Yearend stocks of clinker were 6 percent lower than those at the close of 1962.

RAW MATERIALS

About 71 percent of the domestic production of portland cement was made from limestone, clay, and shale as well as from muscovite schist in one case. Argillaceous limestone (cement rock) or a mixture of cement rock and limestone was used for 24 percent of the portland cement produced. One plant used marl instead of limestone; one used a combination of marl and limestone; and 11 used clay and shell. Blast-furnace and other slags were used as raw materials in producing portland cement at 28 plants; 7 of these plants used approximately 300,000 tons of slag to produce portland-slag cement.

The new cement plant at Atlanta, Ga., is augmenting its own production of cement rock by purchasing 200,000 tons a year of waste marble from Georgia quarries.

[11] Utley, H. F. California Cement Producers. Pit and Quarry, v. 55, No. 8, February 1963, pp. 98–102,109.

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)	
					1962			1963				
					Thousand 376-pound barrels	Value		Thousand 376-pound barrels	Value			
	1962	1963	1962	1963		Total (thousands)	Average per barrel		Total (thousands)	Average per barrel	1962 [2]	1963
New York, Maine	13	13	20,133	23,525	19,083	$63,344	$3.32	22,999	$69,955	$3.04	3,558	3,985
Eastern Pennsylvania	17	17	31,778	30,402	30,974	103,083	3.33	30,513	92,591	3.03	4,413	4,186
Western Pennsylvania	5	5	7,777	7,956	7,489	24,886	3.32	7,803	25,612	3.28	1,631	1,658
Maryland, West Virginia	4	4	9,825	10,277	9,611	32,002	3.33	9,773	30,211	3.09	909	1,181
Ohio	10	10	15,465	16,300	15,353	51,006	3.32	16,218	53,244	3.28	1,857	1,898
Michigan	9	9	23,070	24,194	22,682	73,267	3.23	25,016	76,944	3.08	3,354	2,532
Indiana, Kentucky, Wisconsin	8	8	18,596	19,155	17,905	59,219	3.31	18,280	60,266	3.30	2,411	2,332
Illinois	4	5	9,081	9,465	9,145	30,205	3.30	9,281	30,577	3.29	1,241	1,304
Tennessee	6	6	8,845	8,660	8,509	27,741	3.26	8,283	26,760	3.23	849	916
Virginia, North Carolina, South Carolina	4	5	8,320	8,561	8,271	27,461	3.32	8,295	26,294	3.17	765	1,031
Georgia, Florida	6	7	10,842	11,291	10,526	36,152	3.43	11,226	36,608	3.26	1,179	1,198
Alabama	8	8	12,914	12,611	12,482	40,164	3.22	12,218	38,417	3.14	1,191	1,172
Louisiana, Mississippi	5	5	7,875	8,422	7,751	24,535	3.17	8,327	26,585	3.19	808	843
Minnesota, South Dakota, Nebraska	4	4	8,440	7,883	8,430	28,643	3.40	7,718	26,110	3.38	1,090	1,226
Iowa	5	5	11,869	12,787	12,261	42,417	3.46	12,495	42,891	3.43	1,312	1,471
Missouri	5	5	12,239	12,692	12,739	44,004	3.45	12,402	41,640	3.36	1,397	1,527
Kansas	6	6	8,235	8,248	8,058	25,134	3.12	8,201	25,372	3.09	1,507	1,525
Oklahoma, Arkansas	6	6	9,589	11,299	9,311	27,071	2.91	11,416	33,508	2.93	1,555	1,398
Texas	17	16	26,443	29,150	26,204	83,162	3.17	29,104	92,734	3.19	2,485	2,520
Wyoming, Montana, Idaho	3	4	3,062	3,616	3,054	11,003	3.60	3,418	11,963	3.50	303	501
Colorado, Arizona, Utah, New Mexico	7	7	13,565	13,559	13,762	45,695	3.32	13,562	45,245	3.34	929	926
Oregon, Washington	9	9	7,191	7,799	7,081	24,971	3.53	7,727	27,576	3.57	1,079	1,143
Northern California	6	6	17,340	17,973	17,345	57,297	3.30	18,028	58,839	3.26	1,219	1,164
Southern California	7	7	26,489	28,119	26,322	81,854	3.11	28,250	88,817	3.14	1,684	1,553
Hawaii	2	2	1,140	1,428	1,128	6,055	5.37	1,483	7,125	4.80	199	144
Puerto Rico	2	2	6,365	7,171	6,347	20,018	3.15	7,217	22,090	3.06	226	180
Total	178	181	336,488	352,543	[3] 331,823	1,090,389	3.29	[3] 349,253	1,117,974	3.20	39,151	39,514

[1] Includes Puerto Rico.
[2] Incorporates some revisions.
[3] Does not include finished cement used in manufacturing prepared masonry cement as follows: 1962, 2,665,000 barrels; 1963, 2,927,000 barrels.

TABLE 3.—Portland cement produced and shipped 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 per barrel
General use and moderate heat (types I and II):					
1954–58 (average)	161	278,435	274,492	$820,227	$2.99
1959	171	[2] 316,600	312,970	1,012,836	3.24
1960	175	[2] 297,279	290,968	962,453	3.31
1961	174	[2] 302,107	298,616	980,371	3.28
1962	177	[2] 313,888	309,784	1,004,793	3.24
1963	180	[2] 329,929	326,918	1,032,809	3.16
High-early-strength (type III):					
1954–58 (average)	108	11,813	11,516	40,071	3.48
1959	129	[3] 14,439	14,363	53,484	3.72
1960	135	[3] 13,961	13,772	51,731	3.76
1961	135	[3] 13,530	14,305	53,000	3.71
1962	141	[3] 14,958	14,597	53,576	3.67
1963	145	[3] 14,592	14,559	51,167	3.51
Low-heat (type IV):					
1954–58 (average)	1	25	13	51	3.92
1959	3	10	10	46	4.44
1960	3	7	8	32	4.07
1961	2	18	14	60	4.23
1962	2	----------	9	37	4.45
1963	3	----------	----------	----------	----------
Sulfate-resisting (type V):					
1954–58 (average)	7	147	135	505	3.74
1959	11	189	192	743	3.86
1960	14	445	435	1,664	3.83
1961	13	931	416	1,608	3.87
1962	11	236	244	1,048	4.29
1963	18	349	324	1,267	3.91
Oil-well:					
1954–58 (average)	16	1,538	1,552	5,215	3.36
1959	16	1,288	1,182	4,121	3.49
1960	14	1,055	1,059	3,669	3.46
1961	14	1,015	1,235	4,181	3.39
1962	13	1,281	1,215	4,140	3.41
1963	15	1,239	1,158	3,878	3.35
White:					
1954–58 (average)	4	1,187	1,150	6,923	6.02
1959	4	[4] 1,525	1,515	9,819	6.48
1960	4	[4] 1,504	1,384	9,274	6.70
1961	5	[4] 1,647	1,532	10,387	6.78
1962	5	[4] 1,726	1,668	11,690	7.01
1963	5	[4] 2,050	1,935	13,547	7.00
Portland-slag and portland pozzolan:					
1954–58 (average)	10	4,714	4,598	14,220	3.09
1959	8	[5] 3,653	3,806	12,864	3.38
1960	7	[5] 3,630	3,525	12,057	3.42
1961	8	[5] 3,586	3,316	11,179	3.37
1962	7	[5] 2,848	2,868	9,524	3.32
1963	8	[5] 2,470	2,620	8,681	3.31
Miscellaneous:[6]					
1954–58 (average)	23	1,369	1,160	4,202	3.62
1959	22	[4] 1,387	1,414	5,331	3.77
1960	20	[4] 1,128	1,141	4,366	3.83
1961	19	[4] 1,280	1,317	4,992	3.79
1962	19	[4] 1,551	1,438	5,581	3.88
1963	23	[4] 1,914	1,739	6,625	3.81
Grand total:					
1954–58 (average)	161	299,228	294,616	891,414	3.03
1959	[7] 172	339,091	335,452	1,099,244	3.28
1960	[7] 176	319,009	312,292	1,045,246	3.35
1961	[7] 175	324,114	320,751	1,065,778	3.32
1962	[7] 178	336,488	331,823	1,090,389	3.29
1963	[7] 181	352,543	349,253	1,117,974	3.20

[1] Includes Puerto Rico.
[2] Includes air-entrained portland cement as follows (in thousand 376-pound barrels): 1959, 38,961; 1960, 35,473; 1961, 36,373; 1962, 38,096; 1963, 40,649.
[3] Includes air-entrained portland cement as follows (in thousand 376-pound barrels): 1959, 5,126; 1960, 4,645; 1961, 4,140; 1962, 5,078; 1963, 4,879.
[4] Includes a small amount of air-entrained portland cement.
[5] Includes air-entrained portland cement as follows (in thousand 376-pound barrels): 1959, 1,969; 1960, 1,400; 1961, 1,996; 1962, 1,617; 1963, 1,369.
[6] Includes hydroplastic, plastic, and waterproofed cements.
[7] Includes number of plants making air-entrained portland cement as follows: 1959, 119; 1960, 120; 1961, 120; 1962, 121; 1963, 121.

TABLE 4.—Portland-cement-manufacturing capacity of the United States,[1] by districts

District	Capacity Dec. 31 (thousand 376-pound barrels)		Percent utilized	
	1962	1963	1962	1963
New York, Maine	36,956	37,126	54.5	63.4
Eastern Pennsylvania	41,908	42,161	75.8	72.1
Western Pennsylvania	11,708	11,708	66.4	68.0
Maryland, West Virginia	11,950	11,880	82.2	86.5
Ohio	22,400	22,400	69.0	72.8
Michigan	34,154	34,154	67.5	70.8
Indiana, Kentucky, Wisconsin	26,461	26,591	70.3	72.0
Illinois	10,930	13,930	83.1	67.9
Tennessee	9,974	9,974	88.7	86.8
Virginia, North Carolina, South Carolina	10,590	14,110	78.6	60.7
Georgia, Florida	19,261	20,072	56.3	56.3
Alabama	16,290	16,260	79.3	77.6
Louisiana, Mississippi	9,500	9,500	82.9	88.7
Minnesota, South Dakota, Nebraska	9,322	9,326	90.5	84.5
Iowa	15,190	15,610	78.1	81.9
Missouri	16,277	15,805	75.2	80.3
Kansas	12,490	12,364	65.9	66.7
Oklahoma, Arkansas	16,100	14,225	59.6	79.4
Texas	41,733	42,289	63.4	68.9
Wyoming, Montana, Idaho	3,300	4,700	92.8	76.9
Colorado, Arizona, Utah, New Mexico	17,670	16,600	76.8	81.7
Oregon, Washington	11,190	10,750	64.3	72.5
Northern California	20,900	20,850	83.0	86.2
Southern California	32,520	35,400	81.5	79.4
Hawaii	2,700	2,700	42.2	52.9
Puerto Rico	7,500	7,100	84.9	101.0
Total	468,974	477,585	71.8	73.8

[1] Includes Puerto Rico.

TABLE 5.—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								
	1961	1962	1963	1961	1962	1963	1961	1962	1963	1961	1962	1963
Wet	259,167	275,933	284,601	58.5	58.8	59.6	72.7	70.9	74.0	58.1	58.2	59.8
Dry	183,855	193,041	192,984	41.5	41.2	40.4	73.8	72.9	73.5	41.9	41.8	40.2
Total	443,022	468,974	477,585	100.0	100.0	100.0	73.2	71.8	73.8	100.0	100.0	100.0

[1] Includes Puerto Rico.

TABLE 6.—Portland cement clinker produced and in stock at mills in the United States,[1] by process [2]

Clinker	Number of plants		Thousand 376-pound barrels			
			Production		Stocks on Dec. 31—	
	1962	1963	1962	1963	1962 [3]	1963 [4]
Wet	106	107	193,742	208,410	8,150	9,071
Dry	70	72	142,962	145,836	9,772	7,808
Total	176	179	336,704	354,246	17,922	16,879

[1] Includes Puerto Rico.
[2] Compiled from monthly estimates of producers.
[3] Revised figures.
[4] Preliminary figures.

FUEL AND POWER

More coal and natural gas were used in producing cement than were used in 1962. Use of fuel oil declined in 1963. Coal and oil supplied approximately 53 percent of the heat requirements. Consumption of natural gas increased 5 percent, compared with that in 1962. The active plants used an average of 1.2 million Btu. per barrel of cement. Plants also consumed an average of 23.3 kilowatt-hours of electric energy per barrel of cement produced.

TABLE 7.—Production of portland-cement clinker at mills in the United States [1] in 1963, by months and districts

(Thousand 376-pound barrels)

District	January	February	March	April	May	June	July	August	September	October	November	December
New York, Maine	1,314	1,452	1,686	1,644	2,380	2,444	2,502	2,524	2,565	2,414	2,055	1,825
Eastern Pennsylvania	1,817	1,378	1,908	2,555	3,091	3,073	3,242	2,990	2,720	2,829	2,642	2,643
Western Pennsylvania	229	192	329	644	907	841	800	827	824	893	856	621
Maryland, West Virginia	836	587	754	807	915	954	977	973	853	913	915	758
Ohio	959	1,061	1,086	1,227	1,518	1,602	1,660	1,535	1,570	1,613	1,399	1,230
Michigan	1,860	1,614	1,872	1,888	2,070	2,053	2,050	2,117	2,302	2,240	2,326	1,931
Indiana, Kentucky, Wisconsin	1,101	1,160	1,308	1,706	1,924	1,779	1,677	1,654	1,575	1,648	1,715	1,296
Illinois	769	612	578	729	912	863	894	870	846	905	831	755
Tennessee	665	447	577	730	828	782	828	869	884	790	736	583
Virginia, North Carolina, South Carolina	636	340	505	718	856	758	840	815	842	848	862	871
Georgia, Florida	730	624	808	970	1,040	844	1,157	1,496	1,178	1,159	981	736
Alabama	815	748	1,043	1,137	1,073	1,162	1,218	1,228	987	1,149	1,054	1,068
Louisiana, Mississippi	616	474	683	644	804	771	779	851	617	694	692	626
Minnesota, South Dakota, Nebraska	541	564	625	717	781	721	719	700	659	680	664	550
Iowa	840	583	542	1,087	1,205	1,240	1,276	1,267	1,243	1,239	1,252	954
Missouri	644	548	814	1,071	1,036	1,130	1,183	1,177	1,178	1,207	1,091	816
Kansas	298	402	616	865	853	654	664	834	804	912	673	555
Oklahoma, Arkansas	737	602	895	1,070	1,117	1,050	1,140	958	1,031	1,093	984	839
Texas	1,761	1,932	2,377	2,679	2,747	2,879	2,747	2,549	2,555	2,755	2,520	2,104
Wyoming, Montana, Idaho	164	123	199	441	424	320	376	346	377	339	394	257
Colorado, Arizona, Utah, New Mexico	1,094	974	1,156	1,107	1,161	1,190	1,247	1,280	1,181	1,199	1,036	1,090
Oregon, Washington	375	462	646	685	712	724	776	805	784	736	744	584
Northern California	1,422	1,295	1,469	1,558	1,585	1,476	1,618	1,637	1,629	1,610	1,298	1,394
Southern California	2,043	1,903	2,138	2,243	2,355	2,540	2,711	2,576	2,361	2,438	2,242	2,238
Hawaii	42	20	76	115	159	165	200	144	119	149	179	58
Puerto Rico	476	477	588	517	522	503	599	596	561	597	596	652
Total:												
1963	22,784	20,574	25,278	29,554	32,975	32,518	33,880	33,618	32,245	33,049	30,737	27,034
1962	22,360	19,523	24,591	28,264	31,287	30,539	30,702	31,690	31,382	31,570	28,979	25,817

[1] Includes Puerto Rico.

TABLE 8.—Production and percentage of total output of portland cement in the United States,[1] by raw materials used

Year	Cement rock and pure limestone		Limestone and clay or shale [2] [3]		Blast-furnace slag and limestone	
	Thousand 376-pound barrels	Percent	Thousand 376-pound barrels	Percent	Thousand 376-pound barrels	Percent
1954–58 (average)	67,623	22.6	212,329	71.0	19,276	6.4
1959	79,895	23.5	239,336	70.6	19,860	5.9
1960	85,924	26.9	215,625	67.6	17,460	5.5
1961	70,824	21.9	230,376	71.1	22,914	7.0
1962	75,042	22.3	238,160	70.7	23,286	7.0
1963	85,741	24.3	251,068	71.2	15,734	4.5

[1] Includes Puerto Rico.
[2] Includes output of 3 plants using marl and clay in 1954–58 (average); 4 plants in 1959–60; 3 plants in 1961; 2 plants in 1962; 1 plant in 1963; and 1 plant using marl only.
[3] Includes output of 8 plants using oystershells and clay in 1954–58 (average); 9 plants in 1959–61; 10 plants in 1962; and 11 plants in 1963.

TABLE 9.—Raw materials used in producing portland cement in the United States [1]

(Thousand short tons)

Raw materials	1961	1962	1963
Cement rock	18,482	20,829	17,354
Limestone (including oystershell)	68,139	69,456	77,663
Marl	549	1,689	452
Clay and shale [2]	10,105	9,943	10,650
Blast-furnace slag	1,295	1,119	1,040
Gypsum	2,754	2,826	2,929
Sand and sandstone (including silica and quartz)	1,386	1,423	1,811
Iron materials [3]	623	659	572
Miscellaneous [4]	137	105	200
Total	103,470	108,049	112,671

[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, air-entraining compounds, and grinding aids.

TABLE 10.—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)
1962:						
Wet	108	195,745	58.2	3,998	[2] 3,639	128,352,699
Dry	70	140,743	41.8	3,909	635	59,394,641
Total	178	336,488	100.0	[3] 7,907	[2] 4,274	187,747,340
1963:						
Wet	110	210,678	59.8	4,492	3,560	134,426,751
Dry	71	141,865	40.2	3,830	466	63,961,585
Total	181	352,543	100.0	[4] 8,322	4,026	[5] 198,388,336

[1] Includes Puerto Rico.
[2] Revised figure.
[3] Comprises 188,000 tons of anthracite and 7,719,000 tons of bituminous coal.
[4] Comprises 183,899 tons of anthracite and 8,138,439 tons of bituminous coal.
[5] Includes 125,183 thousand cubic feet of coke-oven gas.

TABLE 11.—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)
1962:						
Coal	59	[2] 103,912	30.9	5,192	----------	----------
Oil	9	[2] 14,842	4.4	----------	2,820	----------
Natural gas	37	[2] 58,604	17.4	----------	----------	69,113,189
Coal and oil	21	48,068	14.3	1,951	[3] 939	----------
Coal and natural gas	19	33,884	10.1	519	----------	31,256,068
Oil and natural gas	21	56,073	16.7	----------	425	65,951,842
Coal, oil, and natural gas	12	21,105	6.2	245	90	21,426,241
Total	178	336,488	100.0	[4] 7,907	4,274	187,747,340
1963:						
Coal	57	[2] 106,921	30.3	5,339	----------	----------
Oil	9	[2] 15,427	4.4	----------	2,757	----------
Natural gas	38	[2] 72,132	20.5	----------	----------	89,351,368
Coal and oil	20	42,743	12.1	1,718	760	----------
Coal and natural gas	30	50,179	14.2	997	----------	[5] 39,034,618
Oil and natural gas	18	47,662	13.5	----------	463	55,886,421
Coal, oil, and natural gas	9	17,479	5.0	268	46	14,115,929
Total	181	352,543	100.0	[6] 8,322	4,026	198,388,336

[1] Includes Puerto Rico.
[2] Average consumption of fuel per barrel of cement produced as follows; 1962—coal, 99.9 pounds; oil, 0.1900 barrel; natural gas, 1,179 cubic feet; 1963—coal, 99.9 pounds; oil, 0.1787 barrel; natural gas, 1,239 cubic feet.
[3] Revised figure.
[4] Comprises 188,049 tons of anthracite and 7,719,000 tons of bituminous coal.
[5] Includes 125,183 thousand cubic feet of coke-oven gas.
[6] Comprises 183,899 tons of anthracite and 8,138,439 tons of bituminous coal.

TABLE 12.—Electric energy used at portland cement plants in the United States,[1] by processes

Year and process	Electric energy used						Finished cement produced (thousand 376-pound barrels)	Average electric energy used per barrel of cement produced (kilowatt-hours)
	Generated at portland cement plants		Purchased		Total			
	Active plants	Million kilowatt-hours	Active plants	Million kilowatt-hours	Million kilowatt-hours	Percent		
1962:								
Wet	21	484	106	3,801	4,285	54.8	195,745	22.0
Dry	25	1,142	69	2,393	3,535	45.2	140,743	25.3
Total	46	1,626	175	6,194	7,820	100.0	336,488	23.2
Percent of total electric energy used	----------	20.8	----------	78.2	100.0	----------	----------	----------
1963:								
Wet	20	471	108	4,271	4,742	57.7	210,678	22.5
Dry	23	1,059	68	2,413	3,472	42.3	141,865	24.5
Total	43	1,530	176	6,684	8,214	100.0	352,543	23.2
Percent of total electric energy used	----------	18.6	----------	81.4	100.0	----------	----------	----------

[1] Includes Puerto Rico.

TABLE 13.—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		In paper bags [2]		Total shipments	
	Thousand 376-pound barrels	Percent	Thousand 376-pound barrels	Percent	Thousand 376-pound barrels	Percent
1962:						
Truck	171,472	60.8	32,711	65.6	204,183	61.5
Railroad	103,660	36.8	16,856	33.8	120,516	36.3
Boat	6,514	2.3	156	.3	6,670	2.0
Used at the plant	335	.1	119	.3	454	.2
Total	281,981	100.0	49,842	100.0	331,823	100.0
Percent of total	85.0		15.0		100.0	
1963:						
Truck	187,723	62.6	34,958	70.7	222,681	63.8
Railroad	103,113	34.4	14,228	28.8	117,341	33.6
Boat	8,700	2.9	144	.3	8,844	2.5
Used at the plant	260	.1	127	.2	387	.1
Total	299,796	100.0	49,457	100.0	349,253	100.0
Percent of total	85.8		14.2		100.0	

[1] Includes Puerto Rico.
[2] Cloth bags and other containers included with paper bags to avoid disclosing individual company confidential data.

TRANSPORTATION

Shipments of cement in bulk increased to a record high of 86 percent of the total. The balance was shipped in paper bags except for a very small quantity packed in cloth bags or other containers. Shipments from mills by truck increased from 62 percent in 1962 to 64 percent in 1963. Water shipments increased from 2 percent to 3 percent of the total. Rail shipments were 34 percent, and less than 1 percent of portland cement removed from stock was used at the plant site.

Construction of modern, automated distribution terminals for storage and transshipment of cement in bulk continued at a rapid pace. At least 150 such distribution points were in operation for the convenience of local customers.

To supply these distribution points the trend has been, wherever possible, to use bulk transport (by water if possible) and automatic loading and unloading facilities. Atlantic Cement Co. uses the three largest ocean going barges in the world to transport cement from its Ravenna, N.Y., plant to the receiving depots. Each barge, Adelaide, Angela, and Alexandra, has a capacity of 90,000 barrels of cement in bulk. Numerous other bulk cement carriers with capacities from 9,000 to 80,000 barrels have been placed in service along the coastlines or on the inland waterways systems.

TABLE 14.—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	
	1962	1963	1962	1963
Alabama	4,764	4,905	84	60
Alaska [1]	(2)	(2)	(2)	(2)
Arizona	5,058	4,622	(2)	(2)
Arkansas	3,053	3,556	26	27
Northern California	14,520	15,883	80	208
Southern California	25,347	26,435	171	40
Colorado	4,775	4,763	17	27
Connecticut [1]	3,609	3,823	358	377
Delaware [1]	896	1,135	97	87
District of Columbia [1]	1,559	1,520	88	87
Florida	[3] 11,143	[3] 12,546	922	692
Georgia	7,066	7,930	96	88
Hawaii	1,129	995		
Idaho	1,091	1,141	2	15
Illinois	17,582	16,838	674	624
Indiana	8,179	8,675	461	424
Iowa	6,460	6,827	221	213
Kansas	5,331	5,024	71	63
Kentucky	4,599	5,818	146	156
Louisiana	8,875	9,112	102	108
Maine	811	816	88	87
Maryland	6,246	6,412	349	399
Massachusetts [1]	4,878	5,356	500	586
Michigan	14,671	15,519	764	745
Minnesota	6,600	6,533	407	370
Mississippi	3,704	3,999	29	17
Missouri	8,814	8,990	278	282
Montana	1,291	1,498	58	17
Nebraska	4,620	4,957	199	206
Nevada [1]	1,598	2,090	14	19
New Hampshire [1]	755	727	92	90
New Jersey [1]	8,862	9,410	1,538	1,576
New Mexico	2,345	2,911	172	200
New York	18,599	18,260	1,600	1,440
North Carolina [1]	5,432	5,742	199	160
North Dakota [1]	1,397	1,523	27	29
Ohio	15,771	17,518	436	551
Oklahoma	5,941	7,105	25	22
Oregon	3,045	3,189	45	91
Eastern Pennsylvania	9,003	9,676	1,048	1,023
Western Pennsylvania	5,763	5,640	216	186
Rhode Island [1]	820	880	65	87
South Carolina	2,578	2,705	41	37
South Dakota	2,023	1,411	94	69
Tennessee	6,270	6,228	152	144
Texas	22,900	24,618	1,180	1,417
Utah	2,857	2,509	65	66
Vermont [1]	380	435	37	33
Virginia	7,266	7,947	453	449
Washington	4,984	5,224	487	480
West Virginia	1,848	1,896	37	46
Wisconsin	7,937	8,599	259	291
Wyoming	1,101	1,190	6	4
Total United States	326,146	343,061	14,576	14,515
Other countries	[4] 5,677	[4] 6,192	[5] 20	[5] 44
Total shipped from cement plants	331,823	349,253	14,596	14,559

[1] Noncement producer.
[2] Included with "Other countries" to avoid disclosing individual company confidential data.
[3] Includes shipments from Puerto Rican mills.
[4] Direct shipments by producers to foreign countries, the State of Alaska, and to Puerto Rico, including distribution from Puerto Rican mills.
[5] Direct shipments by producers to other countries and the States of Alaska and Arizona.

CONSUMPTION

Shipments of cement into the various States are considered to be an index of consumption. These shipments into 38 of the States were higher than those in 1962. The trend in apparent consumption for the years 1900 to 1963 is shown in figure 1.

Shipments to ready-mixed concrete producers increased 9.6 million barrels from the 1962 total, and shipments to highway contractors rose 5.1 million barrels. Nearly all companies supplied breakdowns of shipments by types of customers, as in 1962.

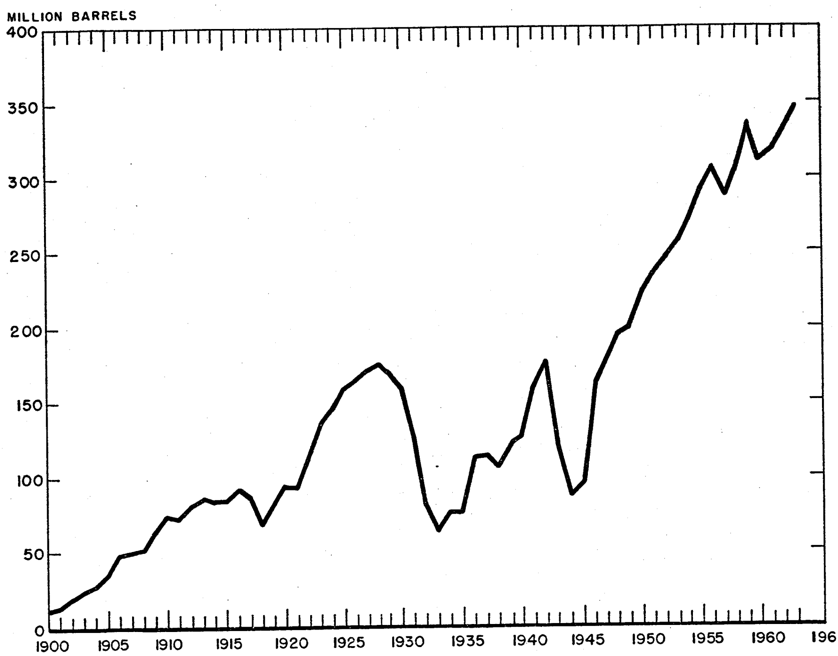

FIGURE 1.—Apparent consumption of finished portland cement in the United States, 1900–63.

About 71 percent of the new interstate highway system built to date has either concrete paving or soil-cement in the base or subbase. Cement users continued to foster concrete sales by new designs and cost-saving techniques. Precasting of concrete building components weighing many tons was of increasing utility. Quality control was enhanced and labor and transportation conserved in some cases by casting at the mixing plant and then trucking to the building site. In at least one instance complete precast concrete modules were being used for building construction. Slip-form pouring of walls and job-site extrusion of nonreinforced concrete pipelines were practiced more frequently. Sculptured panels, geodesic forms, cantilevered roofs, and similar architectural designs continued to improve the appearance of concrete buildings.

STOCKS

Stocks of finished portland cement and clinker at portland cement plants on December 31 were 1 percent higher and 6 percent lower, respectively, than those on hand December 31, 1962. Yearend mill stocks of finished portland cement and portland cement clinker and the annual range in end-of-month stocks, 1959–63 are given in table 16.

PREPARED MASONRY CEMENTS

Prepared masonry cements were produced at 143 cement plants. Production was 3 percent higher than in 1962. North Carolina and Ohio received the greatest total shipments.

Producers reported shipments of masonry cements in 280-pound barrels, although such cements actually varies considerably in composition and bulk density.

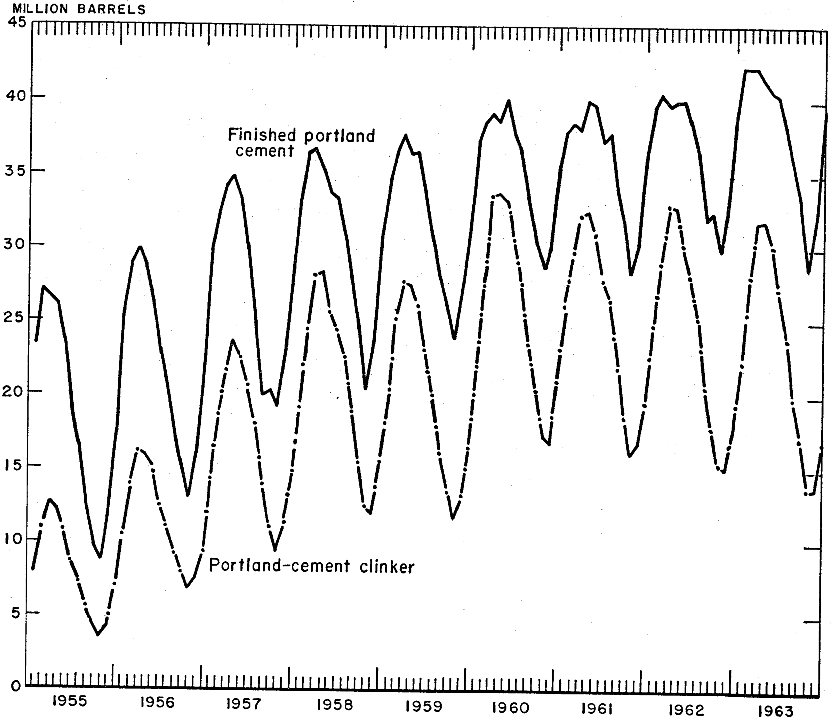

FIGURE 2.—End-of-month stocks of finished portland cement and portland-cement clinker, 1955–63.

TABLE 15.—Cement shipments by types of customers in 1963

(Quantities in 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	10.3	2,366	10.0	2,308	69.3	15,929	8.3	1,899	1.3	302	0.1	45	0.7	150	22,999
Eastern Pennsylvania	17	13.5	4,109	20.2	6,156	55.8	17,040	7.5	2,274	0.8	244	------	5	2.2	685	30,513
Western Pennsylvania	5	8.5	666	17.4	1,358	52.2	4,072	15.8	1,230	4.4	347	0.2	14	1.5	116	7,803
Maryland, West Virginia	4	7.4	725	19.0	1,852	58.2	5,685	14.1	1,382	0.9	87	------	5	0.4	37	9,773
Ohio	10	9.2	1,486	14.8	2,404	60.3	9,786	15.3	2,478	0.1	13	------	3	0.3	48	16,218
Michigan	9	9.6	2,388	13.6	3,400	53.4	13,369	18.7	4,686	3.5	883	0.2	51	1.0	239	25,016
Indiana, Kentucky, Wisconsin	8	8.0	1,458	11.3	2,074	61.4	11,223	15.7	2,868	1.9	347	------	3	1.7	307	18,280
Illinois	5	4.5	417	12.7	1,183	66.5	6,171	14.7	1,365	1.6	145	------	------	------	------	9,281
Tennessee	6	6.5	538	81.0	1,490	55.5	4,597	13.8	1,143	3.0	242	2.5	211	0.7	62	8,283
Virginia, North Carolina, South Carolina	5	7.5	625	19.3	1,602	61.3	5,081	6.4	534	5.0	409	0.1	10	0.4	34	8,295
Georgia, Florida	7	15.2	1,706	20.0	2,243	48.8	5,482	10.8	1,213	2.8	318	1.0	110	1.4	154	11,226
Alabama	7	8.8	1,079	19.0	2,323	54.0	6,598	9.6	1,166	5.6	677	1.0	126	2.0	249	12,218
Louisiana, Mississippi	5	4.2	353	9.3	777	46.7	3,889	23.0	1,916	15.7	1,304	0.3	20	.8	68	8,327
Minnesota, South Dakota, Nebraska	4	17.0	1,315	9.2	706	43.1	3,329	25.2	1,944	5.3	405	0.1	9	0.1	10	7,718
Iowa	5	11.3	1,411	17.8	2,218	53.5	6,688	16.0	2,003	1.1	134	0.2	27	0.1	14	12,495
Missouri	5	8.7	1,078	13.5	1,670	58.4	7,243	17.1	2,125	2.1	266	0.1	13	0.1	7	12,402
Kansas	6	11.7	959	5.7	469	57.1	4,684	14.5	1,186	7.9	651	1.0	79	2.1	173	8,201
Oklahoma, Arkansas	6	8.1	926	7.4	839	46.4	5,298	28.1	3,205	6.5	743	0.4	49	3.1	356	11,416
Texas	17	9.2	2,674	13.2	3,843	54.8	15,954	10.4	3,021	1.9	554	6.2	1,805	4.3	1,253	29,104
Wyoming, Montana, Idaho	4	10.2	350	11.2	382	45.8	1,564	13.3	455	13.6	464	3.1	107	2.8	96	3,418
Colorado, Arizona, Utah, New Mexico	7	11.5	1,564	8.9	1,210	55.7	7,555	12.4	1,681	5.9	799	3.5	469	2.1	284	13,562
Oregon, Washington	9	7.3	566	13.1	1,013	60.5	4,675	10.3	797	7.5	575	1.1	85	0.2	16	7,727
Northern California	6	9.1	1,635	8.2	1,471	66.0	11,904	5.4	982	10.8	1,947	0.2	36	0.3	53	18,028
Southern California	7	12.4	3,494	11.1	3,140	69.5	19,646	3.3	938	3.0	838	0.3	87	0.4	107	28,250
Hawaii	2	12.2	181	8.2	122	46.7	693	0.2	3	1.3	19	31.2	463	0.2	2	1,483
Puerto Rico	2	35.3	2,550	3.4	248	27.4	1,976	0.7	47	0.1	10	2.9	209	30.2	2,177	7,217
Total	181	10.5	36,619	13.3	46,501	57.3	200,131	12.2	42,541	3.6	12,723	1.2	4,041	1.9	6,697	349,253

TABLE 16.—Stocks of finished portland cement and portland-cement clinker at mills in the United States,[1] on Dec. 31 and yearly range in end-of-month-stocks

(Thousand 376-pound barrels)

Year		Dec. 31, quantity	Range			
			Low		High	
			End of month	Quantity	End of month	Quantity
1959	Cement	31,465	October	23,913	March	37,711
	Clinker	16,506	do	11,681	do	27,709
1960	Cement	35,640	do	28,841	May	40,101
	Clinker	20,958	November	16,838	April	33,616
1961	Cement	36,579	October	28,437	do	39,999
	Clinker	19,516	do	16,215	do	32,432
1962	Cement	[2] 39,151	do	29,901	February	40,626
	Clinker	[2] 17,922	November	15,051	March	32,950
1963	Cement	39,514	October	28,485	do	42,333
	Clinker	16,879	do	13,631	April	31,908

[1] Includes Puerto Rico.
[2] Revised figure.

TABLE 17.—Shipments of prepared masonry cement from mills in the United States, by States

(Thousand 280-pound barrels)

Destination	1962	1963
Alabama	570	586
Alaska [1]	(2)	(2)
Arizona	(2)	(2)
Arkansas	272	332
Colorado	289	243
Connecticut [1]	129	117
Delaware [1]	42	53
District of Columbia [1]	289	335
Florida	1,159	1,171
Georgia	1,030	1,166
Idaho	13	12
Illinois	722	659
Indiana	675	699
Iowa	191	183
Kansas	199	192
Kentucky	487	548
Louisiana	314	322
Maine	75	69
Maryland	493	610
Massachusetts [1]	266	270
Michigan	1,058	1,187
Minnesota	399	391
Mississippi	329	329
Missouri	204	215
Montana	20	20
Nebraska	94	92
New Hampshire [1]	66	69
New Jersey [1]	555	576
New Mexico	125	129
New York	1,079	1,058
North Carolina	1,341	1,464
North Dakota [1]	58	59
Ohio	1,360	1,438
Oklahoma	313	322
Oregon	1	1
Eastern Pennsylvania	536	484
Western Pennsylvania	572	558
Rhode Island [1]	27	29
South Carolina	686	752
South Dakota	52	56
Tennessee	942	995
Texas	919	945
Utah	14	12
Vermont [1]	34	36
Virginia	1,120	1,280
Washington	44	42
West Virginia	202	212
Wisconsin	487	493
Wyoming	22	19
Total United States	19,874	20,830
Other countries [3]	124	167
Total shipped from cement plants	19,998	20,997

[1] Noncement producer.
[2] Included with "Other countries" to avoid disclosing individual company confidential data.
[3] Direct shipments by producers to other countries and to Alaska and Arizona.

TABLE 18.—Prepared masonry cement produced and shipped in the United States, by districts

District	Active plants		Production (thousand 280-pound barrels)		Shipments from mills					
					1962			1963		
	1962	1963	1962	1963	Thousand 280-pound barrels	Value (thousands)	Average per barrel	Thousand 280-pound barrels	Value (thousands)	Average per barrel
New York, Maine	12	12	1,145	1,183	1,076	$2,856	$2.65	1,083	$2,798	$2.59
Eastern Pennsylvania	15	15	1,715	1,611	1,694	4,617	2.73	1,676	4,257	2.54
Western Pennsylvania	5	5	870	842	871	2,488	2.86	834	2,354	2.82
Maryland, West Virginia	4	5	920	1,023	869	2,336	2.69	1,084	2,733	2.52
Ohio	8	8	937	1,072	946	2,793	2.95	1,023	3,084	3.02
Michigan	6	6	1,574	1,515	1,517	4,335	2.86	1,684	4,519	2.68
Indiana, Kentucky, Wisconsin	7	7	2,664	2,886	2,703	7,268	2.69	2,880	7,668	2.66
Illinois	4	5	435	396	440	1,320	3.00	472	1,440	3.05
Tennessee	5	5	1,096	1,157	1,089	2,931	2.69	1,161	3,079	2.65
Virginia, North Carolina, South Carolina	4	4	1,461	1,574	1,448	4,216	2.91	1,588	4,660	2.94
Georgia, Florida	5	5	1,145	1,011	1,105	3,237	2.93	1,049	3,177	3.03
Alabama	9	9	2,200	2,475	2,187	6,521	2.98	2,386	7,242	3.04
Louisiana, Mississippi	4	4	368	419	340	887	2.61	350	922	2.63
Minnesota, South Dakota, Nebraska	4	4	272	224	280	903	3.23	287	913	3.18
Iowa	4	4	593	490	568	1,786	3.15	551	1,754	3.18
Missouri	5	5	434	519	455	1,457	3.20	417	1,345	3.22
Kansas	7	7	375	404	392	1,156	2.95	387	1,183	3.05
Oklahoma, Arkansas	6	5	436	586	488	1,453	2.98	558	1,617	2.90
Texas	14	14	877	837	926	2,774	2.99	930	2,858	3.07
Wyoming, Montana, Idaho	3	3	(1)	39	(1)	(1)	(1)	33	116	3.45
Colorado, Arizona, Utah, New Mexico	6	5	(1)	506	(1)	(1)	(1)	510	1,714	3.36
Oregon, Washington	6	6	65	54	56	173	3.11	54	166	3.08
Northern California	1		(1)		(1)	(1)	(1)			
Undistributed			566		548	1,898	3.46			
Total	144	143	20,148	20,823	19,998	57,405	2.87	20,997	59,599	2.84

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.

TABLE 19.—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)	
1955-58 (average)	5	805	795	$2,567	92
1959	4	438	441	1,450	64
1960	4	568	548	1,949	85
1961	4	225	269	968	40
1962	4	440	402	1,611	78
1963	4	357	352	1,407	83

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 (tables 18 and 19). Production figures from 1957 to 1962 are not strictly comparable with those for earlier years because of changes in methods of reporting by some producers.

Producers reported use of about 50,000 tons of cement rock, 15,000 tons of lime, 15,000 tons of slag, 6,000 tons of coal, and 40 million cubic feet of natural gas in processing natural and slag cements.

TABLE 20.—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]
1954-58 (average)	$3.03	$3.21	$2.71	$3.05
1959	3.28	3.28	2.82	3.30
1960	3.35	3.56	2.95	3.37
1961	3.32	3.60	2.89	3.35
1962	3.29	4.01	2.87	3.31
1963	3.20	3.99	2.84	3.23

[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.

PRICES

Cement prices, in 1963, continued to decline due to overcapacity and the pressures generated by resultant sales competition. Most firms reported that despite increased sales profit per unit sale declined.

Average net value of shipments from all cement plants was $3.23 per barrel, compared with $3.31 in 1962.

Portland cement values at plant dropped from $3.27 per barrel in the last quarter of 1962 to $3.22 in the first quarter of 1963 and then declined steadily during the year to $3.17 in the fourth quarter of 1963. The average value of types I and II cement was $3.22 in the fourth quarter of 1962, $3.17 in the first quarter of 1963, and $3.13 in the fourth quarter of 1963. Type III cement was valued at $3.84 in the fourth quarter of 1962, $3.52 in the first quarter of 1963, and $3.48 in the fourth quarter of 1963. The average price of prepared masonry cement was $2.84 (280 pound barrels) in the fourth quarter of 1962, $2.87 in the first quarter of 1963, and $2.83 in the fourth quarter of 1963.

The composite average annual wholesale price index for portland cement, f.o.b. destination, according to the Bureau of Labor Statistics index (1957–59=100) was 101.5 in 1963, compared with 103.1 in 1962. Previous indices (based on 1947–49=100) were convertible to the 1957–59 basis by multiplying by the factor of 0.6671609.

FOREIGN TRADE

Imports.—Imports of hydraulic cement declined from 5.6 million barrels in 1962 to 4.0 million barrels in 1963. The 1963 imports included 898,827 barrels imported from Canada through Rochester and 851,069 barrels imported from Norway through Connecticut. These two countries supplied 60 percent of the total cement imports. Belgium supplied more than half of all white cement imports.

The decline in total imports was caused principally by the displacement of imported cement from Boston and New York City markets. Imports through the New York customs district dropped from 1,706,922 barrels to 511,781 barrels, and in the Massachusetts customs district they dropped from 126,572 barrels to none in 1963.

TABLE 21.—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
1954–58 (average)	3,114	$9,066	217	$394	258	$1,502	3,589	$10,962
1959	4,979	12,268	6	47	280	1,458	5,265	13.773
1960	3,826	8,736	----------	----------	282	1,570	4,108	10,306
1961	3,359	7,858	----------	----------	262	1,367	3,621	9.225
1962	[1] 4,842	[1] 10,464	[1] 472	[1] 883	[1] 319	[1] 1,508	[1] 5,633	[1] 12.855
1963	[2] 3,649	[2] 8,534	[2] 52	[2] 226	329	1,442	4,030	10,202

[1] Revised figure.
[2] Due to changes in classification data not strictly comparable with other years.

Source: Bureau of the Census.

Exports.—Exports of hydraulic cement increased from 380,000 barrels in 1962 to 460,000 barrels in 1963. Larger exports to Canada and the Bahamas more than offset substantial decreases in exports to the Republic of Korea.

TABLE 22.—U.S.[1] imports for consumption of hydraulic cement in 1963,[2] by countries and customs districts

(376-pound barrels)

Custom districts	Belgium-Luxembourg	Canada	Colombia	Denmark	Dominican Republic	France	West Germany	Israel	Japan	Mexico	Norway	Sweden	United Kingdom	Yugoslavia	Total
Alaska		97,405							880						98,285
Arizona										342					342
Buffalo		71,745					662								72,407
Chicago	88														88
Connecticut								29,989			851,069				881,058
Dakota		104,665													104,665
El Paso										252					252
Florida	197,722						2,013		20,277			87,574	6,294		313,880
Georgia	17,364											80,647	5,999		104,010
Hawaii	150			49					850						1,049
Laredo										20,358					20,358
Los Angeles									19,809				2,844		22,653
Maine and New Hampshire		3,048													3,048
Michigan		51,473					10,525								61,998
Mobile	602														602
Montana and Idaho		21,973													21,973
New Orleans	8,030														8,030
New York	41,186	931	15,475	113,011				270,000			67,910		3,268		511,781
North Carolina	9,784														9,784
Ohio	250	44,304													44,554
Oregon									48						48
Philadelphia							15,775						135	20,790	36,700
Puerto Rico	10,719		406,878	49	29,508	11,715	623		9,860						469,352
Rhode Island												85,770			85,770
Rochester		898,827													898,827
Sabine		93													93
St. Lawrence		41,047					813								41,860
San Diego										42,984					42,984
San Francisco		135					1,050						753		1,938
Vermont		127,635													127,635
Washington		42,364							1,658						44,022
Total: Quantity	285,895	1,505,645	422,353	113,109	29,508	11,715	31,461	299,989	53,382	63,936	918,979	253,991	19,293	20,790	4,030,046
Total: Value	$1,054,712	$3,853,781	$974,454	$480,225	$63,060	$51,034	$269,916	$549,979	$218,442	$220,581	$1,807,579	$409,277	$117,241	$131,819	$10,202,100

[1] Includes Puerto Rico.
[2] Changes in Minerals Yearbook 1962, v. I, p. 393, should read as follows: Canada (Rochester customs district) 1,250,618 barrels, $882,685; San Diego customs district deleted; Colombia (Florida customs district) 103,604 barrels, $179,673; Mexico (Minnesota customs district) deleted, San Diego district 54,200 barrels, $171,452; Israel (New York district) 420,000 barrels, $769,997. Total barrels 5,632,699, value $12,855,273.

Source: Bureau of the Census.

TABLE 23.—U.S. exports of hydraulic cement, by countries

Destination	1961		1962		1963	
	376-pound barrels	Value	376-pound barrels	Value	376-pound barrels	Value
North America:						
Bermuda	745	$4,128	3,197	$5,850	1,869	$11,138
Canada	54,802	376,575	29,867	222,012	110,753	607,512
Central America:						
British Honduras	590	2,377	452	3,345		
Canal Zone	32,675	126,962				
Costa Rica	24,083	74,624	16,763	57,080	19,126	37,918
El Salvador	323	1,520	124	2,412	57	598
Guatemala	48	522			500	2,475
Honduras	12	260			394	4,326
Nicaragua	4,813	21,515	3,676	17,714	5,798	25,676
Panama	124	1,382			42	846
Mexico	13,696	61,410	13,177	95,516	59,786	238,451
West Indies:						
British:						
Bahamas	34,236	108,490	25,122	110,403	132,904	482,965
Barbados			25	200		
Jamaica	202	870			1,360	9,130
Leeward and Windward Islands	16,773	52,965	20,832	63,956	28,748	82,374
Trinidad and Tobago	5,048	26,579	798	3,130	252	1,873
Dominican Republic	74	374	34	210	186	1,020
French West Indies	615	2,164	3,687	10,138		
Haiti			1,000	2,800	3,602	15,556
Netherlands Antilles	419	1,310	55	232	885	7,016
Total	189,278	864,027	118,809	594,998	366,262	1,528,874
South America:						
Argentina	8,310	40,501	385	1,961		
Bolivia	4,650	29,251	2,551	21,392	2,684	25,310
Brazil	22	484	3,425	73,563	1,913	18,016
Chile	1,381	17,360	1,604	21,888	5,391	36,485
Colombia	1,203	8,855	380	2,577	275	3,991
Peru	2,505	15,115	2,918	16,540	2,080	11,548
Venezuela	66	1,144			292	2,929
Other	306	2,529	54	338	458	2,133
Total	18,443	115,239	11,317	138,259	13,093	100,412
Europe:						
Belgium-Luxembourg	1,321	2,135	596	8,984	30	744
Germany, West	120	600	187	2,300	218	834
Netherlands			1,425	8,042	788	10,787
Switzerland	1,320	6,446	4,165	12,355	2,263	10,676
Other	1,191	10,506	273	2,974	1,357	6,108
Total	3,952	19,687	6,646	34,655	4,656	29,149
Asia:						
India	562	4,355	818	4,605	78	917
Indonesia	19,159	86,278	20,329	98,099	2,610	23,698
Iraq	1,250	7,791				
Japan	8,762	72,041	5,133	49,203	5,112	47,341
Korea, Republic of	36	970	201,649	846,635	28,347	149,018
Kuwait	804	3,660	372	3,548		
Pakistan	206	1,140	128	520	12,613	50,817
Philippines	1,506	7,721	48	900	7,510	44,647
Saudi Arabia	1,067	3,316	166	1,304	109	2,086
Thailand					5,518	25,996
Turkey			3,543	20,978	1,969	6,668
Other	1,163	7,932	3,316	14,842	3,171	20,493
Total	34,515	195,204	235,502	1,040,634	67,037	371,681
Africa:						
Liberia	3,250	2,326	2,913	13,501	99	860
Libya	400	4,968	3,038	20,135	2,280	11,491
Western Equatorial Africa, n.e.c.					4,085	18,203
South Africa, Republic of	136	658	974	4,405	168	736
Other	6,113	28,397	572	1,773	2,363	10,058
Total	9,899	36,349	7,497	39,814	8,995	41,348
Oceania	29,729	156,340	612	4,616	45	653
Grand total	285,816	1,386,846	380,383	1,852,976	460,088	2,072,117

Source: Bureau of the Census.

WORLD REVIEW [12]

NORTH AMERICA

Canada.—Expansion was the keynote in the cement industry during 1963. Canada Cement Co., Ltd., planned a new 235,000 ton capacity plant at Brookfield, Nova Scotia, to be completed in 1965, began installing a new kiln at Fort Whyte, Manitoba, to increase capacity there to 1 million tons by the end of 1964, and began constructing a $1-million distribution plant at Floral, Saskatchewan. Inland Cement Co., Ltd., announced plans for an $8 million cement plant with an annual capacity of 200,000 tons in the Winnipeg, Manitoba, area. The raw material of this firm will be limestone from Steep Rock, Manitoba, and for fuel, natural gas will be used. The same firm built a new bulk distribution plant at Calgary, Alberta. British American Cement Co., Ltd., announced plans for a similar size plant to be completed in the same area in 1965. St. Lawrence Cement Co., Ltd., plans to double capacity to 800,000 tons at its Villeneuve plant near Quebec. The $5 million expansion should be completed during 1965. Lake Ontario Portland Cement Co., Ltd., acquired 48 million tons of additional limestone reserves as a prerequisite to future expansion of its Pictou, Ontario, plant.

TABLE 24.—World production of hydraulic cement by countries [1]

(Thousand barrels)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada (sold or used by producers)	27,188	33,427	30,782	33,010	36,587	37,314
Cuba	3,301	3,670	[2] 2,345	[2] 1,760	[2] 1,760	[2] 2,050
Dominican Republic	1,395	1,114	998	1,390	1,507	1,343
El Salvador	405	487	504	440	381	457
Guatemala	516	680	657	733	680	921
Haiti	[3] 199	223	281	258	299	270
Honduras	----------	64	199	246	328	352
Jamaica	774	1,155	1,243	1,266	1,173	1,179
Mexico	13,175	15,884	18,112	17,795	19,654	21,577
Nicaragua	211	205	188	229	270	317
Panama	428	569	639	668	633	[2] 633
Trinidad	668	1,055	1,038	575	973	909
United States (including Puerto Rico)	312,870	355,734	334,130	338,628	351,932	368,406
Total	361,130	414,267	391,116	396,998	416,177	435,728
South America:						
Argentina	12,284	13,884	15,485	17,021	17,127	14,629
Bolivia	182	170	223	264	293	340
Brazil	18,446	22,521	26,232	27,610	29,739	30,395
Chile	4,462	4,902	4,855	5,101	6,725	6,837
Colombia	6,667	7,968	8,590	9,334	10,237	10,759
Ecuador	833	921	1,179	1,284	1,137	1,419
Paraguay	59	76	82	94	100	111
Peru	3,201	3,412	3,518	3,483	4,110	4,421
Uruguay	2,052	2,474	2,433	2,281	2,193	1,994
Venezuela	8,572	10,976	8,719	8,871	9,000	9,205
Total	56,758	67,304	71,316	75,343	80,661	80,110
Europe:						
Albania	317	434	428	704	[2] 704	[2] 880
Austria	11,351	14,172	16,593	18,082	17,924	19,372
Belgium	26,373	26,027	25,728	27,874	28,073	27,610
Bulgaria	5,000	8,402	9,300	10,255	11,100	12,929
Czechoslovakia	19,214	27,558	29,616	31,328	34,300	33,421

See footnotes at end of table.

[12] In this section, quantities are in short tons and values in U.S. dollars unless otherwise stated.

TABLE 24.—World production of hydraulic cement by countries [1]—Continued

(Thousand barrels)

Country	1954-58 (average)	1959	1960	1961	1962	1963
Europe—Continued						
Denmark	6,919	8,150	8,455	9,287	9,569	[3] 8,854
Finland	5,758	6,860	7,370	7,904	7,956	8,320
France	67,815	82,080	83,101	90,183	98,984	104,367
Germany:						
East	18,628	24,655	29,504	30,958	31,873	32,014
West	108,360	135,817	146,025	159,153	167,649	171,308
Greece	6,801	8,467	9,598	10,771	[3] 10,876	[3] 13,022
Hungary	6,344	8,402	9,211	9,393	10,161	10,542
Iceland	41	457	428	440	569	575
Ireland	3,541	3,682	4,368	4,362	4,456	4,702
Italy	65,118	84,443	93,895	105,721	118,274	129,509
Luxembourg	1,003	1,126	1,231	1,354	[3] 1,350	[3] 1,350
Netherlands	7,054	9,381	10,542	11,158	11,815	12,202
Norway	5,295	6,631	6,749	7,470	8,279	8,261
Poland	24,397	31,175	38,651	43,177	44,233	44,972
Portugal	5,383	6,045	7,024	7,294	8,214	8,402
Rumania	12,289	16,716	17,907	19,396	20,457	25,617
Spain (includes Canary Islands)	27,153	33,591	33,614	38,862	42,767	41,893
Sweden	14,623	16,535	16,452	17,660	17,907	19,056
Switzerland	12,911	15,731	17,801	21,114	21,847	20,996
U.S.S.R.	150,728	227,402	266,897	299,028	335,967	357,661
United Kingdom	72,535	74,992	79,137	84,291	83,587	82,086
Yugoslavia	9,938	13,017	14,060	13,691	14,764	16,570
Total	694,889	891,948	983,685	1,080,910	1,163,655	1,216,491
Asia:						
Afghanistan [4]	----------	199	217	240	[3] 410	557
Burma	270	211	264	235	311	727
Ceylon	440	557	498	481	498	440
China	37,150	71,943	79,150	46,900	46,900	52,770
Cyprus	[5] 369	487	516	557	575	563
Hong Kong	698	833	879	1,079	1,243	1,272
India	30,389	40,668	45,939	48,337	50,342	54,851
Indonesia	1,161	2,017	2,269	2,609	2,996	[3] 2,996
Iran [4]	1,343	3,395	4,673	4,368	[3] 4,368	[3] 4,368
Iraq	2,674	3,876	3,624	5,494	5,400	5,283
Israel	3,835	4,579	4,726	4,960	5,594	5,992
Japan	75,549	101,247	132,147	144,448	168,787	175,594
Jordan	528	645	967	1,308	1,378	1,671
Korea:						
North	3,876	11,293	13,398	13,263	13,931	14,834
Republic of	645	2,099	2,527	3,067	4,632	4,562
Lebanon	2,738	4,356	5,007	5,125	5,048	5,254
Malaya	616	1,132	1,677	1,941	1,917	2,123
Pakistan	5,095	5,875	6,796	7,288	8,179	8,783
Philippines	2,697	4,263	4,661	5,975	5,635	5,576
Saudi Arabia	----------	[2] 440	[2] 528	616	891	[3] 891
Syrian Arab Republic	1,806	2,621	2,867	3,166	3,559	4,016
Taiwan	3,911	6,256	6,936	8,824	10,970	13,128
Thailand	2,375	2,990	3,084	4,673	5,646	5,840
Turkey	6,186	10,167	11,949	11,891	13,597	15,737
Viet-Nam, North [3]	1,196	2,234	2,392	2,685	2,709	2,932
Total	185,547	284,383	337,691	329,530	365,516	390,760
Africa:						
Algeria	4,151	5,611	6,227	6,285	3,811	5,183
Angola	580	909	944	921	991	1,137
Cameroon, Republic of	[3] 59	[2] 64	----------	----------	----------	----------
Cape Verde Islands	[6] 18	53	23	41	[3] 40	[3] 40
Congo, Republic of the (formerly Belgian)	2,422	2,035	[3] 1,175	821	[3] 950	[3] 910
Ethiopia	170	147	164	176	240	199
Kenya	950	1,841	2,070	1,935	2,029	1,994
Morocco	3,442	2,943	3,401	3,694	4,093	4,368
Mozambique	862	1,249	1,302	1,243	1,050	[3] 1,114
Nigeria	----------	721	985	2,134	2,492	3,137
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	3,453	797	[3] 745	715	[3] 704	[3] 704
Southern Rhodesia		2,486	[3] 2,597	1,636	[3] 1,466	[3] 1,466
Nyasaland		205	[3] 176	217	[3] 176	[3] 176
Senegal	780	1,003	985	1,067	1,073	1,114
South Africa, Republic of	14,336	15,520	15,860	15,233	15,591	16,910
Sudan	[3] 410	586	709	487	498	[3] 586

See footnotes at end of table.

TABLE 24.—World production of hydraulic cement by countries [1]—Continued

(Thousand barrels)

Country	1954–58 (average)	1959	1960	1961	1962	1963
Africa—Continued						
Tunisia	2,076	2,592	2,375	2,105	2,128	2,117
Uganda	405	481	422	369	328	322
United Arab Republic (Egypt)	8,250	10,460	12,002	12,553	13,562	14,072
Total	42,364	49,703	52,162	51,632	51,222	55,549
Oceania:						
Australia	12,688	15,333	16,364	16,757	17,197	18,288
New Zealand	2,680	3,295	3,618	3,817	3,700	4,233
Total	15,368	18,628	19,982	20,574	20,897	22,521
World total (estimate) [1]	1,356,056	1,726,233	1,855,952	1,954,987	2,098,128	2,201,159

[1] This table incorporates some revisions.
[2] Estimate.
[3] Average annual production 1955–58.
[4] Year ended March 20 of year following that stated.
[5] Average annual production 1956–58.
[6] Average annual production 1957–58.

Bahama Islands.—Low-grade bauxite from the Caribbean area will be supplied as cement raw material to the Bahama Cement Co. plant on Grand Bahama.

Costa Rica.—Costa Rica's first cement plant, Industria National de Cemento S.A., at San Jose will be completed in 1964.

El Salvador.—Cemento de El Salvador, S.A., El Salvador's only cement plant, is moving from Acajutla to Metapán due to depleted raw material resources at the former site. Relocation, started in 1963, will take 3 years and includes provisions for increasing capacity from 100,000 to 150,000 tons.[13]

Honduras.—Cementos de Honduras, S.A., the only cement plant in the country, completed installation of a new kiln doubling its capacity to 300 tons per day.

Puerto Rico.—Ponce Cement Corp., Ponce and Puerto Rico Cement Corp., San Juan merged under the name of Puerto Rican Cement Company, Inc.

SOUTH AMERICA

Bolivia.—Increases in output were noted at Bolivia's two cement plants at Sucre and at Viacha.

Brazil.—At the new Capanema plant of Fabrica de Cimento Portland Carneiro, initial annual production rate will be 72,000 tons, one-half the maximum capacity.[14]

Chile.—Capacities of cement plants were: Empresas Industriales El Melón, S.A. La Calera, 800,000 tons; Cemento Cerro Blanco de Polpaico, S.A., Santiago, 500,000 tons; and Cementos Bió-Bió S.A., San Vicente Bay, 150,000 tons.[15]

Colombia.—Cementos del Caribe, S.A., was expanding its plant at Baranquilla to 1,700 tons per day with the help of a $3.3 million Alliance for Progress credit. Cementos Boyaca S.A. announced plans to increase capacity from 800 tons to 1,000 tons daily.[16]

[13] Bureau of Mines. Mineral Trade Notes. V. 56, No. 4, April 1963, pp. 9–10.
[14] Bureau of Mines. Mineral Trade Notes. V. 56, No. 2, February 1963, p. 6.
[15] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, p. 6.
[16] Bureau of Mines. Mineral Trade Notes. V. 57, No. 2, August 1963, p. 10.

Ecuador.—Capacity of La Cemento Nacional, C.A., plant at Guayaquil was 280,000 tons.

EUROPE

Bulgaria.—Cement production in Bulgaria increased ten-fold between 1939 and 1963. The plant at Reka Devnya recently has increased annual capacity to 1.0 million tons.

France.—The cement plant of Lambert Freres et Cie. near Cormeilles was described.[17]

Hungary.—Hungary's largest cement plant, Danube Cement and Lime Works, began production March 20, 1963. The 1.1 million ton plant will reach full capacity production in 1965.[18]

Ireland.—The Irish cement industry was described in detail.[19]

Italy.—A new 1.9 million ton cement plant at Tarento was scheduled to begin production in late 1963.

Norway.—Dalen Portland-Cementfabrik A/S increased capacity to 800,000 tons. Christiania Portland-Cementfabrik A/S, Oslo, installed a new 750-ton-a-day kiln, replacing two smaller obsolete units.

Spain.—Cement production was 7.9 million tons in 1963. This total was for all manufactured cements including Portland, keene's marble, pozzolanic, and slag.

U.S.S.R.—Growth of the Soviet cement industry and standard operating procedures were described.[20] In 1963 more than 60 million tons of cement were produced. A 2.6-million-ton-capacity automated plant was under construction at Balakleya in the Ukraine. Fertilizer was being made from cement dust at a chemical plant near Moscow. Concrete shapes claimed to be equal in strength but lighter and cheaper than standard portland cement concrete blocks were manufactured from ordinary lime and sand by heating to 200° C with saturated steam, molding as desired, and then pressure-treating in a steam autoclave.

United Kingdom.—Several new cement operations were described.[21] Work was started on a 36-mile-long, 10¾-inch-OD pipeline to carry chalk slurry from Dunstable quarry to Rugby Portland Cement Co., Ltd., Rugby.

ASIA

Cambodia.—Completion of the Chakrey Ting cement plant was scheduled for late 1963.

India.—Production, expansion plans, and other Indian cement developments were reviewed.[22] As of March 31, 1963, 36 plants with an annual capacity of 10.5 million tons were operating. Produc-

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17 Cement, Lime and Gravel (London). A French Cement and Concrete Plant. V. 38, No. 9, September 1963, pp. 298–302.

18 Cement, Lime and Gravel (London). Hungary's Biggest Cement Works Goes Into Production. V. 38, No. 4, April 1963, pp. 133–134.

19 Cement, Lime and Gravel (London). Cement in Ireland. V. 38, No. 5, May 1963, pp. 143–154.

20 Kaplin, Mikhail, Kiln Standardization Spurs Soviet Cement Growth. Rock Products, v. 66, No. 10, October 1963, pp. 89–91.

21 Cement, Lime and Gravel (London). Cement Making at Ketton. V. 38, No. 2, February 1963, pp. 47–52.

———. A New Cement Plant in Production. V. 38, No. 6, June 1963, pp. 185–191.

———. A New Cement Works in Scotland. V. 38, No. 11, November 1963, pp. 349–356.

Mine and Quarry Engineering (London). Extensions to Ketton. V. 29, No. 2, February 1963, pp. 72–74.

22 Bureau of Mines. Mineral Trade Notes. V 57, No. 3, September 1963, pp. 12–15.

tion for the year ending March 31, 1963, was 9.75 million tons, 93 percent of capacity. Plans for 36 other projects have been announced which will increase capacity by an additional 1.1 million tons.

Iran.—The cement industry of Iran was reviewed.[23]

Iraq.—In 1963, six cement companies employed about 2,300 persons. About 25 percent of the production was exported, principally to West Pakistan and Ceylon.

Japan.—Japanese production techniques and capacity were reviewed.[24] Two firms, Tokuyama Soda Co., Ltd., and Chichibu Cement Co. have installed computer control systems in their cement plants. In 1963, production of white cement was 175,876 metric tons.

Korea, Republic of.—Korea's third cement plant was under construction at Ssangyong near Yongwol, Kangwon Province. Costs of the 440,000 ton project were $3.1 million in local currency and $6.5 million in foreign exchange costs.[25]

Malaya.—Pan-Malaysia Cements Works was formed as a joint venture of the Japanese Ishikawajima-Harima Co. and the Malaysian Lew Yat Construction Co. The enterprise was capitalized at $8.3 million.[26]

Pakistan.—The Pakistan cement industry was reviewed.[27] Attention was directed to the acute shortage of cement.[28] This situation was expected to be relieved by two new kilns to enter production in 1964.

Philippines.—Two new cement plants were scheduled to open in 1963—Filipinas Cement Corp. and Mindanao Portland Cement Co.; two other plants, San Jose Cement and Luzon Cement were under construction. These expansions were expected to alleviate shortages and result in surplus capacity.[29] Tariff on imported cement is $8.97 per ton. An additional special import tax of 5.1 percent ad valorem and an advanced sales tax of 7 percent of 125 percent of landed costs must also be paid. However, in 1963 cement was permitted to enter tax-free as an emergency measure.

Taiwan.—The new cement plant near Taipei was described.[30]

Turkey.—The Turkish cement industry was reviewed.[31]

Viet Nam.—A French-Vietnamese project was under construction consisting of clinker production facilities at Ha Tien and a grinding and mixing plant at Thu Duc.[32] Trial runs began at the Thu Duc plant on November 16 and at Ha Tien in December.

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[23] Wright, W. S. The Cement Industry of Iran. Symposium of Industrial Rocks and Minerals, Lahore, Pakistan, December 1962. Central Treaty Organization pub. printed by Miner. Res. and Exploration Inst. of Turkey, 1963, pp. 216-226.

[24] Sanada, Y., and Y. Koide. Japan's Cement Quadruples in a Decade. Rock Products, v. 66, No. 3, March 1963, pp. 79-80, 82, 118.

[25] Bureau of Mines. Mineral Trade Notes. V. 56, No. 1, January 1963, p. 4.

[26] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, p. 6.

[27] Ghani, M. A. Cement Industry in Pakistan. Symposium on Industrial Rocks and Minerals, Lahore, Pakistan, December 1962. Central Treaty Organization pub. printed by Miner. Res. and Exploration Inst. of Turkey, 1963, pp. 235-245.

[28] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, pp. 6-7.

[29] Bureau of Mines. Mineral Trade Notes. V. 56, No. 5, May 1963, pp. 11-12.

[30] Pit and Quarry. Asia Cement's New Operation Boosts Formosa Cement Output. V. 55, No. 8, February 1963, pp. 138-140, 145.

[31] Cement, Lime and Gravel (London). Cement, Lime and Gravel in Turkey. V. 38, No. 7, July 1963, pp. 221-222.

The Turkish Cement Industry, Inc. Cement Industry in Turkey and its Raw Materials. Symposium of Industrial Rocks and Minerals, Lahore, Pakistan, December 1962. Central Treaty Organization pub. printed by Miner. Res. and Exploration Inst. of Turkey, 1963, pp. 227-234.

[32] Bureau of Mines. Mineral Trade Notes. V. 57, No. 4, October 1963, p. 8.

AFRICA

Ethiopia.—An agreement was signed on April 25, 1963, between the Government and Friedrich Krupp, Rheinhausen, West Germany, for construction of a 80,000-ton-per-year plant at Massawa.[33]

Kenya.—Capacity of the Bamburi cement plant, Mombasa, owned by British Standard Portland Cement Co., was being raised to 450,000 tons per year. Production of cement raw materials in 1963 was: Limestone, 546,600 tons; clay, 81,217 tons; gypsum, 22,849 tons; and volcanic ash, 932 long tons.

Mozambique.—Companhia de Cimentos de Mozambique dedicated its third cement plant on November 3, 1963, at Nacala.[34]

Nigeria.—Northern Nigeria Development Corp. and Ferrostahl of West Germany signed a contract to establish a 110,000-ton-per-year cement plant near Sokoto.[35]

Sudan.—At Cimenteria d'Atbara, capacity was increased from 75,000 to 110,000 tons per year. The Nile Cement Co. at Rabak has a 500,000-ton plant under construction.

Tanganyika.—Plans were announced for Tanganyika Portland Cement Co., Ltd., to build a 150,000-ton-per-year cement plant.[36]

United Arab Republic (Egypt).—Because of increased industrial development, expansion of the cement industry was given high priority.[37]

TECHNOLOGY

The Bureau of Mines began a nationwide program of examination and testing of pozzolan raw materials.

Significant progress continued toward total automation of cement plants.[38]

Computers were used in increasing numbers to centralize plant control and concomitantly increase product quality and efficiency of the plant.[39] Maintenance techniques for such centrally controlled plants also were discussed.[40] In other published articles, increased instrumentation and automatic control of individual circuits were discussed.[41]

The use of pure oxygen or air-oxygen mixtures instead of air for kiln combustion is theoretically advantageous and technically feasible. No U.S. trend toward this innovation was established in 1963 pending evaluation of the relationship between conversion and operation costs for rotary kilns against projected benefits.

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[33] Bureau of Mines. Mineral Trade Notes. V. 57, No. 3, September 1963, p. 12.
[34] Bureau of Mines. Mineral Trade Notes. V. 58, No. 2, February 1964, pp. 8–9.
[35] Bureau of Mines. Mineral Trade Notes. V. 56, No. 2. February 1963, pp. 6–7.
[36] Bureau of Mines. Mineral Trade Notes. V. 56, No. 2. February 1963, p. 7.
[37] Bureau of Mines. Mineral Trade Notes. V. 57, No. 3. September 1963, p. 15.
[38] Sullivan, Patrick. Progress Toward Automation in Cement Plants. Miner. Processing, v. 4, No. 6, June 1963, pp. 48–50.
Swanson, N. E., Automation in the Cement Industry. Min. Cong. J., v. 49, No. 4, April 1963, pp. 69–72.
[39] Kaiser, V. A., and J. W. Lane. Optimizing Cement Plant Operations With a Centralized Computer Control System. Miner. Processing, v. 4, No. 6, June 1963, pp. 44–46.
Lee, W. T. Cement Manufacture Under Computer Control. Cement, Lime and Gravel (London), v. 38, No. 3, March 1963, pp. 79–84.
Pokorney, E. J. Computer Process Automation. Miner. Processing, v. 4, No. 8, August 1963, pp. 20–22.
[40] Richardson, W. O., and Nels Swanson. Instrument Maintenance for Centrally Controlled Cement Plants. Pit and Quarry, v. 55, No. 12, June 1963, pp. 93–94, 97, 116.
[41] Daniel, S. W. Some Concepts of Automatic Grinding Mill Control Systems. Miner. Processing, v. 4, No. 7, July 1963, pp. 16–18.
Levine, Sid. Instrumentation Assures Quality at Marquette's Rebuilt Superior Plant. Miner. Processing, v. 4, No. 2, February 1963, pp. 24–27.
Rowland, C. A. Automation of Grinding Circuits. Pit and Quarry, v. 56, No. 1, July 1963, pp. 176–179.

As a means of conserving land resources, a possible new design for highways with concrete conduits incorporated within the subbase to carry utility lines in place of the present high-tower lines was suggested.

The commercial use of expansive cements was of interest.[42] These cements chemically compensate for concrete shrinkage by changes in the cement formula. Gypsum, alunite, bauxite, or high alumina cement are among the components used for such purposes. Research continued on quantitative control of the expansive action.

The chemistry of cement, particularly as it pertained to hydration reactions, was the subject of many investigations.[43] Research on process development also continued.[44]

The use of railroad rail for kiln tires and standard railroad flanged wheels for trunnions offered improved means of support and drive for large diameter kilns, driers, and mills.[45] Types of refractories and the use of metal shims in rotary kiln linings were discussed.[46]

Changes in concrete resulting from extended mixing time were the subject of a research paper.[47]

Kiln Feed.—British and German patents were issued for treating oil-shale to permit its use as a carbon-containing ingredient of kiln feed [48] and also for pretreating coal-slate for similar purposes.[49] A German patent was granted for sorting coal according to ash content and adding the low-ash coal to kiln feed.[50]

Slurries.—Canadian patents were issued for addition of sulfuric acid and aluminum sulfate or ammonium aluminum sulfate to disperse lumps in slurries [51] and for the use of pebbles of the same rock being ground as the grinding media during slurry preparation.[52]

Preheating.—A multiple-cyclone method of preheating portland cement raw material powders was devised.[53] Another cyclone arrange-

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[42] Concrete Products. Expansive Cements. V. 66, No. 6, June 1963, pp. 42–45, 56.
Shaw, Kenneth. Water-Impermeable Expansive Portland Cement. Cement, Lime and Gravel (London). V. 38, No. 9, September 1963, pp. 289-290.

[43] Blank B., D. R. Rossinton, and L. A. Weinland. Adsorption of Admixtures on Portland Cement. J. Am. Ceram. Soc., v. 46, No. 8, August 1963, pp. 395-406.
Brunauer, Stephen. Some Aspects of the Hydration of Portland Cement. AIME Trans. Soc. of Min. Eng., v. 226, No. 2, June 1963, pp. 155-164.
Chatterji, S., and J. W. Jeffery. Studies of Early Stages of Paste Hydration of Different Types of Portland Cements. J. of Am. Ceram. Soc., v. 46, No. 4, April 1963, pp. 187-191, v. 46, No. 6, June 1963, pp 268-273.
Nurse, R. W. The Chemistry of Cement. Cement, Lime and Gravel (London), v. 38, No. 8, August 1963, pp. 249-254.

[44] Kester, B. E. Developments of Low Alkali Processes in Portland Cement. AIME Soc. of Min. Eng., preprint No. 63 H 43, 1963, 14 pp.
Tonry, J. R. The Clinkering Process in Portland Cement Manufacturing. AIME Soc. of Min. Eng., preprint No. 63 H 34, 1963, 16 pp.

[45] Diehl, K. B. Simplified Mill Mounting and Drive. Miner. Processing, v. 4, No. 6, June 1963, pp. 35-36.

[46] Diehl, K. B. Circular Shims Reduce Cost of Hot Zone Linings. Miner. Processing, v. 4, No. 2, February 1963, pp. 20-21.
Sanada, Y. Use of Portland Cement Clinker Brick as Refractory in Rotary Cement Kilns. Pit and Quarry, v. 56, No. 1, July 1963, pp. 158-161.
Shaw, Kenneth. Use of Periclase Chrome-Magnesite Linings in Rotary Cement Kilns. Cement, Lime and Gravel (London), v. 38, No. 5, May 1963, p. 168.
Wicken, O. M., and R. E. Birch. Refractories Selection for Modern Rotary Kilns. Pit and Quarry, v. 56, No. 1, July 1963, pp. 162-164, 175, 181.

[47] Gaynor, R. D. Effects of Prolonged Mixing on the Properties of Concrete. National Ready Mixed Concrete Assoc., Pub. 111, June 1963, 18 pp.

[48] Metallgesellschaft, A.G. British Pat. 917,801, Feb. 6, 1963.
Friess, G. (assigned to Metallgesellschaft A.G.). German Pat. 1,143,142, Jan. 31, 1963.

[49] Grzymek, J. British Pat. 938,761, Oct. 9, 1963.

[50] Lobet, J. F. German Pat. 1,147,524, Apr. 18, 1963.

[51] Bretsznajder, S. (assigned to Institut Chemii Ogolnej). Canadian Pat. 664,959, June 11, 1963.

[52] Cleemann, J. O. (assigned to F. L. Smidth and Co.). Canadian Pat. 668,725, Aug. 13, 1963.

[53] Helming, B. H. Apparatus for Preheating Cement Powder or Similar Materials. U.S. Pat. 3,083,472, Apr. 2, 1963.

ment was particularly adapted for low height installations.[54] Another technique precipitated alkalies from the preheater gases directly on the cold cement raw materials.[55]

Calcination.—Optimizing flame shape and location in gas-fired and oil-fired rotary kilns was discussed.[56] Several patents were issued on automatic kiln control and recorder systems.[57] Alkali content of cement clinker was lowered by filtering kiln gases after they passed through cyclone dust collectors and before they made a second pass through the raw materials.[58] Leaching cyclone dust also helped to lower the alkali content.[59] Oxygen injected into a rotary kiln fuel stream increased clinker production, decreased fuel consumption, and minimized dust.[60] In Canada a patent was issued for simultaneous production of sodium aluminate and cement clinker.[61] A method for producing self-disintegrating clinker was patented in West Germany.[62]

Cement was made from magnesium carbonate by a double calcination technique.[63] Raw materials entering a kiln were sintered while suspended in a stream of gases in one method for making white cement clinker.[64] A traveling grate sintering machine produced light-colored to white portland cement clinker from a pelletized raw mix containing returned fines and petroleum coke.[65]

Vertical Kilns.—Use of vertical kilns to perform fully uniform sintering of cement clinker by remote control was described.[66] Several patents were issued for shaft kiln methods and apparatus.[67] One American cement firm was testing a vertical kiln but no immediate acceptance has been indicated for vertical kiln systems by the domestic cement industry.

Cooling.—Clinker was more evenly distributed by air jets in the inlet zone of a traveling grate cooler.[68] Efficiency of a shaft cooler

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[54] Bartmann, R. J. W. G. (assigned to Beteiligungs-und Patentverwaltungs G.m.b.H. Essen, West Germany). Heating Arrangement. U.S. Pat. 3,116,054, Dec. 31, 1963.

[55] Klockner-Humboldt-Deutz, A. G. British Pat. 942,893, Nov. 27, 1963.

[56] Garnick, R. H. Gas and Oil Firing of Rotary Kilns, Miner. Processing, v. 4, No. 6, June 1963, pp. 29–32.

[57] Gieskieng, D. H. (assigned to Allis-Chalmers Mfg. Co., Milwaukee, Wis.). Control System for Automatically Regulating Cement Kilns and Auxiliary Apparatus. U.S. Pat. 3,075,756, Jan. 29, 1963.
Hall, J. I., and C. S. Forde (assigned to Kaiser Aluminum and Chemical Corp., Oakland, Calif.). Writer for Recording Rotation and Vertical Variations of an Apparatus. U.S. Pat. 3,112,153, Nov. 26, 1963.
Hance, R. J. (assigned to Leeds & Northrup Co., Philadelphia, Pa.). Rotary Kiln Shell Temperature Scanning System. U.S. Pat 3,101,618, Aug. 27, 1963.
Romig, J. R., and J. H. Herz (assigned to California Portland Cement Co., Los Angeles, Calif.). Kiln Control Method and Apparatus. U.S. Pats. 3,091,442 and 3,091,443, May 28, 1963.

[58] Baxa, E. H. (assigned to Allis-Chalmers Manufacturing Co., Milwaukee, Wis.). Method of and Apparatus for Removing Alkali From Cement System. U.S. Pat. 3,110,483, Nov. 12, 1963.

[59] Bade, E. (assigned to Allis-Chalmers Manufacturing Co., Milwaukee, Wis.). Process for Reduction of the Alkali Content in Cement Clinker. U.S. Pat. 3,110,751, Nov. 12, 1963.

[60] Humphries, J. J., A. L. Hodge, R. S. Babcock, and B. C. Whitemore. (assigned to Union Carbide Corp., New York). Process for the Manufacture of Cement. U.S. Pat. 3,074,707, Jan. 22, 1963.

[61] Crzymek, J. Canadian Pat. 667,092, July 23, 1963. 11 pp.

[62] Staude, H., and J. Huhn (assigned to VEB Farbenfabriken Wolfen). German Pat. 1,145,984, Mar. 21, 1963, 2 pp.

[63] Artemis, E. C. Cement. U.S. Pat. 3,073,709, Jan. 15, 1963.

[64] Koch, A. (assigned to Portland Zementwerke Heidelberg A. G., Heidelberg, West Germany). Process and Apparatus for the Production of Cement Clinker, More Especially for White Cement. U.S Pat. 3,085,022, Apr. 9, 1963.

[65] Rea, J. E. (assigned to Koppers Co., Inc., Pittsburgh, Pa.). Process for the Production of Hydraulic Cement. U.S. Pat. 3,114,648, Dec. 17, 1963.

[66] Gottlieb, S. Vertical Kilns Allow Remote Control Sintering. Rock Products, v. 66, No. 5, May 1963, pp. 75–79.

[67] Fiedler, R. German Pat. 1,150,309, June 12, 1963.
Kramer, H. (assigned to VEB Zementanlagenbau Dessau). British Pat. 928,378, June 12, 1963.
Zeltner, E. (assigned to L. von Roll A.G., Zürich, Switzerland). Method and Kiln for Burning Cement, Lime, Dolomite and the Like. U.S. Pat. 3,101,935, Aug. 27, 1963.

[68] Helming, B., and W. Breves. Method and Apparatus for Cooling Clinker. U.S. Pat. 3,079,701, Mar. 5, 1963.

was improved by structures attached to the grate and rotary spokes to retain and reduce oversize.[69] Both vertical and horizontal coolers provided with slicing blades were patented.[70]

Grinding.—A Rodpeb mill has been used since 1960 for grinding cement raw materials at Nashville, Tenn.[71] Patents were issued for wet grinding of raw materials.[72] A rotating screen was devised to grind cement clinker, using a baffle to retain the clinker while abraded fines sifted through the screen.[73] Another method cooled the coarse clinker fraction in a fluidized-bed cooler before recycling through the grinding circuit.[74]

Additives.—Results were described of tests to determine optimum amounts of gypsum required to control cement setting.[75] In Japan a patent was issued for high-early-strength blended hydraulic cement consisting of 2 percent red mud from the Bayer process manufacture of alumina and 98 percent portland cement.[76] Oleic acid dissolved in oleophilic petroleum sulfonate was used in preparing cement resistant to hydration in storage.[77] Calcium acetate and a lignin sulfonate, introduced during grinding, improved clinker grindability and reduced "pack setting" of the finished cement.[78] Butyl acetate prevented cement from excessive settling due to vibration.[79] Addition of an aqueous mixture of powdered alum, calcium chloride, and sulfuric acid improves workability of the wet mix and increases hardness of the resultant concrete.[80] Another mixture consisted of adding a copolymer of maleic anhydride and vinyl hetero-n-cyclic compounds to hydraulic cement.[81]

High-Alumina Cements.—A sulfoaluminate hydraulic cement comparable with high alumina cement consisted of pulverized calcium aluminate slag, calcined anhydrite, gypsum, and zinc sulfate.[82] A method for preparing self-disintegrating alumina cement clinker in shaft furnaces from clay, anhydrite, coke, and silica sand was patented in Britain,[83] and a similar method using clay, gypsum, lime, and carbon-bearing material in West Germany.[84]

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69 Helming B., and G. Schultz (assigned to Allis-Chalmers Manufacturing Co., Milwaukee, Wis.). Shaft Cooler. U.S. Pat. 3,084,878, Apr. 9, 1963.

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Special Cements.—A Japanese patent was issued for manufacturing hydraulic cement by treating Bayer process red mud to replace contained sodium with calcium and then calcining at 900° C.[85] Another cement composition consisted of hydraulic cement, colloidal clay, sodium or calcium chloride, and an organic dispersing agent.[86] A new coating composition was devised from white portland cement, lime, exfoliated vermiculite, and water.[87] A water-soluble, high molecular weight polymer of an amide added to asbestos-cement improved its properties.[88]

Special Concretes.—The changes in physical properties of aluminous cement concretes after exposure to temperatures from 100° to 1,100° C were studied.[89] Titanium dioxide was mixed with white portland cement, limestone, and sand to form a self-cleaning white concrete.[90] Cellular concrete was made by decomposing perhydrol in the concrete mix.[91] The use of vacuum-treated concrete was discussed.[92] A dry pulverulant monalkylsiloxane polymer or similar copolymer may be added to concrete to impart water-repellant properties.[93] Portland cement and diatomite were cast and then crushed for use as a high quality terrazzo aggregate.[94]

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Chromium

By R. W. Holliday [1]

NO CHROMITE was mined in the United States during 1963 (or during the preceding year). Although consumption was 5 percent higher than in 1962 imports decreased by nearly 4 percent and stocks held by domestic consumers were reduced by nearly 7 percent.

Production from most of the world's major sources declined because of large inventories from previous years, increasing use of low cost fines, large quantities available from U.S.S.R., and possibly other factors. Estimated production from Albania and U.S.S.R. showed increases and the two countries together accounted for 37 percent of the world total.

Excess world capacity for producing ferrochromium resulted in a highly competitive situation throughout the year.

TABLE 1.—Salient chromite statistics

(Thousand short tons and thousand dollars)

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Production (shipments)	167	[1] 105	[1] 107	[1] 82		
Value	7,305	[2] $3,765	[2] $3,813	$2,939		
Imports for consumption	1,805	1,554	1,387	1,329	1,446	1,391
Exports	1	11	5	5	3	10
Consumption	1,465	1,337	1,220	1,200	1,131	1,187
Stocks Dec. 31: Consumer	1,352	1,800	1,707	1,633	1,700	1,583
World: Production	4,310	4,315	4,885	4,660	4,840	4,475

[1] Produced for Federal Government only.
[2] Estimate by Bureau of Mines.

LEGISLATION AND GOVERNMENT PROGRAMS

Chromite was eligible for acquisition under the agricultural barter program administered by the U.S. Department of Agriculture, Commodity Credit Corporation. No transactions were negotiated during 1963. Government financial assistance was available for exploring for domestic chromite deposits upon approval by the Office of Minerals Exploration.

The General Services Administration sold 1,890 long tons of metallurgical-grade chromite through bids received on August 15, 1962.

[1] Commodity specialist, Division of Minerals.

The chromite in the form of mixed lumps and fines was stored at Calvert City, Ky.

The Tariff Schedules of the United States, Annotated, 1963, effective September 1, 1963, provided a revised statistical classification for chromite ores. Under the new schedule chromite was classified according to Cr_2O_3 content rather than by metallurgical, refractory, or chemical grade.

On May 13, the Manufacturing Chemists' Association, Inc., on behalf of the manganese and chromium ferroalloys producers, filed a request with the Office of Emergency Planning to determine the effect of imports of chromium and manganese ferroalloys on national security, as provided under section 232 of the Trade Expansion Act of 1962. The Association recommended an import quota equal to 7.5 percent of total 1962 consumption of these alloys.

DOMESTIC PRODUCTION

No chromite was produced in the United States in 1963.

Pittsburgh Metallurgical Co., division of Air Reduction Co., Inc., announced plans for a $6.5 million expansion and modernization program at its Calvert City, Ky., ferroalloys plant. Two 25,000-kilowatt submerged arc furnaces, new materials-handling facilities, and improved maintenance facilities were included in the plans.

Pittsburgh Plate Glass Co., a consumer of chemical-grade chromite and producer of chromium chemicals, closed its Jersey City, N.J., plant. The firm's Corpus Christi, Tex., plant continued in operation.

CONSUMPTION AND USES

Domestic consumption of chromite totaled 1,187,000 short tons containing about 355,000 tons of chromium. Of this total, the metallurgical industry consumed 53 percent; the refractory industry consumed 31 percent; and the chemical industry consumed 16 percent.

The metallurgical industry consumed 619,000 tons of chromite, containing 206,000 tons of chromium in producing 300,000 tons of chromium, ferroalloys and chromium metal, containing 180,000 tons of chromium. Based on these data, 87 percent of the chromium contained in the ore was recovered in the form of ferrochromium and chromium metal. An additional 13,000 tons of chromite was used directly in alloying steel.

Of the 619,000 tons consumed in manufacturing ferroalloys, 501,000 tons (averaging 49.2 percent Cr_2O_3) was classified by consumers as metallurgical-grade ore; 73,000 tons (averaging 47.3 percent Cr_2O_3) was classified as chemical grade; and 45,000 tons (averaging 44.2 percent Cr_2O_3) was classified as refractory grade. Seventy-eight percent of the metallurgical-grade chromite had a chromium to iron ratio of 3:1 and above; 18 percent, a ratio between 2:1 and 3:1; and 4 percent, a ratio of less than 2:1.

Producers of refractories consumed 358,000 tons of chromite containing 84,209 tons of chromium. An additional 10,000 tons of chromite containing 2,900 tons of chromium was used in repairing furnace linings.

Producers of chemicals consumed 187,000 tons of chromite, containing 58,000 tons of chromium in producing 130,000 tons of chemicals (sodium bichromate equivalent).

Production of chromium ferroalloys and chromium metal increased an average of 13 percent compared with 1962. Increases in the separate categories were:

Low-carbon ferrochromium increased 12 percent
High-carbon ferrochromium increased 16 percent
Ferrochromium silicon increased 20 percent
Chromium metal increased 26 percent

Consumption of chromium ferroalloys and chromium metal increased an average of 12 percent compared with 1962. Low-carbon and high-carbon ferrochromium increased 23 percent and 8 percent, respectively. Ferrochromium silicon consumption increased 19 percent and exothermic ferrochromium silicon, 12 percent. Chromium metal consumption decreased 9 percent.

The increased consumption of chromium ferroalloys was in part a reflection of the high rate of stainless steel production. (Shipments of stainless and heat resisting steel products by U.S. producers approximated 660,000 tons in 1963, compared with about 632,000 tons in 1962).

An example of the long-term trend to use of higher quality steels was seen in the purchase of 600 subway cars made of high-strength type 201 stainless steel by the New York City Transit Authority. In addition to savings in maintenance, the use of stainless steel permitted a weight reduction of 4,600 pounds per car. Deliveries scheduled to begin in July 1964 were to continue at a rate of 40 cars per month.

TABLE 2.—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)
1954-58 (average)	933	46.7	386	34.6	146	45.1	1,465	43.3
1959	796	46.7	379	35.0	162	45.4	1,337	43.2
1960	665	46.4	391	34.9	164	45.3	1,220	42.6
1961	662	46.5	375	34.6	163	45.2	1,200	42.6
1962	590	46.6	365	35.0	176	45.3	1,131	42.7
1963	632	48.7	368	34.6	187	45.1	1,187	43.8

TABLE 3.—Production, shipments, and stocks of chromium ferroalloys and chromium metal in 1963

(Short tons, gross weight)

Alloy	Net production	Chromium contained	Shipments	Producer stocks Dec. 31
Low-carbon ferrochromium	98,342	68,413	101,620	19,159
High-carbon ferrochromium	115,620	75,948	115,488	30,631
Ferrochromium silicon	63,457	24,514	59,654	17,424
Other [1]	22,510	11,557	23,428	2,959
Total	299,929	180,432	300,190	70,173

[1] Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

TABLE 4.—Consumption of chromium ferroalloys and chromium metal in the United States in 1963, by major end uses

(Short tons, gross weight)

	Low-carbon ferrochromium	High-carbon ferrochromium	Ferrochromium silicon	Exothermic ferrochromium silicon	Chromium briquets	Other [1]	Total
Stainless steels	96,529	55,047	60,754	3	527	93	212,953
High-speed steels	564	1,012	39			17	1,632
Other tool steels	749	1,764	58			25	2,596
Other alloy steels [2]	14,341	38,903	6,921	4,120	390	11,070	75,745
Gray and malleable iron	366	4,305	510	1	304	502	5,988
High-temperature alloys	5,955	701	226		23	1,128	8,033
Nickel-base alloys	321	30				65	416
Other nonferrous alloys [3]	426	1,372			16	695	2,509
Total (gross weight)	119,251	103,134	68,508	4,124	1,260	13,595	309,872
Chromium content	82,151	66,178	28,870	1,695	700	7,221	186,815

[1] Includes exothermic high and low-carbon ferrochromium, chromium metal, and other chromium alloys.
[2] Includes quantities that were believed used in producing high-speed and other tool steels and stainless steels because some firms failed to specify individual uses.
[3] Includes cutting and wear-resistant alloys, hard-facing alloys, welding rods, electrical-resistance alloys, and other nonferrous alloys.

STOCKS

Yearend stocks of chromium ferroalloys and chromium metal at producers' plants totaled 70,173 short tons, 4 percent less than at the end of 1962. Stocks at consumers' plants (18,263 tons) were 16 percent more than the yearend total for 1962.

Stocks of chromium chemicals at producers' plants totaled 12,626 tons (sodium bichromate equivalent) at yearend.

TABLE 5.—Consumers' stocks of chromite, Dec. 31

(Thousand short tons)

Industry	1959	1960	1961	1962	1963
Metallurgical	[1] 955	[1] 863	[1] 773	[1] 771	686
Refractory	730	719	728	764	723
Chemical	115	125	132	165	174
Total	[1] 1,800	[1] 1,707	[1] 1,633	[1] 1,700	1,583

[1] Includes stocks at locations other than consumer plants.

TABLE 6.—Consumers' stocks of chromium ferroalloys and chromium metal, Dec. 31

(Short tons, gross weight)

	1959	1960	1961	1962	1963
Low-carbon ferrochromium	9,266	5,125	10,006	5,531	7,293
High-carbon ferrochromium	12,352	5,427	10,086	5,684	6,049
Ferrochromium silicon	3,609	3,061	5,022	2,119	2,558
Exothermic ferrochromium silicon	875	771	822	729	610
Chromium briquettes	622	695	513	409	276
Other (including chromium metal, exothermic high and low-carbon ferrochromium, and other chromium alloys	2,094	1,451	1,754	1,330	1,477
Total	28,818	16,530	28,203	15,802	18,263

TABLE 7.—Chromium materials in Government inventories on Dec. 31, 1963

(Thousand short dry tons)

Chromite	National (strategic stockpile)	DPA inventory	CCC and supplemental stockpile	Total
Chemical grade	559		700	1,259
Metallurgical grade	3,795	1	1,562	5,358
Refractory grade	1,047		180	1,227

PRICES

Published price quotations for chromite ores were unchanged during the year but were listed, for the most part, as nominal. E&MJ Metal and Mineral Markets quotations were suspended from October 31 to the end of the year.

Values listed in table 9 represent reported values at points of shipment. However, only the combined total for each country is shown and averages necessarily include low-cost fines as well as the higher quality materials.

TABLE 8.—Price quotations for various grades of foreign chromite in 1963

Source	Cr_2O_3 (percent)	Cr/Fe ratio	Price per long ton [1]	
			Jan. 1	Oct. 31
Rhodesia [2]	48	3:1	$35.75–36.25	$35.75–36.25
Do	48	2.8:1	32.00–33.50	32.00–33.50
Do	48		27.00–28.00	27.00–28.00
South Africa, Republic of	48		25.50–27.00	25.50–27.00
Do	44		19.75–20.50	19.75–20.50
Turkey	48	3:1	36.00–38.00	36.00–38.00
Do	46	3:1	33.50–34.00	33.50–34.00

[1] Quotations are on a dry basis, subject to penalties if guarantees are not met, f.o.b. cars, east coast ports.
[2] Term contract.

Source: E&MJ Metal and Mineral Markets.

FOREIGN TRADE

Imports.—Imports of chromite ores and concentrates decreased approximately 4 percent, compared with 1962. Fifty-four percent of the total imports contained more than 40 percent but less than 46 percent chromic oxide, 28 percent contained 46 percent or more chromic oxide, and 18 percent contained 40 percent or less chromic oxide. Of the 1.4 million tons imported, 44 percent came from the Republic of South Africa, 20 percent from the Federation of Rhodesia and Nyasaland, 15 percent from the Philippines, 14 percent from the U.S.S.R., 6 percent from Turkey, and the remaining 1 percent from Mozambique, British East Africa, and Austria.

Imports for consumption of chrome or chromium metal totaled 860 tons valued at $1,308,120; 382 tons came from Japan, 248 tons from United Kingdom, and 230 tons from France. Imports for consumption of chromium carbide was 35 tons valued at $68,863; ferrosilicon chromium, 13 tons valued at $3,820; chrome yellow, green chromic oxide, and other chromium colors, 867 tons valued at $412,241; potassium chromate and dichromate, 2 tons valued at $581; sodium chromate and dichromate, 3,469 tons valued at $562,480; chrome brick and shapes, 60 pounds valued at $275.

Exports.—Exports of chromium products included 936 tons of chromic acid and anhydride valued at $552,534; sodium bichromate and chromate, 5,077 tons valued at $1,116,744; chromium and chromium bearing alloys in crude form and scrap, 39 tons valued at $24,179; chromium and chromium alloys in semi-fabricated forms, 10 tons valued at $25,627; and ferrochromium, 2,354 tons valued at $772,937.

Tariff.—On August 31, 1963, the Tariff Schedules of the United States (TSUS) went into effect. These revised schedules replaced those established by the Tariff Act of 1930, as amended. Under the new schedules as before there were no import duties on chromite ores and concentrates (TSUS No. 601.15). The duty on ferrochromium, less than 3 percent carbon, (TSUS No. 607.30) was 8.5 percent ad valorem; on ferrochromium, more than 3 percent carbon, (TSUS No. 607.31) the duty was 0.625 cents per pound on chromium content.

TABLE 9.—U.S. imports for consumption of chromite, by grades and countries, in 1963

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		
	Short tons		Value	Short tons		Value	Short tons		Value	Short tons		Value
	Gross weight	Cr_2O_3		Gross weight	Cr_2O_3		Gross weight	Cr_2O_3		Gross weight	Cr_2O_3	
Europe:												
Austria	6	2	$193							6	2	$193
U.S.S.R.[1]							191,706	93,252	$3,658,030	191,706	93,252	3,658,030
Total	6	2	193				191,706	93,252	3,658,030	191,712	93,254	3,658,223
Asia:												
Philippines	208,654	68,142	3,812,500	2,240	986	$44,550				210,894	69,128	3,857,050
Turkey[2]	9,113	3,667	122,995	33,013	14,346	554,638	40,208	18,973	760,049	82,334	36,986	1,437,682
Total	217,767	71,809	3,935,495	35,253	15,332	599,188	40,208	18,973	760,049	293,228	106,114	5,294,732
Africa:												
British East Africa[2]				4,107	1,818	40,602				4,107	1,818	40,602
Mozambique	5,340	1,907	68,595	3,376	1,493	35,875				8,716	3,400	104,470
Rhodesia and Nyasaland, Federation of[2]	10,119	3,237	189,727	120,329	54,125	2,327,813	144,441	72,685	2,951,900	274,889	130,047	5,469,440
South Africa, Republic of[2]	21,192	7,224	289,665	579,206	254,987	5,083,972	18,066	8,505	194,190	618,464	270,716	5,567,827
Total	36,651	12,368	547,987	707,018	312,423	7,488,262	162,507	81,190	3,146,090	906,176	405,981	11,182,339
Grand total	254,424	84,179	4,483,675	742,271	327,755	8,087,450	394,421	193,415	7,564,169	1,391,116	605,349	20,135,294

[1] Includes 34,327 short tons, gross weight; 16,359 short tons, Cr_2O_3, valued at $695,125 reported by the Bureau of the Census from Latvia.
[2] Adjusted by the Bureau of Mines.

Source: Bureau of the Census.

TABLE 10.—U.S. imports for consumption of ferrochromium, by countries

Year and country	Low-carbon ferrochromium (less than 3 percent carbon)			High-carbon ferrochromium (3 percent or more carbon)		
	Short tons		Value	Short tons		Value
	Gross weight	Chromium content		Gross weight	Chromium content	
1962:						
North America: Canada				6,111	3,582	$1,134,738
Europe:						
France	4,048	2,921	$1,249,761	39	27	10,098
Germany, West	5,183	3,792	1,764,768	1,357	851	178,219
Greece	109	79	39,417			
Italy	60	45	20,528	94	66	19,373
Norway	[1] 2,025	[1] 1,405	[1] 648,604	926	644	186,111
Sweden	[1] 7,075	[1] 5,218	[1] 2,301,574	53	37	10,705
United Kingdom	166	118	52,754			
Yugoslavia	264	187	94,913			
Total	[1] 18,930	[1] 13,765	[1] 6,172,319	2,469	1,625	404,506
Asia: Japan	[1] 4,483	[1] 3,008	1,348,836	2,327	1,557	404,918
Africa:						
Rhodesia and Nyasaland, Federation of	509	370	157,563			
South Africa, Republic of	162	86	39,928	[1] 1,535	[1] 921	[1] 182,124
Total	671	456	197,491	[1] 1,535	[1] 921	[1] 182,124
Grand total	[1] 24,084	[1] 17,229	[1] 7,718,646	[1] 12,442	[1] 7,685	[1] 2,126,286
1963:						
North America: Canada				2,947	1,625	514,137
Europe:						
France	4,405	3,163	1,151,547	28	19	6,597
Germany, West	803	591	253,640	110	77	21,912
Italy				21	14	4,177
Norway	5,076	3,503	1,219,177	598	422	113,053
Sweden	8,164	5,979	2,105,402	359	247	66,612
Yugoslavia	502	356	154,956			
Total	18,950	13,592	4,884,722	1,116	779	212,351
Asia: Japan	3,151	2,112	775,623	939	628	132,366
Africa:						
Mozambique				1,129	692	129,870
Rhodesia and Nyasaland, Federation of	308	223	78,353			
South Africa, Republic of	102	57	24,951	401	237	54,551
Total	410	280	103,304	1,530	929	184,421
Grand total	22,511	15,984	5,763,649	6,532	3,961	1,043,275

[1] Revised figure.

Source: Bureau of the Census.

TABLE 11.—U.S. exports of chromite ore and concentrate

Year	Exports[1]		Reexports[2]	
	Short tons	Value	Short tons	Value
1954–58 (average)	1,097	$65,321	14,708	$589,609
1959	11,080	530,714	[3] 26,591	1,064,612
1960	5,184	320,179	19,927	720,575
1961	5,201	344,907	35,890	1,373,083
1962	2,686	108,112	51,254	2,032,941
1963	9,726	352,181	71,324	2,827,260

[1] Material of domestic origin or foreign material that has been ground, blended, or otherwise processed in the United States.
[2] Material that has been imported and later exported without change of form.
[3] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

WORLD REVIEW

The world chromite market was highly competitive. Estimated production in the U.S.S.R. and Albania increased by more than 100,000 tons. The combined production of Turkey, Republic of South Africa, Southern Rhodesia, and the Philippines declined by 447,000 tons. World chromite production decreased by 365,000 tons, 8 percent.

Widely publicized protests by free world producers, early in 1963, credited marketing difficulties to increased exports by the U.S.S.R. However, the problem involved other considerations: Large stocks at the year's beginning, progressive depletion of higher grade deposits, and changing technology all contributed to the problems of producers. Increasing use of concentrate, use of low-cost fines, and sale of stockpiled inventory were significant factors in the production curtailment.

Producers of ferrochromium in the United States, Europe, and Japan also had excess productive capacity and two new plants in the Republic of South Africa were scheduled for completion in 1964.

TABLE 12.—World production of chromite by countries [1] [2]

(Short tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Cuba	86,859	[3] 43,732	[3] 32,774	[4] 27,600	[4] 39,000	[4] 55,800
Guatemala	736	452	200	110	22	----------
United States	[5] 166,846	[6] 105,000	[6] 107,000	[6] 82,000	----------	----------
Total	254,441	149,184	139,974	109,710	[4] 39,000	[4] 55,800
South America:						
Brazil	5,181	6,861	6,246	17,037	27,380	[7] 18,798
Colombia	----------	55	77	204	154	[4] 150
Total	5,181	6,916	6,323	17,241	27,534	18,948
Europe:						
Albania	162,820	273,373	318,650	256,241	[4] 283,000	[4] 310,000
Greece (marketable)	41,008	22,802	38,451	34,324	26,633	18,347
U.S.S.R. [4] [8]	800,000	940,000	1,010,000	1,015,000	1,270,000	1,355,000
Yugoslavia	133,001	117,965	110,873	119,188	106,974	103,364
Total [1] [4]	1,160,000	1,380,000	1,510,000	1,450,000	1,720,000	1,820,000
Asia:						
Cyprus (exports)	8,895	13,637	15,702	21,078	10,669	----------
India	73,703	105,376	110,354	50,625	64,390	71,419
Iran [9]	35,838	60,627	74,957	81,268	121,254	[4] 110,000
Japan	41,344	63,578	74,394	77,350	64,024	48,205
Pakistan	25,300	17,946	20,265	28,116	31,747	[4] 28,000
Philippines	627,670	720,345	809,579	705,811	585,574	502,884
Turkey	784,927	427,324	530,676	443,932	580,964	445,212
Viet-Nam, North [4]	(1)	7,300	21,400	32,500	36,000	35,300
Total [8]	1,597,677	1,416,133	1,657,327	1,440,680	1,494,622	1,241,020
Africa:						
Malagasy (Madagascar)	----------	----------	----------	11,600	20,342	[10] 13,200
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	522,718	543,104	668,401	590,888	507,685	412,392
Sierra Leone	19,943	19,974	6,023	[10] 10,080	[10] 10,527	----------
South Africa, Republic of	684,964	749,878	850,921	989,725	1,006,173	873,212
Sudan	----------	----------	----------	----------	----------	[4] 18,700
United Arab Republic, (Egypt)	381	276	331	1,532	----------	----------
Total	1,228,006	1,313,232	1,525,676	1,603,825	1,544,727	1,317,504
Oceania:						
Australia	3,329	134	592	----------	413	----------
New Caledonia	64,277	48,463	43,166	40,413	17,036	[10] 19,793
Total	67,606	48,597	43,758	40,413	17,449	[10] 19,793
World total (estimate) [1]	4,310,000	4,315,000	4,885,000	4,660,000	4,840,000	4,475,000

[1] In addition to countries listed, Bulgaria and Rumania produce chromite, but data on output are not available; estimates by author of chapter included in total. Data not available, no estimate included in total North Viet-Nam, 1954–58.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] United States imports.
[4] Estimate.
[5] Includes 45,710 tons of concentrates from low-grade ores and concentrates stockpiled near Coquille, Oreg. during World War II.
[6] Produced for Federal Government only; excludes quantity consumed by American Chrome Co.
[7] Bahia only.
[8] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[9] Year ended March 20 of year following that stated.
[10] Exports.

EUROPE

U.S.S.R.—The U.S.S.R. continued as the leading world producer of chromite and may have increased exports from the 438,000 tons reported in 1962. However, any increase is believed slight. Exports to the United States increased from 37,038 tons in 1962 to 191,706 tons in 1963. Exports to Japan were reported at 75,000 tons, about the same as in 1962. However, unconfirmed reports indicated that exports to Western Europe may have decreased.

Italy.—Interlake Iron Corp. of Cleveland, Ohio, announced an agreement to join with Finanziaria Ernesto Breda, S.p.A., Milan, and Italian associates in construction of a large plant in Italy to produce ferroalloys. First production was expected in 1965.

ASIA

India.—A brief review [2] of the chromite resources of India suggested that because of the meager domestic supply and the strategic nature of chromite, stockpiling might be worthwhile. The export of high-grade chromite had been restricted since 1948.

Increased domestic consumption in the near future was foreseen, with completion of the several alloy and special steel plants licensed both in the public and private sectors.

Iran.—In September the Faryab Mining Co. announced suspension of operations because of marketing difficulties. Reportedly the company had 170,000 tons of chromite in stock at the time of suspension. A council of Ministers' decree dated September 8, provided a governmental subsidy of 20 percent of the f.o.b. price for exports of chromite and other commodities.

A description [3] of the chromite mining industry furnished details on geology, mining methods and costs, and economics, especially ore transportation. Transportation costs, including donkey transport from mine to trucking point, and port charges were shown to be about equal to the cost of ore at the mine site. Nevertheless a significant potential existed, contingent on improved transport and port facilities.

Japan.—Chromite was imported from the Philippines, U.S.S.R., Republic of South Africa, and India. Interest in chromite from Iran, including trial shipments, also was reported. The Japanese Ferro-Alloy Producers' Association organized an export cooperation group for more orderly management of exports and prices, following efforts by European and U.S. ferrochrome producers to restrict ferrochrome imports. Japan produced 90,256 short tons of ferrochrome in 1963.

Pakistan.—On October 1, Czechoslovakia agreed to take 15,000 tons of chromite worth US$300,000 from Pakistan in exchange for automobiles, machinery, and other manufactures.

In June, the principal producer, Pakistan Chrome Mines Ltd., suspended operations but reopened later in the year to produce about 500 tons per month. Reduction of stocks by half in the barter transaction with Czechoslovakia indicated that further sales might necessitate resumption of mining.

Philippines.—Production declined by about 14 percent from the 1962 output. Of the 502,884 short tons, 84 percent was classified as refractory grade and the remainder as metallurgical grade. The United States received nearly 45 percent of the total exports; Japan received 28 percent, including all of the metallurgical grade; and the United

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[2] Misra, G. B. The Future of Mineral Industry in India. J. Mines, Metals, and Fuels (Calcutta, India), v. 11, No. 5, May 1963, pp. 1–11, 28.

[3] Watts, M. Chromite in Iran. Mine and Quarry Eng. (London). V. 29, No. 1, January 1963, pp. 2–13.

Kingdom received 16 percent. The remaining 11 percent went to Canada, Austria, Italy, the Netherlands, and Spain.

Exports to the United States declined from 319,000 tons in 1962 to 211,000 tons in 1963. Reported stocks of chromite on hand totaled 1,887,000 tons compared with reported stocks of about 100,000 tons in 1962. However, the difference obviously was due to a change in reporting procedures, not inventory buildup, because mine production and exports were virtually equal. The stocks reported in 1963 included 1,792,000 tons of fines, minus 1/4 inch, minus 3/16 inch, and minus 10 mesh, all with high silica content.

Turkey.—According to the Turkish Chrome Producers' Association, only 8 companies operating 12 mines comprised the industry during much of 1963, whereas, 36 companies exported chromite in 1962. Production in 1963 was 445,000 short tons compared with 581,000 tons in 1962.

Exports declined 38 percent to 233,937 short tons and the value of exports declined by 51 percent. Of the total exports, an estimated 50,000 tons was refractory-grade and low-grade material.

Exports to the United States dropped from 183,762 tons in 1962 to 82,334 tons, due largely to the cessation of barter shipments. In 1962, some 90,000 tons had been shipped to the United States under an agricultural product barter arrangement and placed in the U.S. supplemental stockpile.

AFRICA

Rhodesia and Nyasaland, Federation of.—Of the three territories—Southern Rhodesia produced all of the chromite and all of the ferrochrome. The Federation, established March 24, 1953, was dissolved December 31, 1963.

Chromite production decreased 19 percent from the 1962 output and exports decreased 33 percent, to 289,900 short tons. Exports to the United States comprised 67 percent of the total. Chromite exports comprised 8.4 percent of the nation's mineral exports in 1963.

South Africa, Republic of.—Production of chromite decreased by 13 percent from that of 1962. Exports of 654,909 short tons and local sales of 90,718 were reported during the year. Exports to the United States comprised 94 percent of total exports.

Two new ferrochrome plants were scheduled for initial production in May 1964. The plant of RMB Alloys (Pty.) Ltd. (Rand Mines Blelock, Ltd.) a subsidiary of Rand Mines, Ltd. was designed for a capacity of 35,000 tons of low-carbon ferrochrome per year. The plant of Transalloys (Pty.) Ltd. was designed for an initial capacity of 15,000 tons of low-carbon ferrochrome, 5,000 tons of high-carbon ferrochrome, and 1,000 tons of ferrochrome silicon a year. The Transalloys plant is a joint venture by Anglo-American Corporation of South Africa, Ltd. and Avesta Jernverks AB of Sweden.

TECHNOLOGY

The major uses of chromium were in stainless and other alloy steels and in chromium plating. However, renewed interest was noted in chromium alloys for high-temperature applications.

A penetrating review [4] cited a number of problems that, until now, have limited the development of chromium base alloys. New knowledge about chromium and the failure of other refractory metals in air-ambient applications were credited with a renewal of attention to chromium.

In one study,[5] small additions of strong nitride-forming elements (cerium, tantalum, titanium, yttrium, or zirconium) were found to improve chromium ductility. A proposed explanation was that the formation of stable nitrides restricts the entrance of nitrogen into Cottrell-locking and precipitation reactions to which brittleness in chromium has been ascribed.

A cobalt-chromium-iron superalloy, UMCo 50, was reported to have high resistance to thermal shock, to corrosion by slags, to high-temperature oxidation, and to wear and abrasion. The alloy was employed in some 60 uses, including furnace parts, burner tips, grates, and sintering machines. UMCo 50 was developed by Belgium metallurgists in cooperation with Union Minière du Haut-Katanga and was being produced by several U.S. firms, under various trade names.

In the field of chromium plating, greatly improved corrosion resistance was claimed for microcracked chromium. This involves a fine network of deliberately introduced discontinuities or cracks, between 1,000 and 2,000 per inch, in the chromium plating. Corrosion was said to be due to electrolytic action between the chromium and substrata at points of imperfection. By spreading the current over a great number of points, the local attack at any one point was reduced.[6]

A Japanese innovation was reported [7] in which cold-rolled steel strip, plated with 0.002 mil of chromium and coated with lacquer, proved satisfactory as a material for canning food.

Another process, involving chromium diffusion, reportedly [8] would permit use of chromium-surfaced carbon steel strip as a substitute for more expensive stainless steel.

Growing use of chromium-plated plastics, to provide lightweight, abrasion-and corrosion-resistant parts was reported.[9] Numerous applications in the automotive and appliance fields, such as gearshift knobs, pushbuttons, and ornamental lettering, were listed.

A trend to the use of beneficiated chromite ores and blending or substitution of one grade for another appeared to be growing. However, it was slowed by the large tonnage of quality chromite currently available on world markets from the U.S.S.R. An example was the new plant at Middleberg, Republic of South Africa, to produce low-carbon ferrochromium from chemical-grade ores. Initial production was scheduled for April 1964.

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[4] Sims, Chester T. The Case for Chromium. J. Metals, v. 15, No. 2, February 1963, pp. 127–132.

[5] Henderson, F., S. T. M. Johnstone, and H. L. Wain. The Effect of Nitride-Formers Upon the Ductile-Brittle Transition in Chromium. J. Inst. Metals (London), v. 92, pt. 4, December 1963, pp. 111–117.

[6] Chemical & Engineering News. Microcracked Chromium Gains Favor. V. 41, No. 3, Jan. 21, 1963, pp. 80–81.

[7] Uchida, Hiroma, and Akira Horiguchi. Chromium Plated Steel for Cans. Metal Prog., v. 83, No. 1, January 1963, pp. 113–116.

[8] American Metal Market. V. 70, No. 130, July 9, 1963, pp. 1, 9.

[9] Chemical & Engineering News. ABS Joins Plastics That Can be Plated. V. 41, No. 12, Mar. 25, 1963, pp. 48–49.

A study of the reactions in decarburization of solid ferrochromium was described.[10]

A new bonding technique for periclase-chrome refractory brick was found to greatly increase brick life.[11] Essentially the technique involved firing the brick at high temperatures to bond chromite directly to periclase.

Previously these crystals were linked by a film of silicate. Other requirements were high purity periclase and chromite ore low in silicates. The exact significance of the iron-oxide content of the chromite was not established. However, high firing diminished the objectionable characteristics of brick made with high-iron-oxide chromite and permitted the use of African chromite which contain more iron oxide but less silicon dioxide than the Philippine material.

Comprehensive reviews[12] of three branches of science relating incidentally to chromium (catalysts, composites, and electrochemistry of molten salts) were published.

Bureau of Mines publications[13] included one on thermodynamic properties and one on the Mouat chrome mine in Montana.

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[10] Hancock, H. A., and L. M. Pidgeon. Equilibria Controlling the Decarburization of Solid Ferrochromium by Chromium Oxide. Trans. AIME, v. 227 (Met. Soc.), No. 3, June 1963, pp. 608–615.

[11] Hubble, D. H., and W. H. Powers. High Fired Basic Brick for Open-Hearth Roofs. Am. Ceram. Soc. Bull., v. 42, No. 7, July 1963, pp. 409–413.

Sandford, J. E. Silica-Free Bonds Add Strength to Basic Refractory Brick. Iron Age, v. 192, No. 18, Oct. 31, 1963, pp. 106–107.

[12] Burke, Donald P. Catalysts. Chem. Week, v. 93, No. 7, Aug. 17, 1963, pp. 50–63; No. 8, Aug. 24, 1963, pp. 51–64.

Reddy, Thomas B. The Electrochemistry of Molten Salts. Electrochem. Technol., v. 1, Nos. 11–12, November-December 1963, pp. 325–351.

Steel. The Materials System. V. 153, No. 17, Oct. 21, 1963, pp. 89–112.

[13] Price, Paul M. Mining Methods and Costs, Mouat Mine, American Chrome Co., Stillwater County, Mont. BuMines Inf. Circ. 8204, 1964, 58 pp.

Wicks, C. E., and F. E. Block. Thermodynamic Properties of 65 Elements—Their Oxides, Halides, Carbides, and Nitrides. BuMines Bull. 605, 1963, 146 pp.

Clays

By James D. Cooper [1]

Contents

PRODUCTION of clays of all types in the United States exceeded 50 million tons in 1963, establishing a new record. Production of each individual type of clay was also up, and records were set for all types except fire clay and fuller's earth.

Emphasis was on new and improved clay products, new clay processing and product manufacturing methods, and automation of plant production equipment and control systems. Diversification into new fields by large firms continued to be reflected in changes of ownership of clay producers and clay products manufacturers.

TABLE 1.—Salient clay and clay products statistics in the United States

(Thousand short tons and thousand dollars)

	1954–58 (average)	1959	1960	1961	1962	1963
Domestic clays sold or used by producers	[1] 46,151	49,383	49,069	47,389	47,797	50,199
Value	[1] $145,033	$159,659	$162,411	$156,829	$163,012	$180,873
Imports for consumption	171	176	160	156	132	126
Value	$2,847	$3,288	$3,103	$3,055	$2,540	$2,413
Exports	436	489	530	559	617	739
Value	$11,498	$13,490	$13,714	$14,285	$16,855	$21,374
Clay refractories, shipments (value)	[2] $177,859	$178,632	$178,836	$166,628	$166,095	$179,506
Clay construction products,[3] shipments (value)	$458,180	$522,700	$488,500	$480,300	$510,500	$524,400

[1] Includes Puerto Rico 1954.
[2] Does not include value of shipments of ground crude, high-alumina, and silica fire clay for 1954.
[3] Principal products only.

[1] Commodity specialist, Division of Minerals.

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TABLE 2.—Value of clays produced in the United States, by States

(Thousand dollars)

	1962	1963	Kinds of clay produced in 1963
Alabama	[1] $1,947	[1] $3,003	Kaolin, fire clay, miscellaneous clay.
Arizona	[2 3] 184	[2 3] 203	Fire clay, bentonite, miscellaneous clay.
Arkansas	1,693	1,763	Fire clay, miscellaneous clay.
California	7,349	8,031	Kaolin, ball clay, fire clay, bentonite, fuller's earth, miscellaneous clay.
Colorado	1,573	1,334	Fire clay, bentonite, miscellaneous clay.
Connecticut	[1] 287	339	Miscellaneous clay.
Delaware	(4)	13	Do.
District of Columbia.	(4)	78	Do.
Florida	6,741	7,777	Kaolin, fuller's earth, miscellaneous clay.
Georgia	47,462	54,024	Do.
Idaho	70	[1 2 3] 15	Kaolin, fire clay, bentonite, miscellaneous clay.
Illinois	4,151	4,368	Fire clay, miscellaneous clay.
Indiana	2,255	2,347	Do.
Iowa	1,427	1,405	Do.
Kansas	1,091	1,104	Do.
Kentucky	[5] 2,158	[5] 2,397	Ball clay, fire clay, miscellaneous clay.
Louisiana	641	655	Miscellaneous clay.
Maine	63	55	Fire clay, miscellaneous clay.
Maryland	899	897	Ball clay, fire clay, miscellaneous clay.
Massachusetts	96	213	Miscellaneous clay.
Michigan	1,917	2,149	Do.
Minnesota	291	[3] 298	Fire clay, miscellaneous clay.
Mississippi	5,742	5,968	Ball clay, fire clay, bentonite, fuller's earth, miscellaneous clay.
Missouri	5,033	4,467	Fire clay, miscellaneous clay.
Montana	[3] 77	[3] 45	Do.
Nebraska	142	148	Miscellaneous clay.
New Hampshire	37	103	Do.
New Jersey	1,476	1,392	Fire clay, miscellaneous clay.
New Mexico	156	140	Do.
New York	1,618	2,186	Miscellaneous clay.
North Carolina	[1] 1,782	[1] 1,761	Kaolin, miscellaneous clay.
North Dakota	124	[2 6] 10	Fire clay, bentonite, miscellaneous clay.
Ohio	12,979	13,959	Fire clay, miscellaneous clay.
Oklahoma	[2] 756	[2] 911	Fire clay, bentonite, miscellaneous clay.
Oregon	305	330	Bentonite, miscellaneous clay.
Pennsylvania	[1] 12,815	[1] 14,717	Kaolin, fire clay, miscellaneous clay.
South Carolina	7,165	7,589	Kaolin, miscellaneous clay.
South Dakota	690	1,958	Bentonite, miscellaneous clay.
Tennessee	[7] 4,597	[7] 5,248	Ball clay, fuller's earth, miscellaneous clay.
Texas	[7] 5,634	[7] 6,849	Fire clay, bentonite, fuller's earth, miscellaneous clay.
Utah	1,403	[1 3] 470	Kaolin, fire clay, bentonite, fuller's earth, miscellaneous clay.
Virginia	1,444	1,558	Miscellaneous clay.
Washington	[2 3] 100	[3] 123	Fire clay, bentonite, miscellaneous clay.
West Virginia	2,086	2,044	Fire clay, miscellaneous clay.
Wisconsin	156	140	Miscellaneous clay.
Wyoming	11,138	11,387	Fire clay, bentonite, miscellaneous clay.
Other [8]	3,262	4,902	
Total	163,012	180,873	
Puerto Rico	131	158	Miscellaneous clay.

[1] Value of kaolin included with "Other" to avoid disclosing individual company confidential data.
[2] Value of bentonite 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] Included with "Other."
[5] Value of ball clay included with "Other" to avoid disclosing individual company confidential data.
[6] Value of miscellaneous clay included with "Other" to avoid disclosing individual company confidential data.
[7] Value of fuller's earth included with "Other" to avoid disclosing individual company confidential data.
[8] Includes Hawaii, Nevada, and Vermont, and value indicated by footnotes 1 through 7.

REVIEW OF DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE BY TYPE OF CLAY

KAOLIN

Kaolin sold or used in 1963 increased by 6 percent in volume and 12 percent in value, establishing a new production high for the fifth consecutive year. Total annual value for kaolin sold or used has increased each year since 1952. The average unit value in 1963 was

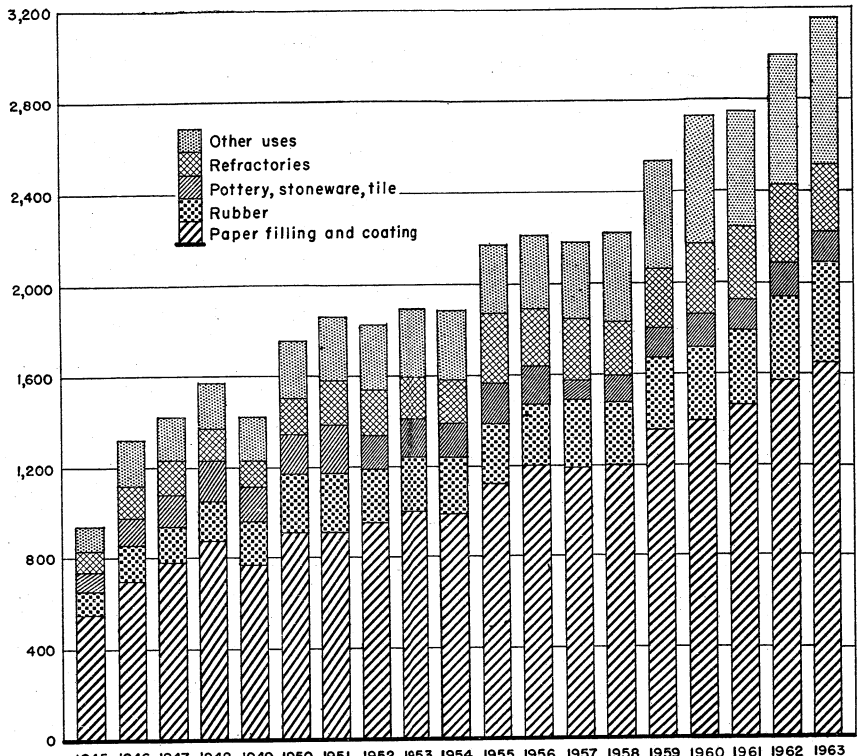

FIGURE 1.—Kaolin sold or used by domestic producers for specified uses, in thousand short tons, 1945–63.

$19.66 per ton for the quantity sold and $10.05 for that used by producers. Corresponding values for 1962 were $18.89 and $8.29.

The major uses for kaolin in 1963 were as paper coating, which accounted for 33 percent of the total sold or used, paper filler, which accounted for 19 percent; other fillers, 21 percent; and refractories, 9 percent.

Kaolin imports totaled 107,203 short tons in 1963, a drop of 4 percent from 1962 imports. The United Kingdom supplied 106,698 tons; Canada, Mexico, and West Germany supplied the balance.

Exports of kaolin in 1963 totaled 111,717 tons valued at $3.3 million. Canada, Mexico, and Italy were the largest recipients, accounting for 68, 8, and 5 percent respectively. Japan, Venezuela, and the Netherlands each received 3 percent, and Argentina and Colombia received 2 percent. The balance went to many other countries.

Prices for domestic kaolin were quoted in Oil, Paint and Drug Reporter in December 1963, as follows: Dry-ground, calcined, air-floated, bags, carlots, works, $43 to $68 per short ton; dry-ground, uncalcined, air-floated, 99 percent through 325 mesh, Georgia, bags, carlots, f.o.b. plant, $11 to $17 per ton; water-ground, washed, bags, carlots, f.o.b. plant, $21.50 to $50 per ton.

According to Oil, Paint and Drug Reporter, the following prices were in effect for imported china clay in December 1963: White, lump, bulk, carlots, ex dock (Philadelphia, Pa., and Portland, Maine), $23 to $35 per long ton; white, powdered, bags, carlots, ex dock, $50 per long ton.

Southern Clays, Inc., one of the largest kaolin producers, was purchased by Freeport Sulphur Co. Mining and processing facilities at Gordon, Ga., will be operated under the name Freeport Kaolin Co. Additional deposits are owned by the company near Sandersville.

A kaolin-processing plant was planned by Tennessee Valley Kaolin Corp., Natchitoches, La. The new facility will employ 60 men, and was to be completed in July 1964.

A kaolin deposit near Narvon, Pa., was reopened by Narvon Mines, Ltd. Reserves were reported to exceed 20 million tons.

Chemically treated kaolin, designed to prevent caking of high-analysis granular fertilizers, was placed on the market.

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
1954-58 (average)	1,925,035	$31,121,378	214,003	$2,163,603	2,139,038	$33,284,981
1959	2,305,134	39,267,837	230,340	2,414,117	2,535,474	41,681,954
1960	2,432,918	43,417,589	297,533	2,259,506	2,730,451	45,677,095
1961	2,471,518	44,877,971	268,298	2,054,899	2,739,816	46,932,870
1962:						
California	17,196	294,202			17,196	294,202
Florida and North Carolina	32,326	704,145			32,326	704,145
Georgia	2,161,471	43,820,582	116,813	834,687	2,278,284	44,655,269
South Carolina	(1)	(1)	(1)	(1)	527,993	6,279,131
Other States [2]	491,927	6,227,670	178,424	1,613,501	142,358	1,562,040
Total	2,702,920	51,046,599	295,237	2,448,188	2,998,157	53,494,787
1963:						
California	18,941	297,989			18,941	297,989
Florida and North Carolina	33,178	707,123			33,178	707,123
Georgia	2,343,260	49,297,909	146,737	995,974	2,489,997	50,293,883
South Carolina	(1)	(1)	(1)	(1)	484,757	6,622,756
Other States [2]	516,547	6,936,959	104,910	1,534,320	136,700	1,848,523
Total	2,911,926	57,239,980	251,647	2,530,294	3,163,573	59,770,274

[1] Included with "Other States."
[2] Includes States indicated by footnote 1, and Alabama, Connecticut (1963), Idaho, Pennsylvania, Utah and Vermont.

TABLE 4.—Georgia kaolin sold or used by producers, by uses

(Thousand short tons and thousand dollars)

Year	China, paper, etc.	Refractories	Total		
				Value	
	Quantity	Quantity	Quantity	Total	Average per ton
1954-58 (average)	1,380	184	1,564	$25,613	$16.38
1959	1,751	189	1,940	33,965	17.51
1960	1,861	260	2,121	37,822	17.83
1961	1,925	222	2,147	39,557	18.42
1962	2,094	184	2,278	44,655	19.60
1963	2,276	214	2,490	50,294	20.20

BALL CLAY

Domestic ball clay sold or used by producers in 1963 increased 12 percent in quantity and 11 percent in value over that of 1962. Tennessee was the largest producing State with 65 percent of the tonnage and 62 percent of value; Kentucky ranked second. Other States reporting ball clay production were California, Maryland, and Mississippi.

In 1963, the principal uses for ball clay were for pottery, floor and wall tile, and refractories, which together accounted for over 85 percent of the total quantity sold or used.

The following prices were quoted for ball clay in Oil, Paint and Drug Reporter in December 1963: Crushed, shed-moisture, bulk, carlots, f.o.b. plant (Tennessee), $8 to $11.25 per short ton; air-floated, in bags, carlots, f.o.b. plant (Tennessee), $18 to $22 per ton. The average value per ton for ball clay, as reported by producers, was $13.77, compared with $13.99 in 1962.

Prices for imported ball clay in December were quoted by Oil, Paint and Drug Reporter as follows: Air-floated, in bags, carlots, Atlantic ports, $43 to $47 per short ton; lump, bulk, Atlantic ports, $31.50 to $37.50 per ton.

TABLE 5.—Ball clay sold or used by producers in the United States

Year	Short tons	Value	Year	Short tons	Value
1954–58 (average)	400,716	$5,332,169	1961	444,593	$6,090,091
1959	475,235	6,459,902	1962	486,936	6,810,441
1960	444,369	5,977,963	1963	547,668	7,541,471

Imports of unmanufactured blue and ball clay in 1963 were 13,414 short tons valued at $140,302. The 1962 imports were 13,198 tons valued at $148,919. Imports of wrought and manufactured blue and ball clays in 1963 totaled 1,189 tons valued at $34,553, compared with imports of 1,594 tons valued at $34,591 in 1962. Total blue and ball clay imports in 1963 were essentially equal in quantity to those of 1962, but the vlaue was about 5 percent below that of 1962. The United Kingdom supplied nearly all of the imported blue and ball clay in 1963. Canada, the only other supplier, accounted for about 2 percent of the total.

Imports of clays not separately classified, but consisting in large part of Gross Almerode clays, including fuller's earth, totaled 914 tons. West Germany supplied 46 percent, the United Kingdom 43 percent, and Canada 11 percent.

FIRE CLAY

The quantity of fire clay sold or used in 1963 increased 4 percent, and the value was 10 percent higher than in 1962. The increased quantity was due to greater use of nonrefractory items, principally heavy clay products.

Ohio, Pennsylvania, and Missouri were the leading fire-clay-producing States in 1963, accounting for 55 percent of total production. The same States produced 57 percent of the total in 1962.

Principal uses for fire clays in 1963 were for heavy clay products which accounted for 50 percent of the total sold or used, compared with 47 percent in 1962; and for refractories, which required 45 percent in 1963 compared with 49 percent in 1962. Floor and wall tile manufacturers used 3 percent of the total fire clay, compared with 2 percent in 1962. Various other uses made up the remaining 2 percent.

The average value reported by producers for fire clay sold in 1963 was $3.83, compared with $3.38 in 1962. Fire clay used by producers was valued at $5.08 per ton in 1963, compared with $4.80 for 1962. Total clay sold or used was valued at $4.71 per ton in 1963, and $4.44 per ton in 1962.

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
1954–58 (average)	2,953,127	$9,079,249	7,257,565	$35,106,217	10,210,692	$44,185,466
1959	2,272,451	7,877,026	7,589,235	37,313,810	9,861,686	45,190,836
1960	2,489,945	8,840,604	7,425,427	36,390,257	9,915,372	45,230,861
1961	2,067,833	7,084,999	6,621,884	31,716,800	8,689,717	38,801,799
1962:						
Alabama	(2)	(2)	(2)	(2)	222,646	683,705
Arkansas			286,080	1,328,478	286,080	1,328,478
California	80,962	254,498	373,716	1,499,802	454,678	1,754,300
Colorado	119,122	364,170	98,172	413,139	217,294	777,309
Illinois	(2)	(2)	(2)	(2)	316,609	1,737,172
Indiana	(2)	(2)	(2)	(2)	347,121	568,847
Iowa	(2)	(2)	(2)	(2)	41,155	82,767
Kansas			159,689	355,834	159,689	355,834
Kentucky	39,123	181,404	156,714	1,014,836	195,837	1,196,240
Maine			27	79	27	79
Missouri	86,138	241,319	994,373	3,819,259	1,080,511	4,060,578
New Jersey	(2)	(2)	(2)	(2)	114,645	880,760
North Dakota			6,000	12,000	6,000	12,000
Ohio	610,067	1,915,440	1,606,500	8,091,226	2,216,567	10,006,666
Oklahoma			425	4,250	425	4,250
Pennsylvania	(2)	(2)	(2)	(2)	1,276,145	8,267,676
Texas	(2)	(2)	(2)	(2)	615,110	1,557,669
Other States [3]	1,098,920	3,916,858	2,349,020	12,395,323	514,509	2,533,585
Total	2,034,332	6,873,689	6,030,716	28,934,226	8,065,048	35,807,915
1963:						
Alabama	(2)	(2)	(2)	(2)	220,582	1,755,483
Arkansas			194,498	1,190,100	194,498	1,190,100
California	(2)	(2)	(2)	(2)	531,390	1,920,589
Colorado	98,306	371,644	95,761	329,542	194,067	701,186
Illinois	(2)	(2)	(2)	(2)	331,836	1,711,576
Indiana	(2)	(2)	(2)	(2)	447,539	723,676
Iowa	(2)	(2)	(2)	(2)	31,455	56,841
Kentucky	67,072	374,240	144,229	1,014,259	211,301	1,388,499
Maine			27	79	27	79
Mississippi	591	2,955	156,873	330,253	157,464	333,208
Missouri	(2)	(2)	(2)	(2)	849,702	3,567,900
New Jersey	(2)	(2)	(2)	(2)	106,809	900,242
North Dakota			5,200	10,400	5,200	10,400
Ohio	775,382	2,389,398	1,477,603	8,329,628	2,252,985	10,719,026
Oklahoma			449	4,490	449	4,490
Pennsylvania	545,937	1,611,303	958,633	8,300,535	1,504,570	9,911,838
Texas	4,962	45,393	802,853	2,008,314	807,815	2,053,707
Other States [3]	962,464	4,597,930	2,099,334	8,647,407	542,485	2,609,030
Total	2,454,714	9,392,863	5,935,460	30,165,007	8,390,174	39,557,870

[1] Includes stoneware clay (in tons) as follows: 1954–58 (average), 45,562; 1959, 27,418; 1960, 27,470; 1961, 24,554; 1962, 57,820; 1963, 44,798.

[2] Included with "Other States."

[3] Includes States indicated by footnote 2 and Arizona, Idaho, Kansas (1963), Maryland, Minnesota, Mississippi (1962), Montana, Nevada, New Mexico, Utah, Washington, West Virginia, and Wyoming.

Fire-clay exports in 1963 totaled 264,440 short tons valued at $5,184,000, compared with 188,282 tons valued at $3,462,000 in 1962. The average value per ton of exported fire clay in 1963 was $19.60, compared with $18.39 for 1962. The countries receiving the largest quantities were Canada, 35 percent; Mexico, 19 percent; Japan, 15 percent; Italy, 7 percent; and West Germany, 6 percent.

Kaiser Refractories, Division of Kaiser Aluminum & Chemical Corp. completed a new plant at Moss Landing, Monterey County, Calif. and started production. The Troy, Idaho facility of A. P. Green Fire Brick Co. was improved by addition of a new shuttle kiln which greatly increased the plant's firing capacity.

Wellsville Fire Brick Co., Wellsville, Mo., planned major additions to its production and storage facilities in new buildings aggregating more than 40,000 square feet in area, which were to be completed by the end of 1963. A $1 million conversion plan for the Vanport, Pa., refractories plant of H. K. Porter Co., Inc., was announced. Ladle firebrick production was to be replaced by bonded magnesite refractories for lining basic oxygen furnaces.

Frank Samuel & Co., National Paint & Manganese Co., and Kittanning Refractories, Inc., were combined into a single entity known as the Refractories Division of Howe Sound Co. with headquarters at Conshohocken, Pa. The Babcock and Wilcox Co. transferred its Refractories Division headquarters from New York City to Augusta, Ga., and completed expansion of its facilities for making special oxide refractories. Other new additions were under construction. A new refractories product research and development laboratory was completed at Crooksville, Ohio, by the Refractories Division of Ferro Corp. The new facility will serve five plants in Ohio, Texas, and California.

BENTONITE

Domestic bentonite sold or used by producers increased 10 percent in quantity and 14 percent in value in 1963. Principal uses were in foundries and steelworks, drilling mud, and iron-ore pelletizing, which accounted for 29, 27, and 18 percent, respectively, of the total sold or used.

Use of bentonite for pelletizing iron ores continued to increase in 1963, and new mining and processing operations were required to meet present and anticipated demand. Iron-ore pelletizing required 278,849 tons, an increase of 71 percent over the 1962 requirement of 163,201 tons.

Wyoming continued as the leading producing State, with 63 percent of the total reported output. Mississippi and Texas furnished 18 and 8 percent, respectively.

Bentonite prices at the end of 1963 as quoted in Oil, Paint and Drug Reporter were unchanged from yearend prices in 1962. They were as follows: 200 mesh, in bags, carlots, f.o.b. mines (Wyoming), $14 per short ton; imported, Italian, white, high-gel, in bags, 5-ton lots, ex warehouse, $98.20 per ton; and Italian, low-gel, in bags, 5-ton lots, ex warehouse, $97 per ton.

According to reports from producers to the Bureau of Mines, the average value of bentonite sold or used was $11.70 per ton, an improvement over the 1962 average value of $11.26.

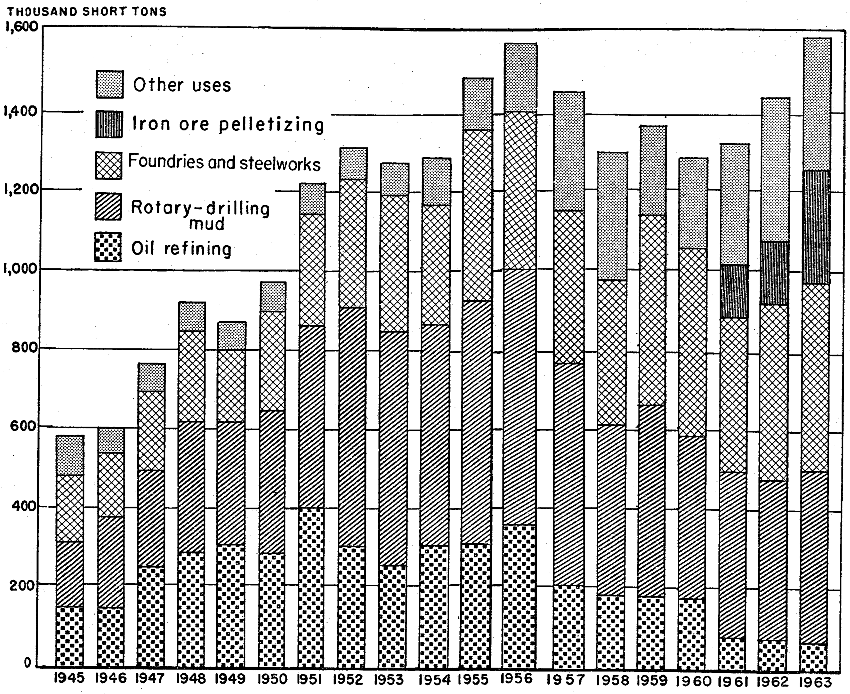

FIGURE 2.—Bentonite sold or used by domestic producers for specified uses, 1945–63.

Black Hills Bentonite Co., a large supplier of Canadian iron-ore pelletizers, explored a large deposit of bentonite which may supply the feed for a processing facility which was planned for Natrona County, Wyo.

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
1954–58 (average)	1,414,298	$16,696,096	1963:		
1959	1,372,286	15,841,455	Colorado	931	$6,051
1960	1,268,800	15,004,757	Mississippi	280,077	3,480,643
1961	1,307,191	15,224,347	Texas	120,480	1,366,596
			Utah	6,711	90,515
1962:			Washington	100	1,000
California	14,444	282,928	Wyoming	991,078	11,189,446
Colorado	1,200	7,800	Other States [1]	185,139	2,401,978
Mississippi	276,380	3,428,894			
Oregon	702	8,430	Total	1,584,516	18,536,229
Texas	117,677	872,899			
Utah	2,359	31,938			
Wyoming	957,231	10,889,866			
Other States [1]	74,142	731,460			
Total	1,444,135	16,254,215			

[1] Includes Arizona, California (1963), Idaho, Nevada, North Dakota, Oklahoma, Oregon (1963), South Dakota, and Washington (1962).

FULLER'S EARTH

The quantity of fuller's earth sold or used by producers increased 18 percent over that reported in 1962; value increased 20 percent. Florida was the leading State in production, and Florida and Georgia together supplied 86 percent of the U.S. total. Absorbent uses, which have more than doubled in the past decade, continued to grow in 1963, and for the second consecutive year accounted for more than 50 percent of the total fuller's earth sold or used. Other major uses were in insecticides and fungicides, in oil-well-drilling muds, and as a filtering, decolorizing, and clarifying agent for mineral and vegetable oils and animal fats.

According to producers the average value of fuller's earth sold or used in 1963 was $23.27 per ton, the highest unit value for any type of clay. The average value in 1962 was $22.87 per ton.

Prices for fuller's earth have not been quoted in trade journals for several years. The latest available prices, from Oil, Paint and Drug Reporter in February 1960, were as follows: Insecticide-grade, dried, powdered, in bags, carlots, Georgia or Florida mines, $17.50 per ton; oil-bleaching grade, 100 mesh, in bags, carlots, f.o.b. Georgia and Florida mines, $16.30 to $17 per ton; and 200 mesh, same basis, $17.50 to $18.

Imports and exports data for fuller's earth are included with other clays.

A processing plant was planned to heat treat fuller's earth from deposits at Dubach, La. Headquarters for the new firm, Plantation Clay Co., was at Chidester, Ark.

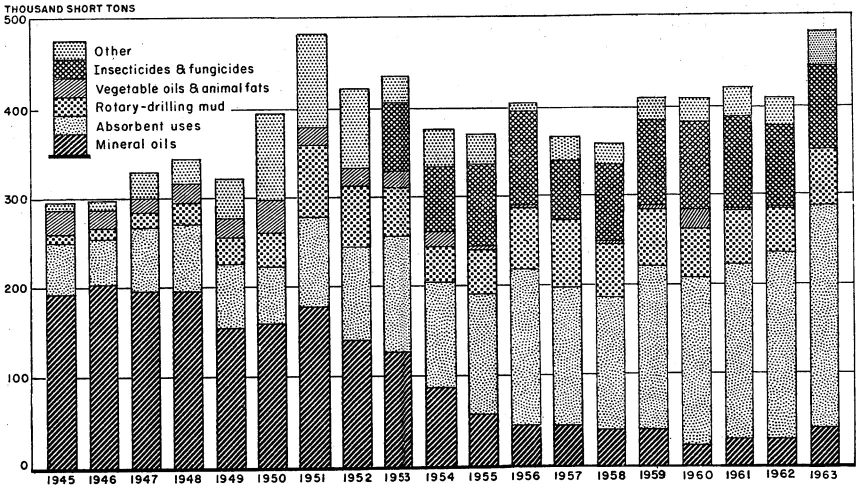

FIGURE 3.—Fuller's earth sold or used by producers for specified uses, 1945–63.

TABLE 8.—Fuller's earth sold or used by producers in the United States, by States

Year and State	Short tons	Value
1954–58 (average)	377,548	$7,805,427
1959	409,622	9,027,059
1960	408,325	9,161,658
1961	422,181	9,518,238
1962:		
Florida and Georgia	349,465	8,264,850
Utah	3,942	53,774
Other States [1]	56,582	1,058,731
Total	409,989	9,377,355
1963:		
Florida and Georgia	415,458	$10,060,750
Utah	3,167	42,756
Other States [1]	63,192	1,107,112
Total	481,817	11,210,618

[1] Includes California, Mississippi, Nevada, Tennessee, and Texas.

MISCELLANEOUS CLAY

Miscellaneous clay consists principally of the large quantities of common clays and shales used for manufacturing brick, tile, and other clay construction products, portland cement, and lightweight aggregates. For statistical reporting, the category also includes smaller quantities of clays which cannot be identified by specific type.

The quantity of miscellaneous clay sold or used by producers increased 5 percent over that reported for 1962; the value increased 7 percent. Of the major uses for miscellaneous clay, heavy clay products showed the largest increase, about 690,000 tons, followed closely by portland cement, which used about 626,000 tons more in 1963 than in 1962. The increases amounted to 4 percent for heavy clay products and 7 percent for cement. The quantity required for lightweight aggregates increased less than 1 percent over that for 1962.

Most of the miscellaneous clay mined in the United States is not sold in the raw state, but is used by the producers for manufacturing clay construction products, cement, and lightweight aggregates. The captive tonnage accounted for 97 percent of the total miscellaneous clay sold or used in 1963.

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
1954–58 (average) [1]	1,433,390	$2,225,290	30,175,938	$35,503,446	31,609,328	$37,728,736
1959	851,006	1,562,552	33,879,888	39,893 102	34,703,894	41,455,654
1960	1,457,387	2,101,850	32,842,407	39,263,112	34,299,794	41,364,962
1961	916,772	1,035,824	32,871,157	39,227,174	33,787,929	40,262,998
1962:						
Alabama			1,408,969	1,262,567	1,408,969	1,262,567
Arizona			138,492	184,098	138,492	184,098
Arkansas			368,175	364,974	368,175	364,974
California	97,801	137,188	2,523,586	4,695,537	2,621,387	4,832,725
Colorado	(2)	(2)	(2)	(2)	583,380	787,611
Connecticut			178,942	286,513	178,942	286,513
Georgia			1,415,540	639,529	1,415,540	639,529
Illinois	(2)	(2)	(2)	(2)	1,612,455	2,413,871
Indiana	(2)	(2)	(2)	(2)	1,103,257	1,686,472
Iowa	(2)	(2)	(2)	(2)	998,068	1,343,780
Kansas			734,611	734,611	734,611	734,611
Kentucky			739,690	961,620	739,690	961,620
Louisiana			637,883	640,723	637,883	640,723

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
1962—Continued						
Maine	----------	----------	47,885	$63,145	47,885	$63,145
Massachusetts	----------	----------	125,470	95,547	125,470	95,547
Michigan	(2)	(2)	(2)	(2)	1,751,317	1,916,828
Mississippi	----------	----------	645,847	647,347	645,847	647,347
Missouri	----------	----------	972,626	972,802	972,626	972,802
Montana	----------	----------	55,806	76,592	55,806	76,592
Nebraska	----------	----------	142,445	142,445	142,445	142,445
New Hampshire	----------	----------	37,115	37,115	37,115	37,115
New Jersey	----------	----------	469,199	594,947	469,199	594,947
New York	(2)	(2)	(2)	(2)	1,396,579	1,617,733
North Carolina	----------	----------	2,730,690	1,782,305	2,730,690	1,782,305
North Dakota	----------	----------	91,935	111,935	91,935	111,935
Ohio	163,552	$169,798	2,370,620	2,802,099	2,534,172	2,971,897
Oklahona	----------	----------	736,954	752,477	736,954	752,477
Oregon	39,000	58,500	208,925	237,913	247,925	296,413
Pennsylvania	(2)	(2)	(2)	(2)	1,617,317	4,547,197
South Carolina	----------	----------	989,733	885,796	989,733	885,796
Tennessee	37,350	14,000	689,238	422,843	726,588	436,843
Texas	(2)	(2)	(2)	(2)	3,011,173	3,203,023
Virginia	----------	----------	1,464,417	1,443,927	1,464,417	1,443,927
Washington	----------	----------	102,881	100,136	102,881	100,136
Wisconsin	(2)	(2)	(2)	(2)	136,616	155,850
Undistributed [3]	619,498	623,575	13,407,186	19,322,973	1,816,522	2,274,183
Total	957,201	1,003,061	33,434,860	40,262,516	34,392,061	41,265,577
1963:						
Alabama	(2)	(2)	(2)	(2)	1,386,525	1,247,940
Arizona	----------	----------	162,395	203,194	162,395	203,194
Arkansas	----------	----------	574,161	572,540	574,161	572,540
California	128,922	234,341	2,671,978	4,931,078	2,800,900	5,165,419
Colorado	(2)	(2)	(2)	(2)	491,138	626,659
Connecticut	(2)	(2)	(2)	(2)	189,344	338,560
Delaware	----------	----------	12,700	12,700	12,700	12,700
District of Columbia	----------	----------	77,858	77,858	77,858	77,858
Georgia	----------	----------	1,581,337	771,229	1,581,337	771,229
Idaho	----------	----------	30,900	15,300	30,900	15,300
Illinois	(2)	(2)	(2)	(2)	1,617,406	2,656,156
Indiana	(2)	(2)	(2)	(2)	1,098,016	1,623,411
Iowa	(2)	(2)	(2)	(2)	1,032,551	1,347,994
Kentucky	----------	----------	772,433	1,008,510	772,433	1,008,510
Louisiana	----------	----------	655,076	655,076	655,076	655,076
Maine	----------	----------	42,365	55,250	42,365	55,250
Maryland	(2)	(2)	(2)	(2)	551,738	656,198
Massachusetts	----------	----------	157,442	213,242	157,442	213,242
Michigan	----------	----------	1,958,222	2,148,548	1,958,222	2,148,548
Minnesota	----------	----------	198,743	298,140	198,743	298,140
Mississippi	----------	----------	725,464	726,762	725,464	726,762
Missouri	(2)	(2)	(2)	(2)	896,676	899,180
Montana	----------	----------	37,850	45,013	37,850	45,013
Nebraska	----------	----------	147,807	147,807	147,807	147,807
New Hampshire	----------	----------	109,875	103,375	109,875	103,375
New Jersey	----------	----------	390,994	491,530	390,994	491,530
New York	(2)	(2)	(2)	(2)	1,597,973	2,186,322
North Carolina	----------	----------	2,735,290	1,761,100	2,735,290	1,761,100
Ohio	159,745	157,255	2,428,286	3,082,466	2,588,031	3,239,721
Oklahoma	(2)	(2)	(2)	(2)	897,150	907,050
Pennsylvania	(2)	(2)	(2)	(2)	1,686,035	4,805,392
South Carolina	----------	----------	1,005,942	965,893	1,005,942	965,893
Tennessee	(2)	(2)	(2)	(2)	882,452	570,794
Texas	17,500	17,500	3,253,205	3,411,625	3,270,705	3,429,125
Utah	(2)	(2)	(2)	(2)	114,652	336,555
Virginia	----------	----------	1,410,098	1,558,327	1,410,098	1,558,327
Washington	925	463	132,596	121,511	133,521	121,974
Wisconsin	----------	----------	111,169	140,262	111,169	140,262
Undistributed [3]	734,731	780,504	13,605,245	19,548,965	1,898,320	2,127,258
Total	1,041,823	1,190,063	34,989,431	43,067,301	36,031,254	44,257,364

[1] Includes Puerto Rico 1954.
[2] Included with "Undistributed."
[3] Includes States indicated by footnote 2 and Delaware (1962), District of Columbia (1962), Florida, Hawaii, Idaho (1962), Kansas (1963), Maryland (1962), Minnesota (1962), Nevada, New Mexico, North Dakota (1963), Oregon (1963), South Dakota, Utah (1962), Vermont, West Virginia, and Wyoming.

The States reporting greatest production of miscellaneous clay were Texas, California, North Carolina, and Ohio, each with over 2 million tons. Production in excess of 1 million tons was reported by 10 other States.

The average value of miscellaneous clay in 1963 was $1.14 per ton for that sold by producers and $1.23 per ton for that used by producers. In 1962, average unit values were $1.05 for that sold by producers and $1.20 for that used by producers.

Exports of clay other than kaolin and fire clay are not reported separately by type, but are included in a blanket category. Exports of clay not elsewhere classified totaled 363,191 tons valued at $12,875,481 in 1963. In 1962, exports were 309,776 tons valued at $10,454,496. The increases in 1963 were 17 percent and 23 percent for quantity and value, respectively. Canada, the United Kingdom, Australia, and Mexico received the greatest quantities, accounting for 39, 8, 6, and 5 percent, respectively. Japan, the Netherlands, West Germany, and Venezuela each imported more than 10,000 tons from the United States.

A dual purpose plant capable of producing either brick or facing tile was completed by Texas Clay Tile, Inc., at Malakoff, Tex. Approximately 70,000 brick or 100 tons of facing tile per day can be produced by the plant, which was partially financed by the Area Redevelopment Administration. The Gulf, N.C., plant of Pomona Pipe Products was doubled in size and the Greensboro plant was rebuilt, to produce a new dense unglazed ceramic pipe with increased resistance to sewage gases and acids. Brick production capacity was nearly doubled at the General Shale Products Corp. plant near Louisville, Ky., when a new tunnel kiln was fired up in 1963. The production rate went from 26 million to 46 million brick per year.

Adobe brick production by the Papago Indians at Sells, Ariz., was initiated due to a housing shortage on the reservation, and plans were made for a similar project on the Gila Indian Reservation.

The Bessemer, Pa., plant of Metropolitan Brick Co., once the largest manufacturing facility for paving brick in the United States, was scheduled to close by the end of 1963. The Ava Brick Corp., at Ava, Ohio, resumed production after a shutdown of nearly 4 years.

Extensive modernization and expansion plans were announced by Acme Brick Co., for its 22 plants. The firm was producing at the rate of 450 million brick per year in 1963. A modernization and expansion program involving several plants of W. S. Dickey Clay Manufacturing Co. in Kansas, Texas, Arkansas, Alabama, and Mississippi was to be completed over an 18-month period. Production capacity was to be more than doubled by addition of a new tunnel kiln at Bennett Brick and Tile Co., Gastonia, N.C. Output for the expanded plant was to be nearly 70,000 brick per day.

The Waco Brick Manufacturing Co., Waco, Tex., announced plans to construct a sand brick plant which would employ 20 to 30 workers. Land was purchased by American Olean Tile Co., and plans were made to build a glazed tile plant in Madison County, Tenn., which will employ 200 workers. A small brick plant, to be financed by Cuban funds and operated by Cuban refugees, was planned for Plant City, Fla.

The Williamsgrove Clay Products Co., at Bigler, Pa., a manufacturer of face brick employing 45 men, was purchased by North American Refractories Co. Athens Brick Co., Athens, Tex., purchased Caddo Clay Products, Mooringsport, La., and Wes-Tex Clay Products Corp., Deleon, Tex. Ideal Brick Co., Fayetteville, N.C., purchased the Norwood Brick Co., Lillington, N.C.

CONSUMPTION AND USES

Heavy clay products accounted for 45 percent of all clays consumed in 1963, followed by cement with 21 percent; lightweight aggregates, 14 percent; and refractories, 10 percent. Quantities consumed in all major use categories increased over those of 1962.

Refractories.—Clay refractories shipments increased in value from $166.1 million in 1962 to $179.5 million in 1963. The value of nonclay refractories was $263.2 million in 1963, compared with $231.9 million in 1962.

The trend in the clay refractories was toward greater use of brick and shapes. For nonclay refractories the largest increases in shipments were in mortars, ramming mixes, and gunning mixes, indicating increased use of monolithic structures which can be installed more economically and with less skilled labor than brick and shapes. In total quantities of shipments, fire clay brick and shapes were up 5 percent, and other fire clay refractories were up 3 percent. For nonclay refractories shipments of brick and shapes increased 6 percent, and shipments of other nonclay refractories increased 19 percent.

TABLE 10.—Clay sold or used by producers in the United States in 1963 by kinds and uses

(Short tons)

Use	Kaolin	Ball clay	Fire clay and stoneware clay	Bentonite	Fuller's earth	Miscellaneous clay including slip clay	Total
Pottery and stoneware:							
Whiteware, etc.	[1] 129,780	[1] 273,588	----	----	----	----	[1] 403,368
Stoneware, art pottery, flowerpots, and glaze slip	(1)	(1)	44,798	----	----	63,000	[1] 107,798
Total	129,780	273,588	44,798	----	----	63,000	511,166
Floor and wall tile	5,556	119,492	231,492	----	----	77,953	434,493
Refractories:							
Fire brick and block	235,789	19,440	2,844,230	----	----	17,277	3,116,736
Bauxite, high-alumina brick	(2)	----	44,054	----	----	253,258	[3] 297,312
Fire-clay mortar	----	----	83,101	----	----	(2)	[3] 83,101
Clay crucibles	----	----	(2)	----	----	(2)	(2)
Glass refractories	(2)	(2)	----	----	----	----	(2)
Zinc retorts and condensers	----	----	(2)	----	----	----	(2)
Foundries and steelworks	(2)	(2)	602,211	[4] 466,614	----	(2)	1,082,893
Saggers, pins, stilts, and wads	(2)	(2)	(2)	----	----	----	72,443
Other refractories	60,074	65,809	244,183	(4)	----	14,233	297,788
Total	295,863	85,249	3,817,779	466,614	----	284,768	4,950,273
Heavy clay products: Building brick, paving brick, draintile, sewer pipe, and kindred products	----	(5)	4,180,310	----	----	18,403,162	[6] 22,583,472
Architectural terra cotta	3,420	----	4,095	----	----	----	7,515
Lightweight aggregates	----	----	----	----	----	6,796,961	6,796,961
Filler:							
Paper filling	601,062	----	----	----	----	----	601,062
Paper coating	1,046,091	----	----	----	----	----	1,046,091
Rubber	443,417	----	(2)	----	----	----	[3] 443,417
Paint	62,344	----	(2)	----	----	----	[3] 62,344
Fertilizers	12,121	----	(2)	----	----	(2)	[3] 12,121
Insecticides and fungicides	33,579	----	4,914	7,263	95,382	(2)	[3] 141,138
Other fillers	111,601	(5)	5,224	940	(5)	(5)	129,432
Total	2,310,215	(5)	10,138	8,203	[5] 95,382	(5)	2,435,605
Portland and other hydraulic cements	(5)	----	----	(5)	----	10,204,146	10,313,065
Miscellaneous:							
Filtering, decolorizing, and clarifying	----	----	----	68,186	41,839	----	110,025
Rotary-drilling mud	----	----	(5)	432,493	62,371	7,329	[6] 502,193
Chemicals	(5)	----	(5)	(5)	(5)	----	118,508
Absorbent uses	(5)	----	(5)	(5)	248,293	(5)	388,405
Exports	156,892	(5)	----	(5)	(5)	(5)	243,574
Enameling	(5)	(5)	----	(5)	----	----	(5)
Catalysts (oil refining)	(5)	----	----	----	----	----	(5)
Pelletizing:							
Iron ore	----	----	----	278,849	----	----	278,849
Other	----	----	----	14,318	(5)	----	[6] 14,318
Other uses	261,847	69,339	101,562	315,853	33,932	193,935	510,580
Total	418,739	69,339	101,562	1,109,699	386,435	201,264	2,166,452
Grand total:							
1963	3,163,573	547,668	8,390,174	1,584,516	481,817	36,031,254	50,199,002
1962	2,998,157	486,936	8,065,048	1,444,135	409,989	34,392,061	47,796,326

[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	1962		1963	
		Quantity	Value (thousands)	Quantity	Value (thousands)
Clay refractories:					
Fire-clay brick, standard and special shapes, except superduty.	1,000 9-inch equivalent.	277,878	$43,336	286,490	$44,161
Superduty fire-clay brick and shapes	do	63,349	18,020	67,497	19,185
High-alumina brick and shapes (50 percent Al_2O_3 and over) made substantially of calcined diaspore or bauxite.[1]	do	28,539	12,998	32,596	15,373
Insulating firebrick and shapes	do	42,852	10,823	44,302	11,337
Ladle brick	do	177,827	19,379	184,961	20,705
Sleeves, nozzles, runner brick, and tuyères	do	38,365	8,174	42,457	9,361
Glasshouse pots, tank blocks, feeder parts, and upper structure shapes used only for glass tanks.[1]	Short ton	13,402	4,151	13,516	4,391
Hot-top refractories	do	61,164	4,171	61,621	4,429
Clay-kiln furniture, radiant-heater elements, potters' supplies, and other miscellaneous shaped refractory items.	do		6,505		7,210
Refractory bonding mortars, air-setting (wet and dry types).[2]	do	50,213	5,629	53,503	6,515
Refractory bonding mortars, except air-setting types.[2]	do	8,945	955	9,488	956
Ground crude fire clay, high-alumina clay, and silica fire clay.	do	379,742	3,545	330,944	3,226
Plastic refractories and ramming mixes [1]	do	143,750	11,977	165,668	13,638
Castable refractories (hydraulic-setting)	do	98,117	9,921	120,971	12,075
Insulating castable refractories (hydraulic-setting).	do	21,554	2,499	18,310	2,338
Other clay refractory materials sold in lump or ground form.[3][4]	do	170,567	4,012	204,299	4,606
Total clay refractories			166,095		179,506
Nonclay refractories:					
Silica brick and shapes	1,000 9-inch equivalent.	119,161	23,497	119,290	22,499
Magnesite and magnesite-chrome (magnesite predominating) brick and shapes (excluding molten-cast).	do	65,485	56,187	77,422	68,344
Chrome and chrome-magnesite (chrome ore predominating) brick and shapes (excluding molten-cast).	do	33,775	26,387	35,292	27,906
Graphite crucibles, retorts, stopper heads, and other shaped refractories containing natural graphite.	Short ton	12,493	9,851	13,024	10,077
Mullite brick and shapes made predominantly of kyanite, sillimanite, andalusite, or synthetic mullite (excluding molten-cast).	1,000 9-inch equivalent.	[5] 4,962	[5] 6,096	6,073	7,058
Extra-high-alumina brick and shapes made predominantly of fused bauxite or fused or dense-sintered alumina (excluding molten-cast).	do	[5] 3,366	[5] 5,783	3,173	5,661
Silicon carbide brick and shapes made substantially of silicon carbide.	do	[5] 4,205	[5] 10,088	4,113	9,552
Zircon and zirconia brick and shapes made predominantly of either of these materials.	do	[5] 858	[5] 3,558	953	3,867
Forsterite, pyrophyllite, molten-cast, and other nonclay brick and shapes.			[5] 23,874		30,314

See footnotes at end of table.

TABLE 11.—Shipments of refractories in the United States, by kinds—Continued

Product	Unit of quantity	1962		1963	
		Quantity	Value (thousands)	Quantity	Value (thousands)
Nonclay refractories—Continued					
Nonclay refractory bonding mortars, air-setting (wet and dry types).	Short ton	142,966	$13,969	204,089	$17,897
Nonclay refractory bonding mortars, except air-setting types.	do	13,825	1,320	19,910	1,758
Nonclay refractory castables (hydraulic-setting).	do	[5] 28,110	[5] 2,789	13,255	2,060
Nonclay plastic refractories and ramming mixes (wet and dry types).	do	[5] 165,850	[5] 19,769	182,695	21,979
Dead-burned magnesia or magnesite	do	173,420	10,548	198,002	12,947
Carbon refractories; brick, blocks, and shapes, excluding those containing natural graphite.	do	[5] 189,924	[5] 18,240	233,140	21,229
Other nonclay gunning mixes	do				
Other nonclay refractory materials sold in lump or ground form.[3]	do				
Total nonclay refractories			[5] 231,956		263,148
Grand total refractories			[5] 398,051		442,654

[1] Excludes data for mullite or extra-high-alumina refractories. These products are included with mullite and extra-high-alumina brick and shapes in the nonclay refractories section.
[2] Includes data for bonding mortars that contain up to 60 percent alumina (Al_2O_3), dry basis. Bonding mortars that contain more than 60 percent Al_2O_3, dry basis, are included in the nonclay refractories 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] Revised figure.

Source: Bureau of the Census.

Heavy Clay Products.—The continued high construction activity in 1963 was reflected in an increase of 5 percent in the quantity of clay consumed in manufacturing heavy clay products. Building brick production in 1963 was 7.4 billion, compared with 6.9 billion in 1962. Production decreased slightly in the New England, Middle Atlantic, and Mountain States, but increased in all other geographic divisions. The largest brick outputs reported for individual States were North Carolina, 765 million; Ohio, 703 million; Texas, 633 million; and Pennsylvania, 552 million.

Clay floor and wall tile production increased 6 percent, and vitrified sewer pipe production increased 9 percent. Facing tile production was down 8 percent, and other structural clay tile production was down 19 percent. The value of shipments of all heavy clay products was $524.4 million, an increase of about 3 percent over 1962 shipments valued at $510.5 million.

The quantity of clay used for producing lightweight aggregate increased slightly in 1963, and the quantity used in cement manufacture increased 8 percent.

New lightweight aggregate plants were completed in Connecticut and Utah, and a plant was under construction near Castleton, Vt., designed to produce lightweight aggregates from waste slate fines which had accumulated at an abandoned roofing granule plant.

Typical investment and operating costs for a 200-ton-per-day plant for production of expanded clay aggregates, which might be operated in conjunction with existing clay products plants, were published.[2] At least one of the new plants completed during the year utilized the data contained in the article.[3]

TABLE 12.—Shipments of principal structural clay products in the United States

Product	1954-58 (average)	1959	1960	1961	1962	1963
Unglazed brick (building) 1,000 standard brick..	6,868,060	7,258,000	6,502,200	6,427,600	6,913,100	7,405,000
Value..........thousands..	$215,480	$241,400	$223,500	$225,300	$246,500	$260,800
Unglazed structural tile.......short tons..	755,240	521,300	488,200	476,000	422,900	383,500
Value..........thousands..	$8,380	$8,000	$7,800	$7,400	$6,600	$5,600
Vitrified clay sewer pipe and fittings short tons..	1,830,020	1,973,100	1,854,500	1,749,000	1,714,000	1,747,500
Value..........thousands..	$81,920	$98,300	$94,800	$89,600	$88,600	$91,800
Facing tile, ceramic-glazed, including glazed brick.....1,000-brick equivalent..	411,940	369,600	369,500	388,000	370,300	328,500
Value..........thousands..	$29,740	$31,300	$30,300	$31,600	$31,100	$26,900
Facing tile, unglazed and salt-glazed 1,000-tile, 8- by 5- by 12-inch, equivalent..	23,320	14,300	12,300	[1] 11,200	[1] 10,800	9,100
Value..........thousands..	$3,640	$2,600	$2,600	$2,100	$2,200	$1,900
Clay floor and wall tile and accessories, including quarry tile..1,000 square feet..	212,820	252,500	233,000	228,400	253,100	265,900
Value..........thousands..	$117,020	$141,100	$129,500	$124,300	$135,500	$137,400
Total value of shipments.....thousands..	$458,180	$522,700	$488,500	$480,300	$510,500	$524,400

[1] Revised figure.

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—Reports were issued on the results of studies of lightweight aggregate raw materials in Ontario[4] and Quebec.[5] New lists were published giving data on the mines[6] and ceramic plants[7] in Canada.

Production of lightweight aggregate from clay and shale increased 13 percent in volume and 12 percent in value in 1963. One new plant started production in Laprairie, Quebec.[8]

[2] Brick & Clay Record. Supplement Production and Profits—Add a Lightweight Aggregate Plant. V. 142, No. 1, January 1963, pp. 54-55.

[3] Brick & Clay Record. Making Lightweight Aggregate With Brickmaking Facilities. V. 143, No. 5, November 1963, pp. 48-49, 67.

[4] Wilson, H. S. Lightweight Concrete Aggregates From Clays and Shales in Ontario. Canada Dept. of Mines and Tech. Surveys, Mines Branch, Tech. Bull. 51, October 1963, 47 pp.

[5] Wilson, H. S. Lightweight Concrete Aggregates From Clays and Shales in Quebec. Canada Dept. of Mines and Tech. Surveys, Mines Branch, Tech. Bull. 48, July 18, 1963, 37 pp.

[6] Canada Department of Mines and Technical Surveys, Mineral Resources Division. Metal and Industrial Mineral Mines in Canada. Operators List 2, June 1963, 32 pp.

[7] Canada Department of Mines and Technical Surveys, Mineral Resources Division. Ceramic Plants in Canada. Operators List 6, June 1963, 39 pp.

[8] Wilson, H. S. Lightweight Aggregate, 1962. Canada Department of Mines and Technical Surveys, June 1963, 6 pp.

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TABLE 13.—World production of kaolin by countries [1]

(Short tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Mexico	[2] 66,586	67,415	81,544	66,910	(3)	51,325
United States	2,139,038	2,535,474	2,730,451	2,739,816	2,998,157	3,163,573
South America:						
Argentina	30,721	31,192	45,229	40,141	52,426	(3)
Chile	3,181	[4] 7,500	8,598	15,599	33,581	40,674
Colombia	3,740	16,500	22,000	55,000	77,000	83,000
Ecuador	352	794	348	601	416	388
Peru	111	136	662	514	386	324
Europe:						
Austria	301,232	328,029	356,150	379,076	370,809	385,088
Belgium	(3)	(3)	44,476	284,535	229,945	(3)
Bulgaria	[5] 33,000	44,000	62,000	61,000	67,000	[4] 68,000
Czechoslovakia	254,800	288,000	301,000	331,000	352,000	(3)
Denmark:						
Crude	6,397	6,846	6,950	8,567	[4] 8,800	[4] 8,300
Washed and pressed	6,032	4,851	5,405	4,669	[4] 13,200	[4] 13,200
France	134,200	159,000	150,000	160,000	149,000	(3)
Germany, West (marketable)	385,271	374,578	379,418	411,689	422,262	499,008
Greece	13,828	2,760	28,700	27,800	[4] 27,500	[4] 38,500
Hungary	15,574	36,712	47,939	46,697	44,994	[4] 45,000
Italy:						
Crude	64,726	101,077	95,697	50,207	81,375	81,088
Kaolinic earth	48,020	25,949	50,749	86,906	(3)	(3)
Portugal:						
Crude	27,065	18,770	19,836	21,951	14,082	(3)
Washed	25,441	30,094	31,825	32,810	33,857	(3)
Spain (crude)	77,396	127,828	123,860	139,875	184,960	(3)
Sweden	1,449	21,700	29,464	29,800	(3)	(3)
U.S.S.R. [4]	(3)	1,100,000	1,200,000	1,400,000	1,500,000	1,650,000
United Kingdom	1,288,174	1,469,000	1,835,000	1,924,000	1,640,000	[4] 1,904,000
Yugoslavia	[4] 15,000	17,800	[4] 11,200	[4] 7,800	5,000	4,500
Asia:						
Hong Kong	7,063	8,127	7,462	9,441	7,141	5,621
India	174,908	287,164	395,117	409,280	423,703	452,698
Indonesia (kaolin powder)	[6] 587	935	1,383	(3)	(3)	(3)
Iran [7]	[4] 519	2,419	4,816	3,360	(3)	(3)
Japan	16,904	23,002	23,456	29,695	79,212	120,984
Korea, Republic of	13,486	47,193	56,472	56,523	42,101	57,609
Malaya, Federation of	1,477	1,436	1,370	1,760	3,874	1,317
Pakistan	----	----	82	791	22	(3)
Taiwan	[6] 4,532	6,000	(3)	(3)	(3)	(3)
Viet-Nam, Republic of	3,626	1,253	1,874	(3)	4,365	(3)
Africa:						
Algeria	211	----	----	----	----	----
Eritrea	311	5,500	1,650	3,850	660	(3)
Kenya	1,062	1,280	1,160	816	1,294	7,229
Mozambique	114	132	127	132	198	6
Nigeria	75	6	4	----	6	17
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	----	----	6,614	20,386	----	12,240
South Africa, Republic of	15,950	20,034	29,202	26,474	31,366	37,413
Swaziland	----	----	----	58	2,743	2,212
Tanganyika	113	86	245	171	101	201
United Arab Republic (Egypt)	4,984	12,677	22,046	29,961	14,966	23,158
Oceania: Australia [8]	46,588	41,411	53,978	57,219	40,398	(3)

[1] Kaolin is also produced in Brazil, China, East Germany, Israel, Rumania, and Thailand, but data on production are not available; a negligible quantity is produced in Malagasy, Morocco and Paraguay.
[2] Average annual production 1957–58.
[3] Data not available.
[4] Estimate.
[5] Data for 1958 only.
[6] Average annual production 1956–58.
[7] Year ended March 20 of year following that stated.
[8] Includes ball clay.

A 20-ton-per-hour bentonite-processing plant was completed in December 1962 at the Carol Pellet Co. plant in Labrador, to produce material for use as a bonding agent in iron-ore pelletizing. Treatment methods included grinding to 85 percent minus 200 mesh, drying, and size classification.[9]

SOUTH AMERICA

Chile.—Production of 11,044 tons of fire clay was reported for 1963.

Peru.—Refractory clay production was 5,787 tons, kaolin production 324 tons, and common clay production 275,575 tons in 1963.

Uruguay.—Production of 3,546 tons of fire clay was reported for 1963.

EUROPE

Austria.—Bentonite production was 3,073 tons.

Hungary.—A new deposit of clay with properties reportedly similar to those of Wyoming bentonite was discovered in Hungary in the southwestern part of the Tokay Hills near the town of Mad. Extensive surveys were planned for 1963 to obtain additional data on the deposit,[10] and a mill with a daily capacity to treat 100 tons of raw clay was built.[11] Bentonite production in 1963 was 92,712 tons.

Italy.—Italy reported the largest production of bentonite for any country outside North America. The 1963 figure was 157,548 tons.

Portugal.—Portugal reported production of 14,082 tons of impure kaolin, and 301,175 tons of other clays in 1962.

United Kingdom.—A new fuller's earth granulation plant was completed at Redhill, Surrey. In addition to relieving the supply shortage for conventional fuller's earth granules, the new plant started producing a water-stable granule for use as a carrier for catalysts and pesticides and for several absorbent and adsorbent applications.[12]

Northern Ireland reported production of 26,169 tons of fire clay and 274,450 tons of other clays in 1963.

A short history and description of the china-clay-producing area of southwest England was published, together with information on the types of clay, mining methods, and uses.[13] A new and efficient drying and handling plant using consolidated pushbutton controls was described.[14]

ASIA

Ceylon.—Investigation of large kaolin deposits in the Boralasgamuwa area, near Colombo, resulted in construction work on a processing plant to produce kaolin suitable for use in porcelain and other manufactures.[15]

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[9] Canadian Mining Journal (Gardenvale, Quebec). Bentonite Processing Plant in Labrador. V. 84, No. 5, May 1963, p. 59.

[10] Muszaki Elet (Budapest, Hungary). (Special Quality Clay Found.) V. 18, No. 9, Apr. 25, 1963, p. 11; transl. in Weekly Economic Report on Eastern Europe, No. 454, p. 30.

[11] Mining Journal (London). V. 260, No. 6652, Feb. 15, 1963, p. 159.

[12] Chemical Age (London). New Fuller's Earth Plant Ends Supply Restrictions. V. 90, No. 2298, July 27, 1963, p. 142.

[13] Howes, Helen Clarie. Mining China Clay—The White Pyramids of Cornwall. Precambrian—Mining in Canada, (Winnipeg) v. 36, No. 4, April 1963, pp. 6–7.

[14] Mine and Quarry Engineering (London). A Cornish China Clay Drying Installation. V. 30, No. 5, May 1963, p. 223.

[15] Hearth, J. W. Kaolin in Ceylon. Econ. Geol., v. 58, No. 5, August 1963, pp. 769–773.

India.—Reported clay production in 1963 included 405,955 tons of fire clay.

Israel.—Ball- and fire-clay production totaled 30,095 tons in 1963.

Japan.—Fire-clay production in 1963 was 891,254 tons.

Taiwan.—Clay production was 1,105,600 tons, compared with 1,024,800 tons in 1962. The 1963 breakdown by use was as follows: ceramics and pottery, 44,100 tons; paper, 3,300 tons; cement, 507,100 tons; and brick and tile, 551,100 tons.

U.S.S.R.—Information on present and future requirements for bentonite in the Central Asian Republics was published, together with data on the producing areas, including production and processing methods and costs. Most of the bentonite presently used is obtained outside the region and transportation costs are as much as 2.5 times the basic cost of the bentonite.[16]

AFRICA

Algeria.—Production of bentonite was 93,695 tons in 1963. Fuller's earth production declined by 68 percent in 1962, and early in 1963 only 13 men were employed by the industry. By the end of June 1963, employment had increased to 36 men, and production was up substantially.[17]

Bechuanaland.—Investigations designed to delineate high-grade sedimentary kaolin deposits in the Mokoro area in the central part of the Bamangwato Tribal Territory were conducted. The deposits are crossed by the rail line.[18]

Mozambique.—A montmorillonite-clay-processing plant was completed in October 1963, near Impamputo, 35 miles from Lourenço Marques. About 25 men were employed at the processing plant, and 60 to 80 men worked in the surface mines. Reported production early in November 1963 was approximately 25 tons per day.[19]

Rhodesia and Nyasaland, Federation of.—Fire-clay production was 14,528 tons.

South Africa, Republic of.—Clay production in 1963 included 266,653 short tons of fire clay, 8,614 tons of bentonite, 985 tons of fuller's earth, and 150,144 tons of other clays.

United Arab Republic (Egypt).—White clay production was 3,617 tons. Production of other clays except kaolin was reported as 435,719 cubic meters.

OCEANIA

Australia.—Western Australia clay production was reported as follows: fire clay, 28,002 tons; bentonite 1,341 tons; ball clay, 805 tons; white clay, 84 tons; brick and pipe clay, 63,400 tons (incomplete); and cement clay, 21,025 tons.

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[16] Gazizof, Kh., and A. Pan. (Bentonite—A Universal Material.) Narondnoye Khoxyaystvo Uzbekistana (Tashkent, U.S.S.R.), No. 9, September 1963, pp. 70–74; Office of Tech. Survey, U.S. Dept. of Commerce, USSR Industrial Development, Soviet Regional Economy, No. 86, pp. 18–22; J.P.R.S. 22,118; OTS 63-42,716.

[17] Bureau of Mines. Mineral Trade Notes. V. 58, No. 2, February 1964, p. 9.

[18] South African Mining & Engineering Journal (Johannesburg, Republic of South Africa). Mineral Developments in Bechuanaland. V. 74, pt. 2, No. 3690, Oct. 25, 1963, p. 1411.

[19] Bureau of Mines Mineral Trade Notes. V. 58, No. 2, February 1964, p. 10.

An automatic brick plant under construction was described. Improvements cited included continuous operation, complete product uniformity, and hot extrusion at temperatures not practicable in conventional plants. Total production costs for the automated plant, including packaging, were estimated to be about 30 percent lower than average costs for other plants of equal capacity.[20]

Bentonite was undergoing tests in Australia as a fire retardant to prevent the spread of small fires in isolated areas.[21]

TECHNOLOGY

High-purity kaolin of extreme brightness was produced by a new commercial-scale plant by exact metering of powdered limestone, which is used as a carrier agent in ultraflotation. Impurities are removed in the froth.[22] Processing methods used in producing kaolin in Georgia and South Carolina were described, with emphasis on methods for removing water from clay-water slurries.[23]

Data on the types and quantities of mineral fillers used in paper manufacturing were presented. Although several of the fillers excelled in brightness and other desirable qualities, kaolin was entirely satisfactory for most applications and accounted for nearly 80 percent of paper fillers used in 1960.[24]

A method of quantitative estimates of kaolinite and halloysite in clay mineral mixtures on the basis of NH_4Cl retention was described. Overall accuracy within 10 percent of actual (reported) values for reference clay minerals was possible, and linear results were obtained with artificial mixtures containing 0 to 100 percent of kaolinite and halloysite.[25] Contributions were made to the knowledge of the structure of kaolinite and other kaolin minerals.[26]

Evidence indicates that large kaolin deposits in Florida were formed by alteration of montmorillonite to kaolin. The conversion was apparently direct, with no intermediate phases detected.[27]

Investigation of the Mesa Alta, N. Mex., clay occurrences revealed a greater reserve than had been indicated. The deposits range from 6 to 20 feet in thickness.[28]

Data were presented on the structure and properties of organic derivatives of montmorillonite and other mica-type layer silicates. Possibilities for their industrial uses were discussed.[29]

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[20] Cross, O. H., P. A. Caruso, and J. W. Brandon. Here It Is—The World's First Automatic Plant. Brick & Clay Record, v. 143, No. 3, September 1963, pp. 62–67, 82–83, 86–89.

[21] Mining Journal (London). V. 260, No. 6651, Feb. 8, 1963, p. 134.

[22] Ceramic Age. Limestone Metering. V. 79, No. 5, May 1963, pp. 47–48.

[23] Phillips, William M. Dewatering and Processing Kaolin Clays. Trans. Soc. Min. Eng., v. 226, No. 2, June 1963, pp. 219–223.

[24] Mueller, A. J., and G. W. Phelps. Mineral Fillers in the Paper Business. Canadian Min. and Met. Bull. (Montreal), v. 56, No. 609, January 1963, pp. 50–56.

[25] Wada, Koji. Quantitative Determination of Kaolinite and Halloysite by NH_4Cl Retention Measurement. Am. Mineral., v. 48, Nos. 11–12, November–December 1963, pp. 1286–1299.

[26] Bailey, S. W. Polymorphism of the Kaolin Minerals. Am. Mineral., v. 48, Nos. 11–12, November–December 1963, pp. 1196–1209.

Radoslovich, E. W. The Cell Dimensions and Symmetry of Layer-Lattice Silicates. VI. Serpentine and Kaolin Morphology. Am. Mineral., v. 48, Nos. 3–4, March–April 1963, pp. 368–378.

Wolff, R. G. Structural Aspects of Kaolinite Using Infrared Absorption. Am. Mineral., v. 48, Nos. 3–4, March–April 1963, pp. 390–399.

[27] Altschuler, Z. S., E. J. Dwornik, and Henry Kramer. Transformation of Montmorillonite to Kaolinite During Weathering. V. 141, July 12, 1963, pp. 148–152.

[28] Reeves, C. C., Jr. Geology of A.P.I. Project 49 Kaolin Clay Reference Locality, Mesa Alta, New Mexico. Econ. Geol., v. 58, No. 2, March–April 1963, pp. 237–249.

[29] Weiss, Armin. Organic Derivatives of Mica-Type Layer-Silicates. Angewandte Chemie (International Edition in English), v. 2, No. 3, March 1963, pp. 134–144.

Researchers reported a third buffer range in potentiometric titration of Wyoming bentonite,[30] and a negative electro-optical birefringence phenomenon at low-voltage fields in polydisperse suspensions of Wyoming bentonite.[31]

Detailed data on the properties of natural zeolites were included in a comprehensive volume on the framework silicates.[32]

Data were presented on the green strength of ball clay-flint mixtures with moisture contents ranging from 16 to 0 percent. In all cases the greatest increase in green strength occurred in the final drying from 2 to 0 percent.[33]

A thermally stable mullite porcelain which forms little cristobalite in use was patented. From 20 to 30 percent of the ceramic mix consisted of ball clay.[34] Patents also were issued on the use of ball clay in abrasive tumbling media [35] and in an expanding plaster.[36] A British patent was obtained on a method of drying ball clay and kaolin pellets in a fluidized bed.[37]

Clay screening problems were discussed with particular reference to blinding. The type of wire, diameter of wire, and shape of screen openings were important factors which could be varied to assure optimum production. Electrical heating of the screen was cited as an important method of preventing moist clay particles from sticking to and building up on the screens.[38]

Use of premixed, precalcined, and chemically treated raw materials by whiteware manufacturers was proposed to reduce production costs and improve the competitive position of the U.S. whiteware industry.[39]

Vacuum-assisted slip casting using paper-lined perforated metal molds was described as a potential method of overcoming disadvantages of present slip-casting practices. In addition to clay slips, others made of magnesia, alumina, zirconia, and alumina-zirconia cermet were successfully cast.[40]

Illustrations of ceramic production problem solving through statistical quality-control methods were presented for some common causes of manufacturing losses.[41]

Gel-forming properties of attapulgite were improved in a patented process by rapid drying at 225° to 900° F and simultaneous grinding to minus 48 mesh.[42] Colloidal attapulgite was specified in patents

[30] Schwertmann, U., and M. L. Jackson. Hydrogen-Aluminum Clays: A Third Buffer Range Appearing in Potentiometric Titration. Science, v. 139, No. 3559, Mar. 15, 1963, pp. 1052–1054.
[31] Shah, M. J., and C. M. Hart. Investigations of the Electro-Optical Birefringence of Polydisperse Bentonite Suspensions. IBM J. Res. and Devel., v. 7, No. 1, January 1963, pp. 44–57.
[32] Deer, W. A., R. A. Howie, and J. Zussman. Rock-Forming Minerals: V. 4, Framework Silicates. John Wiley & Sons, Inc., New York, 1963, 435 pp.
[33] Turbett, Paul E. Effect of Moisture on Modulus of Rupture of Some Typical Ball Clays. Am. Ceram. Soc. Bull., v. 42, No. 1, January 1963, pp. 21–22.
[34] Bissell, D. W., and C. D. Bruner (assigned to Ipsen Ceramics, Inc., Pecatonica, Ill.) Mullite Porcelain. U.S. Pat. 3,103,443, Sept. 10, 1963.
[35] Smith-Gorman, R. J. (assigned to Rolls-Royce Ltd., Derby, England). Barrelling Chips. U.S. Pat. 3,089,764, May 14, 1963.
[36] Leonard, R. J. Patching Plaster Composition. U.S. Pat. 3,100,715, Aug. 13, 1963.
[37] Brociner, R. E., and V. H. Miller (assigned to English Clays Lovering Pochin & Co. Ltd.) Brit. Pat. 942,576, Nov. 27, 1963.
[38] Camphell, R. Here's How To Solve Clay Screening Problems. Brick & Clay Record, v. 142, No. 3, March 1963, pp. 46–47, 55–58.
[39] Ceramic Industry. RMS—Key To Whiteware Survival. V. 81, No. 4, October 1963, pp. 76–80.
[40] Adami, A., and L. S. Williams. Vacuum-Assisted Slip Casting. Am. Ceram. Soc. Bull., v. 42, No. 7, July 1963, pp. 391–393.
[41] Kleinkauf, H. Statistical Quality Control—Some Case Histories in Ceramics. Am. Ceram. Soc. Bull., v. 42, No. 3, March 1963, pp. 101–103.
[42] Malone, T. S., and A. P. Allegrini (assigned to Minerals and Chemicals Phillip Corp., Menlo Park, N.J.). Gel-Forming Attapulgite Clay and Method for Preparing Same. U.S. Pat. 3,079,333, Feb. 26 1963.

issued for an agent to be used in decolorizing and ash removal in sugar refining,[43] and in a filter aid for use in clarifying dry cleaning and other solutions.[44] A patent was issued for well-drilling fluid usable in drilling through mud-making rocks in which the use of attapulgite was required.[45]

Results of new studies of the flow characteristics of bentonite suspensions in water, glycerol, and oil were released.[46]

Literature on the technology of drilling fluids was brought up to date with the publication of a comprehensive book which describes the mining, manufacturing, and utilization of clays and other materials. A patent abstract for the period 1887 to 1963 was included.[47]

Data were presented which indicated that bentonite content and moisture content are critical factors in production of dimensionally stable foundry molds with adequate green strength by high-pressure ramming.[48]

Development of low-cost linings for metal-pouring ladles at the Colorado Fuel and Iron Company, Pueblo, Colo., plant since 1956 have more than doubled the ladle lining life and decreased the patching required to maintain the linings. Use of tar and granulated pitch and development of a better ramming mix are credited with most of the improvements in ladle service.[49]

Open-hearth furnace linings were improved by using different refractories in the sections subjected to slag, metal, and atmospheric attacks. Refractory spraying also was evaluated and found to be practicable for increasing the life.[50]

A shift from silica refractories to all-basic refractories for open-hearth steel furnace roofs resulted in a 500-percent increase in roof life. New direct-bonded basic brick were reported to be 50 to 100 percent better than the ordinary basic brick.[51]

Problems associated with the use of round and spherical refractory brick reaction vessel linings have been solved by installing prestressed linings which remain under compression at all times. Although common in Europe and Japan, the new linings have only recently started to gain acceptance in the United States. Advantages and limitations of the prestressed linings were cited.[52]

Criteria for selecting refractories for various types of furnaces, ladles, and ovens used in the steel, copper, and lead industries were published.[53]

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43 Allegrine, A. P., and T. A. Cecil (assigned to Minerals and Chemicals Phillip Corp., Menlo Park, N.J.). Sugar Refining Adsorbent. U.S. Pat. 3,098,045, July 16, 1963.

44 Duke, J. B., and E. W. Green (assigned to Minerals and Chemicals Phillip Corp., Menlo Park, N.J.). Attapulgite Clay Filter Aid Product and Method of Making Same. U.S. Pat. Reissue 25,464, Oct. 15, 1963 (reissue of U.S. Pat. 3,080, 214, Mar. 5, 1963).

45 Mathews, R. G. (assigned to Maquet Cove Barium Corp., Houston, Tex.). Well Fluids and Additive Therefor. U.S. Pat. 3,107,739, Oct. 22, 1963.

46 Gabrysh, W. F., E. Eyring, Pan Lin-Sen, and A. F. Gabrysh. Rheological Factors for Bentonite Suspension. J. Am. Ceram. Soc., v. 46, No. 11, November 1963, pp. 523–529.

47 Rogers, Walter F. Composition and Properties of Oil Well Drilling Fluids. Gulf Pub. Co., Houston, Tex., 3d ed., 1963, 818 pp.

48 Schumacher, J. S. Pressure Makes Perfect—Sometimes. Foundry, v. 91, No. 6, June 1963, pp. 83–87.

49 Malwitz, Dennis G., Carl R. Anderson, and John W. Carlson. Low Cost, Rammed Carbonaceous Metal Ladle Linings. Blast Furnace & Steel Plant, v. 51, No. 4, April 1963, pp. 48, 50, 54, 56, 71.

50 Schroth, P., and Sample MacBeth. Performance of Zoned Front Walls in Open Hearth Furnaces. Iron and Steel Eng., v. 15, No. 8, August 1963, pp. 179–180.

51 Iron Age v. 192, No. 7, Aug. 15, 1963, pp. 102–103.

52 Chemical & Engineering News. Prestressed-Brick Linings Gain Acceptance for High Temperature Use. V. 41, No. 40, Oct. 7, 1963, pp. 54–55.

53 Sullivan, John D. Metallurgical Refractories. Mines Mag., v. 53, No. 9, September 1963, pp. 13–19.

A study was made of the mechanisms involved in elastic, plastic, and viscous deformation of a structural clay body at high temperature. For the body studied, the effects of mechanical loading or thermal gradient were predictable and could be utilized to improve the raw material mixtures or to adjust the firing cycle for optimum operating conditions.[54]

Modern equipment and methods for handling raw materials, materials in process, and finished materials for plants making structural clay products, clay pipe, refractories, and expanded clay aggregate were described.[55]

Raw materials for production of an ideal face brick were formulated on the basis of the desired physical characteristics. A number of mixtures were tested, and two of the best were further refined to produce face brick with all of the requisite physical requirements.[56]

The use of prefabricated high-strength brick panels was cited as an advance which could result in lower construction costs and increased brick sales.[57]

Substantial savings in utility costs were realized by a Georgia brick producer after installation of a gas turbine-powered electric generator. Heat from the turbine exhaust was utilized for nearly all of the company's drying requirements.[58]

Advantages and problems of heating clay mixes prior to extrusion into heavy clay products were studied. Greater workability and lower power requirements were cited as principal advantages and maintenance of comfortable working conditions was a problem requiring additional study.[59]

Production of drain tile was essentially doubled by a North Carolina firm by utilizing an extrusion die which produced a 4-inch tile inside a 6-inch one. The "double" tile were handled as single units through the entire drying and firing cycle, and were separated only after reaching the product storage area. Important savings in labor and fuel per tile unit were realized.[60]

A new fast action automatic tile-pressing device was introduced, which was capable of 40 pressing cycles per minute with a developed force up to 50,000 pounds.[61]

Costly hand labor was eliminated from several production operations by a New York manufacturer of soft mud brick by more fully automating transfer points and pallet return systems.[62]

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[54] McNeilly, C. E., and G. L. DePoorter. Deformation of a Structural Clay Body at High Temperatures. Am. Ceram. Soc. Bull., v. 42, No. 1, January 1963, pp. 1–5.

[55] Brick & Clay Record. Materials Handling, 1963. V. 142, No. 3, February 1963, pp. 39–47.

[56] Earl, W. A., and W. E. Brownell. Composition of an Ideal Face Brick. Am. Ceram. Soc. Bull., v. 42, No. 2, February 1963, pp. 49–51.

[57] Brick & Clay Record. Prefabricated Brick Panels Open New Markets. V. 142, No. 3, March 1963, pp. 40–42.

Construction Methods & Equipment. Hi-Bond Mud Toughens Brick Panels. V. 45, No. 4, April 1963, pp. 179–180.

[58] Brick & Clay Record. Jet Age Penetrates Heavy Clay Products Industry. V. 142, No. 3, March 1963, pp. 36–39.

[59] Anwyl, R. H. Hot Processing Brick & Tile. Ceram. Age, v. 79, No. 3, March 1963, pp. 49–52.

[60] Moffitt, Roy B. Drain Tile—Two for the Price of One. Brick & Clay Record, v. 142, No. 5, May 1963, pp. 54–55.

[61] Ceramic Industry. Straight-Line Tile Pressing Introduced. V. 80, No. 4, April 1963, p. 101.

[62] Brick & Clay Record. Automated Soft Mud Brick Manufacture. V. 143, No. 3, September 1963, pp. 70–71.

Several types of clay research were underway by the Bureau of Mines in 1963, and a number of publications were issued on the results, including methods and equipment for beneficiating marginal and submarginal refractory clays,[63] investigation of problems involved and results of processing halloysitic clays in the Pacific Northwest,[64] research on methods of producing kaolin of paper-coating quality by fine attrition grinding of coarse, low-grade material, much of which is currently wasted,[65] and investigation of clays, shales, and argillites in Minnesota suitable for production of lightweight aggregates.[66] Several processes for obtaining alumina from clay were evaluated by the Bureau.[67] Data were presented on the exploration, mining, processing, and utilization of clay for production of glazed structural tile at a large plant in California.[68]

A pilot plant was established at Alfred University College of Ceramics for research on expanded aggregate blocks suitable for facing material. The initial output of glazed block was used on a new research building.[69]

The manufacturing facilities of three large New York State lightweight aggregate producers were described. Total daily production capacity of the three plants is over 3,000 tons, or about 4,500 cubic yards. Plant equipment details, plant layouts, and flowsheets were included.[70]

Plant improvements by a California firm which permitted utilization of previously wasted clay while improving the quality of lightweight aggregates and masonry "sand," were described.[71]

Several new or improved methods for producing lightweight aggregate were patented in the U.S. including a rotary kiln system with the bloating section inclined slightly upward from the feed end,[72] a vertical heated shaft in which the clay or shale particles are bloated while falling freely,[73] and the use of cigar-shaped briquets

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63 Powell, H. E., W. A. Calhoun, and C. K. Miller. Beneficiation of Refractory Clay. BuMines Rept of Inv. 6142, 1963, 46 pp.
Powell, H. E., and W. A. Calhoun. The Hydrocyclone in Clay Beneficiation. BuMines Rept of Inv. 6275, 1963, 20 pp.

64 Kelly, H. J., G. J. Carter, and T. R. Rehm. Physical and Chemical Properties of Some Pacific Northwest Halloysitic Clays. BuMines Rept. of Inv. 6211, 1963, 32 pp.
Kelly, H. J., G. J. Carter, and G. H. Todd. Bovill Clay and Sand Deposit, Latah County, Idaho. BuMines Rept. of Inv. 6330, 1963, 56 pp.

65 Stanczyk, M. H., and I. L. Feld. Continuous Attrition Grinding of Coarse Kaolin (in two parts). 1. Open-Circuit Tests. BuMines Rept. of Inv. 6327, 1963, 14 pp.

66 Grosh, W. A., and H. P. Hamlin. Lightweight Aggregates. Expansion Properties of Clays, Shales, and Argillites of Minnesota. BuMines Rept. of Inv. 6313, 1963, 30 pp.

67 Peters, F. A., P. W. Johnson, and R. C. Kirby. Methods for Producing Alumina From Clay. An Evaluation of a Potassium Alum Process. BuMines Rept. of Inv. 6290, 1963, 27 pp.
Peters, F. A., P. W. Johnson, and R. C. Kirby. Methods of Producing Aluminia From Clay. An Evaluation of Three Sulfuric Acid Processes. BuMines Rept. of Inv. 6229, 1963, 57 pp.

68 Wild, A., and W. W. Key. Methods and Practices in Clay Mining, Processing, and Utilization, Kraftile Co., Fremont, Calif. BuMines Inf. Circ. 8194, 1963, 44 pp.

69 Ceramic Age V. 79, No. 3, March 1963, p. 64.

70 Brick & Clay Record. Northern Lightweight Doubles Aggregate Production. V. 142, No. 5, May 1963, pp. 44–48.
Pit and Quarry. Hudson's Lightweight Slate Aggregate Plant. V. 56, No. 5, November 1963, pp. 124–125, 128, 131, 136.
Pit and Quarry. Nytralite Barged Down Hudson to New York City Area. V. 55, No. 8, February 1963, pp. 86–95.
Schecter, William. Twin Kilns Toil for Norlite. Rock Products, v. 66, No. 3, March 1963, pp. 63–66.

71 Harder, Paul B. Ridgelite Makes Expanded Aggregates Waste Clay. Minerals Processing, v.4, No. 11, November 1963, pp. 22–26.

72 Pixley, F. V., G. W. Pixley, and H. Lopinct (assigned to Pelm, Research & Development Corp., Newburgh, N.Y.). Apparatus For Forming Lightweight Aggregates. U.S. Pat. 3,116,055, Dec. 31, 1963.

73 Blaha, E. (assigned to Selas Corp. of America, Dresher, Pa.). Apparatus For Forming Clay Spheres. U.S. Pats. 3,071,357, 3,071,358, and 3,071,359 Jan. 1, 1963.

which form a sinter bed easily penetrated by the hot gases in order to bloat uniformly.[74]

British patents were issued on production of expanded blocks made by firing expandable slate in molds,[75] and for production of expanded clay or shale pellets by pneumatic propulsion in downward spiral paths, followed by drying and firing.[76] A fluidized-bed method with low fuel and plant installation costs was patented in Canada.[77] Round vesicular expanded aggregates were produced in Canada by heating a mass of clay to incipient fusion, causing flakes to peel off and expand.[78]

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[74] Tinker, C. D. (assigned to Ohio Kilns, Inc., Grenville, Ohio). Kilns. U.S. Pat. 3,091,444, May 28, 1963.
[75] Engelthaler, K., and Z. Engelthaler. Brit. Pat. 935,946, Sept. 4, 1963.
[76] Sainty, C. L. (assigned to Structural Concrete Components Ltd.). Brit. Pat. 916,046, Jan. 16, 1963.
[77] Dennert, H. (assigned to Veit Dennert K. G.). Canadian Pat. 656,051, Jan. 15, 1963.
[78] Frokjaer-Jensen, A. (assigned to Leca (World)). Canadian Pat. 663,169, May 14, 1963.

Cobalt

By Glen C. Ware [1]

COBALT imports were 10.5 million pounds compared with 12.4 million pounds in 1962, a decrease of 15 percent. Domestic consumption was 10.5 million pounds compared with 11 million pounds in the previous year. Free world cobalt production was 25.4 million pounds, 21 percent less than in 1962.

Large uses for cobalt were for permanent magnet materials and high-temperature, high-strength alloys which accounted for 22 and 23 percent, respectively, of the total cobalt consumed.

Bethlehem Cornwall Corp. was the only domestic producer mining cobalt.

TABLE 1.—Salient cobalt statistics

(Thousand pounds of contained cobalt)

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Domestic mine production of ore or concentrate	3,438	2,994	(1)	(1)	(1)	(1)
Recoverable cobalt	2,633	2,331	(1)	(1)	(1)	(1)
Imports for consumption	16,740	21,245	12,170	10,495	12,433	10,522
Stocks, December 31: Consumer	1,116	1,403	1,856	1,807	1,479	1,099
Consumption	8,670	9,899	8,930	9,596	11,268	10,529
Price: Metal per pound	\$2.60–\$2.00	\$2.00–\$1.75	\$1.75–\$1.50	\$1.50	\$1.50	\$1.50
Free world: Production	30,000	32,600	31,400	29,600	31,800	25,400

[1] Figure withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Bethlehem Cornwall Corp. was the only producer of cobalt concentrate. Production, from the corporation's magnetic iron ores at Cornwall and Morgantown, Pa., was 33 percent more in 1963 than in 1962. Pyrites Co., Inc., Wilmington, Del., processed the concentrate into metal, oxide, and hydrate.

The Bunker Hill Co., at its Kellogg, Idaho, zinc plant, recovered 232 tons of residues containing 11,450 pounds of cobalt, an increase of 33 percent compared with that of 1962. No shipments were made.

[1] Commodity specialist, Division of Minerals.

TABLE 2.—Cobalt materials consumed by refiners or processors in the United States

(Thousand pounds of contained cobalt)

Form [1]	1954–58 (average)	1959	1960	1961	1962	1963
Alloy and concentrate	5,134	3,342	2,062	1,121	721	1,075
Metal	847	1,098	961	1,101	1,255	1,339
Hydrate	73	24	18	16	17	15
Carbonate	----------	3	2	----------	----------	----------
Purchased scrap	145	----------	----------	----------	----------	----------
Other	66	55	28	33	52	6

[1] Total consumption is not shown because the 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	1962				1963			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Oxide	457	320	440	308	424	297	419	294
Hydrate	277	147	270	144	445	216	389	195
Salts:								
Acetate	301	72	241	58	229	54	236	56
Carbonate	381	177	336	157	472	216	419	195
Sulfate	502	112	361	82	589	132	565	126
Other	321	71	168	39	304	73	317	73
Driers	8,717	545	8,412	525	9,165	572	8,886	553
Total	10,956	1,444	10,228	1,313	11,628	1,560	11,231	1,492

[1] Figures on metal withheld to avoid disclosing individual company confidential data.

CONSUMPTION AND USES

Industrial consumption of cobalt during the year was 10.5 million pounds, 7 percent less than in 1962. Cobalt consumed for metallic uses amounted to 7.9 million pounds, a decrease of 13 percent compared with that of the previous year. Cobalt consumed for nonmetallic uses (exclusive of salts and driers), was 1.4 million pounds, 20 percent more than in 1962; and that consumed for salts and other nonmetallic uses was 1.2 million pounds, an increase of about 24 percent over that of 1962.

The largest single use of cobalt, 23 percent of the total, was for high-temperature, high-strength alloys. The use for permanent magnet alloys was second with 22 percent of the total cobalt consumed. Uses in steel amounted to 12 percent of the total and 30 percent more than in 1962. Total metallic consumption of cobalt was 75 percent; nonmetallic (exclusive of salts and driers), 13 percent; and salts and driers, 12 percent of the total.

TABLE 4.—Cobalt consumed in the United States, by uses

(Thousand pounds of contained cobalt)

Use	1954–58 (average)	1959	1960	1961	1962	1963
Metallic:						
High-speed steel	192	214	155	220	343	404
Other tool steel	119	619	53	44	64	138
Other alloy steel			574	540	546	697
Permanent magnet alloys	2,599	2,979	2,387	2,457	2,867	2,352
Cutting and wear-resisting materials	214	139	263	257	316	275
High-temperature, high-strength alloys	2,752	2,423	2,024	2,354	3,015	2,453
Alloy hard-facing rods and materials	491	404	447	550	650	607
Cemented carbide	225	339	320	298	610	409
Nonferrous alloys	252	654	107	145	128	158
Other			495	659	582	426
Total	6,844	7,771	6,825	7,524	9,121	7,919
Nonmetallic (exclusive of salts and driers):						
Ground-coat frit	486	543	465	526	533	580
Pigments	214	200	190	192	168	222
Other	131	254	278	314	474	606
Total	831	997	933	1,032	1,175	1,408
Salts and driers: Lacquers, varnishes, paints, inks, pigments, enamels, glazes, feed, electroplating, etc. (estimate)	995	1,131	1,172	1,040	972	1,202
Grand total	8,670	9,899	8,930	9,596	11,268	10,529

TABLE 5.—Cobalt consumed in the United States, by forms

(Thousand pounds of contained cobalt)

Form	1954–58 (average)	1959	1960	1961	1962	1963
Metal	6,420	7,630	6,761	7,478	9,091	8,146
Oxide	772	877	757	900	998	935
Purchased scrap	483	261	240	178	207	246
Salts and driers	995	1,131	1,172	1,040	972	1,202
Total	[1] 8,670	9,899	8,930	9,596	11,268	10,529

[1] Includes a small quantity of ore and alloy.

STOCKS

As of December 31, 1963, there was 1.1 million pounds of cobalt in consumers' stocks. In addition, there was 96.7 million pounds of specification-grade cobalt in Government inventories of strategic materials that included 76.7 million pounds in the national (strategic) stockpile, 19 million pounds in the Defense Production Act (DPA) inventory, and 1 million pounds in the supplemental stockpile. Of the total, 77.7 million pounds was declared surplus to the maximum objective of 19 million pounds. An additional 6.2 million pounds of cobalt in the DPA inventory did not meet stockpile specifications.

PRICES

The price of cobalt metal granules and regular fines, $1.50 per pound, f.o.b. carrier, ports of New York, N.Y., and Chicago, Ill., packed in 500-pound drums, remained unchanged through 1963. The prices of ceramic-grade oxide (70 to 71 percent cobalt) at $1.12 per pound and ceramic-grade oxide (72.5 to 73.5 percent cobalt) at $1.15 per pound remained the same. These oxide prices are quoted for 250-pound kegs delivered east of the Mississippi River. For deliveries west of the Mississippi River, 3 cents per pound is added to the prices.

FOREIGN TRADE

Imports.—Cobalt imports were 15 percent less than in 1962. The composition of the imports was metal, 95 percent; oxide, 4 percent; and salts and compounds, 1 percent. The Republic of the Congo continued to be the main supplier, providing 47 percent of all the cobalt imported. Belgium, West Germany, and Norway composed the next large group, providing 14, 13, and 10 percent, respectively, of the total. France, Canada, and the remaining suppliers provided, respectively, 7, 6, and 3 percent.

TABLE 6.—U.S. imports for consumption of cobalt, by classes

(Thousand pounds and thousand dollars)

Year	White alloy [1]		Ores and concentrates [2]		Metal	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Value
1954-58	3,540	1,531	49	5	[3 4] 14,690	[3 4] $33,596
1959			[3] 772	[3] 35	20,087	35,926
1960			[3] 6,462	[3] 314	10,801	17,093
1961					10,036	14,867
1962			([3 5])	([3 5])	[6] 11,809	[6] 17,119
1963			29	27	10,322	14,677

Year	Oxide		Salts and compounds		Total	
	Gross weight	Value	Gross weight	Value	Gross weight	Cobalt content (estimated)
1954-58	763	$1,179	342	$206	19,384	16,740
1959	1,557	1,851	278	134	22,694	21,245
1960	1,459	1,520	230	104	18,952	12,170
1961	681	663	159	59	10,876	10,495
1962	978	943	120	47	[6] 12,907	12,433
1963	468	451	94	45	10,913	10,522

[1] Reported by importer to Bureau of Mines, which adjusted the figures for "Ores and concentrates" for 1954-58, as reported by the Bureau of the Census, to exclude "white alloy" from the Republic of the Congo (Belgian Congo).
[2] Figures exclude receipts of "white alloy" from the Republic of the Congo (Belgian Congo).
[3] Adjusted by the Bureau of Mines.
[4] Includes scrap.
[5] Less than 1,000 pounds.
[6] Revised figure.

Source: Bureau of the Census.

TABLE 7.—U.S. imports for consumption of cobalt metal and oxide, by countries

(Thousand pounds)

Country	Metal		Oxide (gross weight)	
	1962	1963	1962	1963
North America: Canada	[1] 428	630	19	8
Europe:				
Belgium-Luxembourg	1,970	1,419	959	460
France	729	763		
Germany, West	1,586	1,351		
Netherlands	20	52		
Norway	[1] 1,245	1,056		
United Kingdom	69	153	(2)	
Total	[1] 5,619	4,794	959	460
Asia: Japan	22	52		(2)
Africa:				
Congo, Republic of the, and Ruanda-Urundi	5,014	4,846		
Rhodesia and Nyasaland, Federation of	726			
Total	5,740	4,846		
Grand total	[1] 11,809	10,322	978	468

[1] Revised figure.
[2] Less than 1,000 pounds.

Source: Bureau of the Census.

Exports.—Exports of cobalt-bearing materials totaled 2,147,000 pounds, approximately the same as in 1962. Scrap (5 percent or more cobalt) was the chief cobalt-bearing item. Exports of semifabricated forms totaled 259,000 pounds compared with 198,000 pounds in 1962. Shipments to Japan were 51 percent of the total; to Canada, 27 percent; to Italy and Belgium, each 4 percent; to Australia and France, each 3 percent; to West Germany and United Kingdom, each 2 percent; and the remaining countries, 4 percent. Total value of cobalt ores, concentrates, metal and alloys, crude forms and scrap was $1.1 million, and that for semifabricated forms was $1.3 million.

Tariff.—Cobalt metal and ore continued to enter the United States duty free. Effective July 1, 1963, the duty was reduced on cobalt oxide from 2.7 cents to 1.5 cents per pound and reduced on the sulfate, from 2 cents to 1.5 cents per pound; the duty on other cobalt salts and compounds, not specially provided for, was reduced from 13.5 percent to 12 percent ad valorem. The duty on cobalt linoleate was increased from 5 cents to 7.25 cents per pound.[2]

WORLD REVIEW

Free world production of cobalt was 20 percent less than in 1962. The Republic of the Congo produced 63 percent of the total, 5 percent less than in the previous year. Morocco ranked second, producing 12 percent of the total. Canada and Northern Rhodesia produced 11 and 6 percent respectively.

[2] U.S. Tariff Commission. Cobalt. Report to the Congress on Investigation No. 332-42 (under Sec. 332 of the Tariff Act of 1930). TC Pub. 64, August 1962, p. 6.

TABLE 8.—Free world production of cobalt by countries [1] [2]

(Short tons of contained cobalt)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
Australia (recoverable cobalt in zinc concentrates)	14	15	14	14	18	18
Canada [3]	1,572	1,575	1,784	1,591	1,741	1,408
Congo, Republic of the (formerly Belgian) (recoverable cobalt)	9,013	9,294	9,063	9,178	10,674	8,050
Cuba (recoverable cobalt from sulfide) [4]	----------	99	68	----------	181	192
Morocco (content of concentrate)	775	1,330	1,401	1,422	1,583	1,511
New Caledonia (content of concentrate)	[5] 44	93	----------	----------	----------	----------
Rhodesia and Nyasaland, Federation of: Northern Rhodesia (content of white alloy, cathode metal and other products)	1,304	2,270	2,036	1,701	951	778
United States (recoverable cobalt)	1,317	1,165	([6])	([6])	([6])	([6])
Free world total (estimate) [1] [2]	15,000	16,300	15,700	14,800	15,900	12,700

[1] Cobalt is also recovered, principally in West Germany, from pyrites produced in Finland, and estimates are included in the world total. Production data for Bulgaria, East Germany, Poland, and U.S.S.R. are not available, and no estimates for these countries are included in the world total. Cobalt concentrates are being stockpiled in Uganda, but exact figures are not available.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Cobalt in all forms. Excludes the cobalt content of nickel-oxide sinter shipped to the United Kingdom by International Nickel Co., Inc. (estimate for which is included in the world total), but includes the cobalt content of Falconbridge shipments of nickel-copper matte to Norway.
[4] Estimate.
[5] One year only, as 1958 was the first year of commercial production.
[6] Figure withheld to avoid disclosing individual company confidential data; United States figure included in world total.

NORTH AMERICA

Canada.—Cobalt was obtained mainly as a byproduct of refining nickel-copper ores from the Sudbury district, Ontario, and Lynn Lake and Thompson, Manitoba. Small quantities of the metal also were produced as a byproduct of silver refining. Canada produced 1,408 tons of cobalt in 1963, 19 percent below that of 1962. Of the 1963 total, Ontario produced 1,033 tons and Manitoba, 375 tons.[3]

The International Nickel Company of Canada, Ltd. (Inco), recovered electrolytic cobalt at its nickel refinery at Port Colborne, Ontario. Impure cobalt oxide was shipped to its Clydach, Wales, plant for further processing and conversion to high-grade oxide, metal, and salts. The company delivered 2.15 million pounds of cobalt compared with 2.28 million pounds in 1962.[4]

Falconbridge Nickel Mines Ltd., delivered 1,262,000 pounds of cobalt, a slight increase from 1,226,000 pounds in 1962. The cobalt was recovered from Sudbury nickel-cobalt matte exported to the Falconbridge Nikkelverk, A/S, refinery at Kristiansand S., Norway.[5]

Sherritt Gordon Mines Ltd. produced 608,000 pounds of cobalt, about the same amount as in 1962. The firm sold 666,000 pounds of the metal, an increase of almost 90 percent over the 1962 figure.[6]

Cobalt Refinery Ltd., a subsidiary of Violamac Mines Ltd., produced 68,000 pounds of cobalt as oxide.[7]

[3] Toombs, R. B., and W. K. Buck. 1963 Record Confirms Canada's Prominence in World Mineral Economy. The Canadian Mineral Industry in 1963, Preliminary. Dept. Mines and Tech. Surveys, Ottawa, Canada, Miner. Inf. Bull. MR 71, 1964, pp. 2–3.
[4] The International Nickel Company of Canada, Ltd. 1963 Annual Report. P. 8.
[5] Falconbridge Nickel Mines, Ltd. 1963 Annual Report. P. 9.
[6] Sherritt Gordon Mines Ltd. 1963 Annual Report. P. 3.
[7] Violamac Mines, Ltd. 1963 Annual Report. P. 18.

EUROPE

Germany, West.—The Duisburger Kupferhütte refinery at Duisburg, the major producer, recovered cobalt mainly from pyritic ores imported from Spain, Norway, and other European countries. The refinery of Gebrüder Borchers A. G. at Goslar treated cobalt-bearing alloy scrap and spent catalyst, producing cobalt oxides and salts in addition to metal powder. In 1963 production was approximately 1,700 tons and consumption about 1,200 tons of cobalt.

Italy.—The electrolytic works at Porto Marghera has a capacity to recover 7 tons of cobalt metal per year as a byproduct from zinc refining. The company used nitroso beta-naphthol to extract cobalt as an impurity of zinc.[8]

United Kingdom.—Gillette Industries installed a cobalt-60 irradiation plant at its Reading factory. The plant will be used to sterilize disposable surgical products.[9]

AFRICA

Congo, Republic of the (formerly Belgian).—The year 1963 was marked by serious political trouble which had a far-reaching influence on Union Minière du Haut-Katanga's mining and metallurgical operations. Particularly damaging were the destruction of power installations, transmission lines, and several railway and road bridges. Despite the political and economic unrest, the firm was able to produce 8,000 tons of cobalt, 2,600 tons less than in 1962.

Preparations are still in progress for the production in Africa of cobalt of very high purity.[10]

Morocco.—Société Minière de Bou-Azzer et du Graara produced about 15,087 tons of concentrate averaging approximately 10 percent cobalt content. New areas were developed recently for cobalt mining. The country's cobalt exports in 1963 totaled 18,383 tons of concentrate, about 22 percent above production. During the year Morocco exported 11,334 tons of cobalt concentrate to France, 2,649 tons to Belgium, and 4,400 tons to China.[11]

Rhodesia and Nyasaland, Federation of.—A secondary product at the Chibuluma Mines Ltd. gave a total of 19,314 short tons of cobalt-copper concentrate. This material was shipped to the cobalt plant at Ndola where the new matte-upgrading section was commissioned early in 1963. The upgraded cobalt-copper matte produced was shipped to Belgium for refining late in the financial year.

Production of ore for the year amounted to 577,000 tons containing 4.27 percent copper and 0.15 percent cobalt. Stoping operations are currently taking place above the 1,300-foot level, and the stoping-sandfilling sequence has been maintained. Stoping commenced in the Chibuluma West area during the year. Sufficient development was completed to maintain production at a rate of 55,000 tons of ore per month.

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[8] de Michelio, T. Institute of Metals Italian Works Visits Monteponi and Montevecchio. Metal Ind. (London), v. 103, No. 16, Oct. 17, 1963, pp. 586–588.
[9] Chemical Trade Journal and Chemical Engineer (London). V. 152, No. 3964, May 31, 1963, p. 872.
[10] Société Générale de Belgique. 1963 Reports. Pp. 96–97.
[11] Statistiques Minières. Note De Documentation. No. 303, March 1964, pp. 36–41.

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The ore reserve on June 30, 1963, was estimated to be 9.8 million tons with an average of 0.15 percent cobalt content. Withdrawn during the past fiscal year was 4.1 million tons.

There was a decline in recovery of cobalt in the cobalt concentrate, because some was lost to the copper concentrate. Production of high-grade cobalt-copper sulfide material was started in March, 1963. Some equipment, necessary for efficient operation, was delivered and installed after the start of operations. Consequently, recoveries and production rates were below expectations.[12]

TECHNOLOGY

At the Federal Bureau of Mines Salt Lake City Metallurgy Research Center the selective recovery of cobalt and nickel from raw materials as a means of preparing high-purity metals was studied. It was found that a combination solvent extraction-electrolytic process enabled preparation of high-quality cobalt and nickel, and a preliminary appraisal indicated that the process might be commercially feasible.[13]

At the Bureau of Mines Rolla (Mo.) Metallurgy Research Center, procedures were developed for reclaiming high-temperature alloy scrap. Preliminary test results showed that a cobalt-base, multicomponent, high-temperature alloy, such as S–816, can be melted successfully without affecting its specified chemical composition. Further test results indicated that the scrap material, after being melted and subjected to other metallurgical processes, was equivalent in room-temperature tensile strength and in high-temperature creep and stress-rupture properties to commercially produced S–816 alloy made from virgin materials.[14] Also at Rolla, isothermal oxidation kinetics were determined for very pure cobalt in oxygen and in air at temperatures ranging from 800° to 1,200° C. Data showed that the diffusion of oxygen ions or of metal ions and electrons in the oxide layer appeared to be the principal agents governing oxidation rate. Results also showed that the oxidation reactions followed approximately the parabolic rate law.[15]

A combined ion-exchange and X-ray spectrographic method for determining parts per million of cobalt and nickel in high-purity tungsten and tungsten trioxide was developed. Data showed that the method was very reliable, and the accuracy at the 5- to 20-microgram level was ±10 percent of the amount present.[16]

The Centre d'Information du Cobalt (Cobalt Information Center), Brussels, Belgium, published several booklets which included a review

[12] Chibuluma Mines Limited. 12th Annual Report. June 30, 1963, pp. 1–14.
[13] Brooks, P. T., and J. B. Rosenbaum. Separation and Recovery of Cobalt and Nickel by Solvent Extraction and Electrorefining. BuMines Rept. of Inv. 6159, 1963, 30 pp.
[14] Higley, L. W., Jr. Reclaiming S–816 High-Temperature Alloy Scrap. BuMines Rept. of Inv. 6230, 1963, 12 pp.
[15] Doerr, R. M. High-Temperature Corrosion Studies. Nickel and Cobalt in Air and Oxygen. BuMines Rept. of Inv. 6231, 1963, 20 pp.
[16] Spano, E. F., T. E. Green, and W. J. Campbell. Determination of Cobalt and Nickel in Tungsten by a Combined Ion Exchange X-Ray Spectrographic Method. BuMines Rept. of Inv. 6308, 1963, 20 pp.

of the role of cobalt in the metals industry [17] and a lengthy list of cobalt alloys.[18]

The diffusion rates of a number of refractory metals into nickel and cobalt were investigated. Results showed that these metals diffused into both nickel and cobalt at rates inversely proportional to the atomic diameters of the refractory metals.[19]

A number of new products that may have wide applications in the future have been reported. Stellite Co., Division of the Union Carbide Corp. announced the development of four new metallic diffusion coatings. Designated as C–9, C–10, C–11, and C–12, the new alloys are expected to be used on copper and cobalt-base alloys.[20]

The Center also published an article describing the chief function of cobalt in heat-resisting alloys, which is to increase their high-temperature strength.[21] In another article the oxidation resistance of a number of cobalt-base alloys was reported. Results of this investigation indicate that alloys with 40 percent or more cobalt content are less resistant to oxidation than those with smaller amounts of cobalt.[22]

A new series of cobalt-refractory-metal alloys was announced for advanced space-vehicles by the National Aeronautics and Space Administration. Cobalt-base alloys with refractory metals as the major alloying constituents were found to be especially suited in reducing material loss by evaporation in the ultra-high-vacuum environment of outer space.[23]

Kanthal Corp. announced the development of an iron-chromium-aluminum-cobalt, electrical-resistance alloy named Kanthal D. The alloy may have property and cost advantages over conventional electric-resistance alloys.[24] Bethlehem Steel Co. developed an improved hot-work, tool steel for high-temperature operations. The alloy, Cromo-Co, is essentially the firm's Cromo-N, to which 10 percent cobalt has been added. Spokesmen of the firm said that the steel is excellent for applications in ultra-high-strength materials and in other situations where tools soften at elevated temperatures.[25] Russian metallurgists have developed a lower cost creep-resistant material to replace LK4 alloy. In contrast to the 60 percent cobalt content in the LK4 alloy, the new material has less than 2 percent cobalt. In tests the new alloy compares favorably with the LK4 alloy.[26]

Girdler Catalyst Division of the Chemetron Corp. introduced a cobalt catalyst with selective performance. Designated as G–61, the

[17] Hinnüber, J., and O. Rüdiger. The Role of Cobalt in the Hard Metals Industry. Cobalt, No. 19, June 1963, pp. 57–68.

[18] Cobalt Information Center. Listing and Classification of Cobalt Alloys. October 1963, 22 pp.

[19] Davin, A., V. Leroy, D. Coutsouradis, and L. Habraken. Comparison of the Diffusion of Some Substitution Elements in Nickel and Cobalt. Cobalt, No. 19, June 1963, pp. 51–56.

[20] Chemical Week. Metallic Coatings. V. 93, No. 19, Nov. 9, 1963, p. 72.

[21] Bollenrath, F. Cobalt in Heat-Resisting Alloys. Cobalt, No. 18, March 1963, pp. 18–21.

[22] Bollenrath, F., G. Wirth, and W. Rohde. The Oxidation Resistance of Some Heat-Resisting Austenitic Alloys. Cobalt, No. 20, September 1963, pp. 117–135.

[23] Freche, J. C., R. L. Ashbrook, and S. J. Klima. A New Series of Cobalt-Refractory-Metal Alloys for Advanced Space Power Systems. Cobalt, No. 20, September 1963, pp. 114–116.

——— Cobalt-Base Alloys for Space-Power Systems. J. Metals, v. 15, No. 12, December 1963, pp. 928–934.

[24] American Metal Market. Cost Advantages Claimed for Cobalt Resistance Alloy. V. 70, No. 231, Dec. 4, 1963, p. 16.

[25] Steel. Cobalt Improves Hot Work Tool Steel. V. 153, No. 20, Nov. 11, 1963, p. 116.

[26] Metal Industry (London). Cobalt-Chromium Creep-Resistant Alloy. V. 103, No. 12, Sept. 19, 1963, p. 386.

new catalyst has intermediate activities as well as a high degree of selectivity in reducing nitriles to primary amines.[27] Sherritt Gordon Mines Ltd. developed five closely sized grades of very pure cobalt powder for powder-metallurgy applications. The purity of the powders ranges from 99.9 plus percent cobalt in the three coarser grades to 99.6 percent for the finest grade.[28]

The Research and Development Division of Lockheed Missiles and Space Co., developed two new metal plating processes that produce thin ferromagnetic films of almost pure metals including cobalt on both metallic and nonmetallic bases.[29] Selectrons, Ltd., developed a modified selective plating technique which may reduce costly rejections of machined parts. Called the Flow-Plating technique, the process appears to have potentially extensive application in the automobile industry. Several metals, particularly cobalt and hard-cobalt alloys, were said to be specially suited for the new plating technique.[30]

Two comprehensive and detailed articles on the analytical chemistry of cobalt dealt with different classical and instrumental procedures for the separation, identification, and determination of cobalt in varying amounts and in various materials.[31]

Patents were issued on the recovery of cobalt from ores,[32] on the separation of cobalt and nickel,[33] and on various alloys.[34]

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[27] Industrial and Engineering Chemistry. Chemetron Corp., Girdler Catalyst Div., G–61–Cobalt. V. 55, No. 9, September 1963, pp. 112, 114.

[28] South African Mining and Engineering Journal (Johannesburg, Republic of South Africa). Pure Cobalt Powder Offered. V. 74, pt. 1, No. 3661, Apr. 5, 1963, p. 781.

[29] Chemical & Engineering News. V. 41, No. 34, Aug. 26, 1963, p. 46.

[30] Chemical & Engineering News. Plating Technique Reduces Scrap Losses. V. 41, No. 40, Oct. 7, 1963, p. 47.

[31] Tombu, C. Analytical Chemistry of Cobalt. Cobalt, No. 20, September 1963, pp. 103–110; No. 21, December 1963, pp. 185–189.

[32] Aveston, J., D. A. Everest, and G. H. E. Sims (assigned to National Research Development Corp., London, England). Resin-in-Pulp Ion-Exchange Process for Recovering Gold, Cobalt, Nickel and Other Values for Ore Leach Solutions. Brit. Pat. 926,873, May 22, 1963.

Grimes, P. G. (assigned to Allis-Chalmers Mfg. Co., Milwaukee, Wis.). Spectrographically Nickel-Free Cobalt Extraction From a Cobalt-Nickel Mixture. Canadian Pat. 664,-480, June 4, 1963.

Hills, R. C. (assigned to Freeport Sulfur Co., New York). Recovery of Nickel and Cobalt by Reduction and Leaching. U.S. Pat. 3,100,700, Aug. 13, 1963.

Sherritt Gordon Mines Ltd. Recovery of Nickel and Cobalt From Ore Leach Solutions Containing Copper Ions. Brit. Pat. 939,921, Oct. 16, 1963.

Thornhill, P. G. (assigned to Falconbridge Nickel Mines, Toronto, Canada). Nickel and Cobalt Recovered From Ore Leach Solution. U.S. Pat. 3,103,414, Sept. 10, 1963.

Vorvali, M. Y., P. Grolla, P. Hubscher, and F. Reynaud (assigned two-thirds to Société d'Électro-Chimie d'Électro-Métallurgie et des Aciéries Électriques d'Ugine, and one-third to Société de Produits Chimiques Bozel-Maletra, Paris, French). Process of Sulphonitric Attack of Arseniureted and/or Sulpharseniureted Ores or Materials Particularly of Cobalt and/or Nickel. U.S. Pat. 3,107,977, Oct. 22, 1963.

[33] Goldstein, E. M. Process for Separating Cobalt and Nickel From Ammoniacal Solutions. U.S. Pat. 3,107,996, Oct. 22, 1963.

[34] Gittus, J. H. (assigned to The International Nickel Co., Inc., New York). Creep-Resistant Nickel-Chromium-Cobalt Alloy. U.S. Pat. 3,107,999, Oct. 22, 1963.

Tsu, I., and M. C. Fritsch (assigned to International Business Machines Corp., New York). Electrodeposition of Magnetic Cobalt-Nickel Alloys. U.S. Pat. 3,111,463, Nov. 19, 1963.

Columbium and Tantalum

By Gilbert L. DeHuff [1] and Richard F. Stevens, Jr.[1]

INCREASED interest in the research of columbium and tantalum for use in aerospace and nuclear applications took place in 1963. Alloys of tantalum and columbium having good strength at both cryogenic and high temperatures were proposed for use in aerospace vehicles.

The reserves, production, utilization, and metallurgy of columbium and tantalum were reviewed in a Bureau of Mines publication.[2]

LEGISLATION AND GOVERNMENT PROGRAMS

On June 29, 1963, General Services Administration (GSA) let two contracts for upgrading tantalum and columbium held in the Government stockpile. Of the upgraded tantalum, approximately 14,250 pounds (contained tantalum) will be tantalum carbide, 65,000 pounds will be high capacitance (grade I) tantalum metal powder, 15,000 pounds low capacitance (grade II) tantalum metal powder, and 20,000 pounds tantalum metal ingots (capacitor grade). The upgraded columbium will consist of approximately 10,860 pounds (columbium content) of columbium carbide, 30,000 pounds of columbium metal (commercial grade), and 21,800 pounds (columbium content) of columbium oxide. The upgrading fees were reimbursed by payment-in-kind of tungsten and ferronickel.

Throughout 1963 columbium and tantalum continued to be eligible for government financial assistance under the regulations of the Office of Minerals Exploration (OME) which permits government contribution of not more than 50 percent of the total allowable costs of specified exploration.

New National Stockpile Specifications were issued by GSA for the following items:

- Ferrocolumbium (P–104–R1, Sept. 5, 1963)
- Columbium carbide powder (P–105–R1, Sept. 3, 1963)
- Tantalum carbide powder (P–106–R1, Sept. 3, 1963)
- Columbium-commercial grade (P–103–R1, July 12, 1963)

National Stockpile Specifications remained unchanged for columbium minerals (P–15–R3, Nov. 7, 1962), tantalum-capacitor grade (P–101–R, Oct. 26, 1962), ferrotantalum-columbium (P–88–R1, Mar. 17, 1961), and tantalum minerals (P–54–R2, July 27, 1959).

[1] Commodity specialist, Division of Minerals.
[2] Barton, William R. Columbium and Tantalum, A Materials Survey. BuMines Inf. Circ. 8120, 1962, 110 pp.

TABLE 1.—Salient columbium-tantalum statistics

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Columbium-tantalum concentrate shipped from mines [1]____________pounds__	212,244	189,263	----------	----------	----------	----------
Imports for consumption:						
Columbium-mineral concentrate_______pounds__	5,604,171	3,395,816	5,051,800	2,777,700	5,050,888	5,909,512
Tantalum-mineral concentrate_______pounds__	1,213,255	652,839	709,936	1,004,151	1,211,757	944,459
Industrial consumption: [3]						
Contained metal short tons__	617	828	1,058	1,283	1,895	1,278
World: Production of columbium-tantalum concentrates_pounds__	7,990,000	6,040,000	7,020,000	[2] 7,540,000	[2] 9,210,000	10,660,000

[1] 1956–59 data are for columbite-tantalite concentrate plus columbium-tantalum oxide content of euxenite concentrate.
[2] Revised figure.
[3] Includes metal content of all raw materials consumed, including columbium-tantalum bearing tin slag.

DOMESTIC PRODUCTION

No domestic mine production of columbium or tantalum ore was reported for 1963.

Production of columbium metal powder and sponge amounted to 52 tons, and production of columbium metal ingots was 64 tons. The following companies produced columbium in 1963: E. I. du Pont de Nemours & Co., Inc., Newport, Del., and Baltimore, Md.; Kawecki Chemical Co., Boyertown, Pa.; Kennametal, Inc., Latrobe, Pa.; Stauffer Chemical Co., Richmond, Calif.; Union Carbide Metals Co., Niagara Falls, N.Y.; Union Carbide Stellite Co., Kokomo, Ind.; and Wah Chang Corp., Albany, Oreg.

Production of tantalum sponge and metal powder (including capacitor-grade powder) totaled 209 tons; tantalum metal ingots, 90 tons. Fansteel Metallurgical Corp., Muskogee, Okla.; Kawecki Chemical Co.; Kennametal, Inc.; National Research Corp., Newton, Mass.; Union Carbide Metals Co.; and Wah Chang Corp. were the principal producers.

During the year a new 15-ton arc furnace began operation at the Kokomo, Ind., plant of Union Carbide Stellite Co., a division of Union Carbide Corp. Production of air-melted alloys from this and an existing 5-ton furnace is expected to exceed several million pounds. Plans were announced to increase facilities by the addition of a 10,000-pound capacity vacuum induction melting furnace and a 30-inch consumable electrode vacuum arc furnace. The expansion is scheduled for completion early in 1964.

CONSUMPTION AND USES

Domestic consumption of columbium raw materials decreased to 1,027 short tons (metal content), a 27 percent decrease from that of 1962. Consumption of tantalum raw materials decreased to 251 short tons (metal content), 47 percent less than in 1962.

Because of its high melting point and ease of fabrication, tantalum was used as a high temperature heating element in vacuum furnaces. Columbium alloys which are resistant to corrosion at 1,000° F. were used as cladding and structural materials in nuclear superheaters.

Columbium and tantalum powders for use in plasma-flame spraying operations became commercially available from Metco, Inc., Westbury, N.Y. These powders produce lightweight, hard, and abrasion-resistant coatings.

A high purity, fine particle (less than 10 microns) columbium metal powder has been developed by Atomergic Chemetals Co., a division of Gallard-Schlesinger Chemical Manufacturing Corp., Garden City, N.Y. It is anticipated that the use of this fine, high purity powder will lead to the development of new columbium alloys.

In October, Phelps Dodge Corp., New York, and Temescal Metallurgical Corp., Berkeley, Calif., formed a jointly owned company, United Metallurgical Co., Berkeley, Calif., to produce high purity refractory metals and high-temperature alloys using the electron-beam melting furnaces and processes developed by Temescal. Temescal will conduct investigations on the applications of electron-beam melting for the benefit of United Metallurgical Co.

In the latter part of the year, Kawecki Chemical Co. began operation of its new columbium processing facility at Boyertown, Pa. This plant can process almost any type and grade of columbium ore into high purity columbium compounds, metals, and alloys.

STOCKS

At yearend consumers and dealers held the following inventories (in short tons): Columbite, 1,206; tantalite, 1,416; tin slag, 19,954; and pyrochlore, 917.

In addition, there were the following columbium inventories: Primary metal, 52,480 pounds; ingot, 51,306 pounds; scrap, 122,073 pounds; oxide, 122,264 pounds; and other columbium compounds, 31,471 pounds. Additional tantalum inventories included: Primary metal, 62,532 pounds; ingot, 35,130 pounds; scrap, 98,733 pounds; oxide, 44,464 pounds; potassium tantalum fluoride, 171,603 pounds; and other tantalum compounds, 38,459 pounds.

Data on columbium and tantalum materials in Government inventories on December 31, 1963 are presented in table 2.

TABLE 2.—Columbium and tantalum items in Government inventories as of Dec. 31, 1963

(Thousand pounds)

Material	National (strategic) stockpile	DPA inventory	Supplemental stockpile	Total
Stockpile grade:				
Columbium	6,137	8,142	356	14,635
Tantalum	1,560	1,470		3,030
(Columbium carbide powder) [1]	(10)			(10)
(Ferrocolumbium) [1]	(448)			(448)
(Ferrotantalum-columbium) [1]	(140)			(140)
(Tantalum carbide powder) [1]	(16)			(16)
Nonstockpile grade:				
Columbium	1,370	81	33	1,484
Tantalum	1,886	60	8	1,954

[1] Figures in parentheses represent upgraded columbium and tantalum materials in inventory. They are included in the columbium and tantalum figures and are not in addition to them.

Source: Office of Emergency Planning. Statistical Supplement, Stockpile Report to the Congress. OEP-4, July-December 1963, pp. 8, 27, 31, 32.

PRICES

Prices for columbite ore, c.i.f. U.S. ports, were quoted by E&MJ Metal and Mineral Markets throughout the year at \$0.90 to \$1.00 per pound of contained pentoxides for material having a Cb_2O_5 to Ta_2O_5 ratio of 10:1, and \$0.85 to \$0.90 for that having an 8.5:1 ratio. Actual sales in the latter part of the year were reported at lower figures. Pyrochlore prices were within the range of the 10:1 ratio columbite quotations, varying within this range according to the quantities involved. Prices for tantalite, 60 percent basis, at the end of the year were reported to be lower than the \$6 to \$7 a pound range appearing in quotations.

Ferrocolumbium containing 50 to 60 percent columbium, maximum 0.40 percent carbon, maximum 8 percent silicon, was quoted by E&MJ Metal and Mineral Markets at the end of the year at \$3.00 per pound of contained columbium, ton lots, 2-inch lump, packed and delivered. Until mid-December the quotation had remained at \$3.45.

TABLE 3.—Average grade of concentrate received by U.S. consumers and dealers in 1963 by country of origin

(Percent of contained pentoxides)

Country	Columbite			Tantalite	
	Cb_2O_5	Ta_2O_5	Ratio	Ta_2O_5	Cb_2O_5
Brazil	38	32	1.2:1	56	15
Canada [1]	49	.17			
Congo, Republic of the	37	31	1.2:1	31	33
Malaya, Federation of	58	14	4.1:1		
Mozambique	41	40	1:1	58	16
Nigeria	68	7	9.7:1	39	42
Norway [1]	57	.56			
Portugal and Spain				31	35
Rhodesia and Nyasaland, Federation of	39	25	1.6:1	49	18

[1] Pyrochlore concentrate.

FOREIGN TRADE

Imports.—In addition to raw materials imports shown in tables 4 and 5, imports for consumption of columbium metal totaled 1,414 pounds, valued at \$28,744, coming from West Germany, France, Switzerland, and small quantities from the United Kingdom; imports for consumption of tantalum metal amounted to 2,025 pounds, valued at \$44,314 and coming from West Germany, Switzerland, Canada, and the United Kingdom.

Exports.—Metal and powder exports (table 6) went to a variety of countries; columbium ore went chiefly to Japan; and tantalum ore was exported to Japan, United Kingdom, West Germany, Austria, France, and Sweden.

TABLE 4.—U.S. imports for consumption of columbium-mineral concentrates by countries

(Pounds)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America: Canada		14,000		35,575	1,509,928	1,881,704
South America:						
Argentina	4,817	3,591				
Bolivia	1,901					
Brazil	134,885	137,648	126,374	73,363	95,767	1,784,558
British Guiana	1,407					
Total	143,010	141,239	126,374	73,363	95,767	1,784,558
Europe:						
Belgium-Luxembourg					32,549	33,732
Finland						2,207
Germany, West	233,110	11,578	6,283		2,204	2,205
Netherlands		13,000	35,554		28,926	20,432
Norway	394,731	454,535	164,486		662,498	346,688
Portugal	97,306	38,083	35,383	22,457	42,565	4,465
Spain	505		976			
United Kingdom	8,164		22,400		56,002	
Total	733,816	517,196	265,082	22,457	824,744	409,729
Asia:						
Aden	270					
Malaya, Federation of; Singapore, Colony of	410,851					
Malaya, Federation of		151,881	249,946	221,161	119,882	261,789
Singapore, Colony of				7,298		
Thailand		13,546				
Total	411,121	165,427	249,946	228,459	119,882	261,789
Africa:						
British East Africa	10,679	2,205	11,670	29,971		22,488
British West Africa	2,904					
Congo, Republic of the, and Ruanda-Urundi [1]	879,473	519,712	227,724	113,085	55,846	163,437
Malagasy, Republic [2]	14,218	11,939	17,412	6,524	7,536	
Mozambique	78,373	85,249	75,851	60,613	25,453	73,498
Nigeria, Federation of [3]	3,251,369	1,936,296	4,071,115	2,181,318	2,388,377	1,301,314
Rhodesia and Nyasaland, Federation of	6,394		1,983	20,700	7,137	853
South Africa, Republic of [4]	52,475		4,643	2,240	4,974	10,142
Western Equatorial Africa, not elsewhere classified [5]	940				11,244	
Total	4,296,825	2,555,401	4,410,398	2,414,451	2,500,567	1,571,732
Oceania: Australia	19,399	2,553		3,395		
Grand total:						
Pounds	5,604,171	3,395,816	5,051,800	2,777,700	5,050,888	5,909,512
Value	$9,574,756	$2,651,783	$3,686,549	$2,305,941	[6] $3,419,361	$3,143,789

[1] Effective July 1, 1960; formerly Belgian Congo.
[2] Effective July 1, 1960; formerly Madagascar and Dependencies.
[3] Effective Jan. 1, 1962; formerly Nigeria.
[4] Effective Jan. 1, 1962; formerly Union of South Africa.
[5] Effective July 1, 1960; formerly French Equatorial Africa.
[6] Revised figure.

Source: Bureau of the Census.

TABLE 5.—U.S. imports for consumption of tantalum-mineral concentrates by countries

(Pounds)

Country	1954–58 (average)	1959	1960	1961	1962	1963
South America:						
Argentina	4,532	1,611		4,444	3,637	4,519
Brazil	195,125	205,898	182,118	159,925	194,955	241,148
French Guiana	13,100					5,031
Total	212,757	207,509	182,118	164,369	198,592	250,698
Europe:						
Belgium-Luxembourg	3,415	21,871	2,426	47,993	31,896	2,137
Germany, West	158,465				11,276	
Netherlands			8,012	26,495		4,779
Norway	2,346					
Portugal	27,685	27,227	34,062	29,793	95,692	72,711
Spain	2,255		3,157	11,148	2,645	
Sweden	4,049					
United Kingdom [1]	5,707					
Total	203,922	49,098	47,657	115,429	141,509	79,627
Asia:						
Japan					4,401	
Malaya, Federation of } Singapore, Colony of }	2,666		14,714	82,807	57,437	11,113
Thailand		4,515			5,941	13,795
Total	2,666	4,515	14,714	82,807	67,779	24,908
Africa:						
British East Africa	2,540	2,690		36,182	9,911	8,287
Congo, Republic of the, and Ruanda-Urundi [2]	554,822	166,317	332,424	164,277	228,185	147,257
Malyagasy Republic [3]	10,316	9,375	30,738	11,953	12,126	52,246
Mozambique	49,262	68,343	87,801	219,847	351,087	156,528
Nigeria, Federation of [4]	87,247	50,902	7,698	121,110	48,551	64,831
Rhodesia and Nyasaland, Federation of	32,416	44,720		53,098	98,716	93,990
South Africa, Republic of [5]	11,939	24,805	2,239	31,677	8,733	31,597
Western Equatorial Africa, not elsewhere classified [6]					26,455	
Western Portuguese Africa, not elsewhere classified					3,490	6,746
Total	748,542	367,152	460,900	638,144	787,254	561,482
Oceania: Australia	45,368	24,565	4,547	3,402	16,623	27,744
Grand total:						
Pounds	1,213,255	652,839	709,936	1,004,151	1,211,757	944,459
Value	$2,151,973	$1,165,536	$1,136,868	$2,001,944	$3,526,948	$2,410,814

[1] Presumably country of transshipment rather than original source.
[2] Effective July 1, 1960; formerly Belgian Congo.
[3] Effective July 1, 1960; formerly Madagascar and Dependencies.
[4] Effective Jan. 1, 1962; formerly Nigeria.
[5] Effective Jan. 1, 1962; formerly Union of South Africa.
[6] Effective July 1, 1960; formerly French Equatorial Africa.

Source: Bureau of the Census.

TABLE 6.—U.S. exports of columbium and tantalum, by classes in 1963

Class	Pounds	Value
Columbium ores and concentrates	46,887	$36,915
Tantalum ores and concentrates	56,010	176,712
Metals and alloys in crude form and scrap	46,973	315,912
Metals and alloys in semifabricated forms	11,693	862,508
Tantalum metal powder	14,146	424,612

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—Production of pyrochlore concentrate by St. Lawrence Columbium and Metals Corp., Oka, Quebec, increased substantially in 1963. In doing so, from 850 to 1,050 tons of ore per day were put through the mill which has a rated daily capacity of 1,000 tons.

Three grades of concentrate were marketed having the following Cb_2O_5 contents: Grade A, minimum of 50.0 percent; grade B, 52.0 to 56.0 percent; and grade C, 55.0 to 58.0 percent. Shipments were primarily to consumers in the United States, but substantial quantities also went to West Germany and France. Ta_2O_5 content of the concentrates averaged 0.40 percent. Some byproduct magnetite, and crushed stone from the pit wall, were produced, and consideration was given to possible recovery of calcite sands and fillers, mica, and apatite, as additional byproducts. Flotation was the primary feature of the mill flowsheet, with magnetite recovery achieved by magnetic separation.[3]

During 1963, St. Lawrence Columbium acquired control of Oka Columbium & Metals Ltd., whose Oka property is credited with a reserve of approximately 22.5 million tons of ore containing 0.4 to 0.5 percent Cb_2O_5.[4]

A report was published on the tantalum mineral, wodginite, found at Bernic Lake, Manitoba.[5]

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[3] Guimond, Roger. St. Lawrence Columbium and Metals Corporation—World's Largest Columbium Concentrate Producer. Pre-Cambrian (Winnipeg, Manitoba), v. 36, No. 5, May 1963, pp. 13–20.

[4] Metal Bulletin (London). No. 4854, Dec. 10, 1963, p. 21.

[5] Nickel, E. H., J. F. Rowland, and R. C. McAdams. Wodginite—A New Tin—Manganese Tantalate From Wodgina, Australia, and Bernic Lake, Manitoba. Canada Dept. Mines and Tech. Surveys (Ottawa), Research Report R112, June 10, 1963, 13 pp.

TABLE 7.—Free world production of columbium and tantalum concentrates [1] by countries [2]

(Pounds)

Country	1954–58 (average)		1959		1960		1961		1952		1963	
	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum	Columbium	Tantalum
North America:												
Canada	26	93	[3] 14,000	------			[4] 119,261	------	[4] 1,909,433	------	[4] 2,692,935	------
United States (mine shipments)	212,244		189,263		------	------	------	------	------	------	------	------
South America:												
Argentina	3,932		[3] 3,591	[3] 1,611	------	------	------	[3] 4,444	------	[3] 3,637	------	[3] 4,519
Brazil (exports)	181,942	172,136	33,459	207,232	26,460	257,951	38,477	264,519	38,164	322,804	[5] 1,728,900	231,500
French Guiana	13,845		------	------	------	------	------	------	------	------	------	[3] 5,031
Europe:												
Norway	539,810	------	639,114	------	762,792	------	708,118	------	656,971	------	[3] 346,688	------
Portugal (U.S. imports)	97,306	27,685	38,083	27,227	35,383	34,062	22,457	29,793	42,565	95,692	4,465	72,711
Spain (U.S. imports)	505	2,255	------	------	976	3,157	------	11,148	------	2,645	------	------
Sweden (U.S. imports)	------	4,049	------	------	------	------	------	------	------	------	------	------
Asia: Malaya, Federation of	414,131	------	268,800	------	208,320	------	212,800	------	246,400	------	197,120	------
Africa:												
Congo, Republic of the (formerly Belgian) and Ruanda-Urundi [6]	787.483		522,490		[3] 227,724	[3] 332,424	[3] 113,085	[3] 164,277	[3] 55,846	[3] 228,185	[3] 163,437	[3] 147,257
Malagasy Republic	28,571		22,100		22,300		46,750		20,720		------	[3] 52,246
Mozambique	179,826		320.004		335,487		303,166		231,437		187,390	
Nigeria	5,103,616	36,418	3,559,875	31,114	4,587,520	24,640	5,257,280	26,230	5,066,880	38,013	4,506,880	33,600
Rhodesia and Nyasaland, Federation of	7,228	44,550	------	116,820	------	108,080	------	138,380	------	159,820	------	151,000
Sierra Leone	3,584	------	------	------	------	------	------	------	------	------	------	------
South Africa, Republic of	------	22,560	------	11.500	------	14,000	------	20,000	------	8,000	------	64,000
South-West Africa	10.764	6,556	2,610	1.539	2,899	7,491	670	5,790	1,116	10,444	418	4,143
Uganda [7]	14,210		5,264		5,226		16,240		28,851		[3] 22,488	[3] 8,287
Oceania: Australia	73,621		18,950		23,677		31,808		43,098		[8] 30,000	
Free world total (estimate) [2]	7,990,000		6,040,000		7,020,000		7,540,000		9,210,000		[5] 10,660,000	

[1] When the composition (Cb_2O_5–Ta_2O_5) of the concentrate lies in an intermediate position, neither Cb_2O_5 nor Ta_2O_5 being strongly predominant, the production figure has been centered.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail. The world total does not include U.S.S.R., for which country no production data are available.

[3] U.S. imports.

[4] Shipments.

[5] Includes 1,687,000 pounds of pyrochlore concentrates imported by the United States, which represents a portion of 3,527,000 pounds produced in Brazil during 1961–62.

[6] In addition, tin-columbium-tantalum concentrate was produced as follows: 1954–58 (average) 5,097,035 pounds; 1959, 2,773,387 pounds; 1960, estimated 1,500,000 pounds; 1961, estimated 1,400,000 pounds; 1962 and 1963 not available; 1962, columbium-tantalum content averaging about 10 percent.

[7] In addition, tin-columbium-tantalum concentrate was produced as follows: 1954–55 (average), 3,618 pounds; no further production recorded.

[8] Estimate.

SOUTH AMERICA

Brazil.—Distribuidora e Exportadora de Mineiros e Adubas, S.A. (DEMA), at Araxa, Minas Gerais, was reported to have settled its difficulties with regard to exporting its 1,600 tons of stockpiled pyrochlore concentrate, but then was faced with a threat of possible expropriation by the State of Minas Gerais. The matter remained unresolved at the end of the year. Nevertheless, mining operations were resumed on a minimal basis in order to meet legal requirements for holding the property.

Cía. Desenvilvimento de Industrias Minerais, an affiliate of Union Carbide Corp., investigated tin-tantalite placer deposits along the Rio de Mortes Grande, below the Volta Grande tantalite mine, Nazareno, Minas Gerais. Mineracao Rio de Mortes, a Brazilian affiliate of Cía. Estanifera do Brazil, holds the concession.[6]

EUROPE

Belgium.—Fansteel-Hoboken, S.A., owned jointly by Societe Generale Metallurgique de Hoboken, Hoboken, Belgium and Fansteel Metallurgical Corp., North Chicago, Ill., produced and fabricated refractory metals and their alloys. A precision rolling mill was acquired to roll tantalum foil and strip, particularly very high purity tantalum foil, for electrical capacitors.[7]

Portugal.—The long awaited rains which arrived during 1963 relieved the water shortage for the producers of tantalite concentrate. Metallium Corp. reported in the latter portion of the year that they had shipped about 80 percent of the year's Portuguese tantalite production.[8]

AFRICA

Congo, Republic of the.—Production of tantalum as a coproduct of tin mining was conducted by the Geomines Co. of Manono, North Katanga. In spite of the acute transportation difficulties of the region, the company's 1963 tantalite production was about 75 percent of the 1959 level and about 4 times the 1961 level when operations were affected by fighting and political disturbances.

Kenya.—A deposit of pyrochlore associated with goethite at Mrima Hill was estimated to contain over 50 million tons of ore averaging 0.7 percent Cb_2O_5. Tests on methods of recovering the columbium indicated that a 51-percent Cb_2O_5 concentrate could be produced using high-intensity magnetic separation and flotation techniques. Other carbonatite deposits are known to exist but have not been evaluated.[9]

Malagasy Republic.—A comprehensive review of the columbium and tantalum resources of the Malagasy Republic was published as a Bureau of Mines report during 1963. Columbite-tantalite ores occur in association with beryl, and much of the 1962 columbite-tantalite

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[6] Engineering and Mining Journal. V. 164, No. 8, August 1963, p. 176.
[7] Metal Industry (London). V. 103, No. 14, Oct. 3, 1963, p. 454.
[8] American Metal Market. V. 70, No. 224, Nov. 21, 1963, p. 17.
[9] Mine and Quarry Engineering (London). Niobium and Tantalum. V. 30, No. 1, January 1964, p. 6.

production was obtained by reworking the dumps of the Berere beryl field.[10]

Mozambique.—Sociedade Mineira de Marropino, Lda., was the only major producer of tantalum ores (microlite and tantalite) in 1963. Both Marropina and Sociedade Mineira de Mutala Lda., installed or planned to install new rod mills, jigs, and shaking tables in efforts to improve recoveries, apparently with some success. Production of both companies was from pegmatites from which beryl as well as some lepidolite was recovered.

Nigeria.—Most tin-mining areas produced columbite from ground which averaged 0.02–0.50 pounds columbium per cubic yard. Jig-hydrocyclone on-site installations were used in some instances to produce a heavy mineral concentrate which was then shipped to the main mills for further processing.[11]

Rhodesia and Nyasaland, Federation of.—Most of the tantalum production in 1962 was obtained from the Benson mine, 32 miles north of Mtoko, Southern Rhodesia. The Johannesburg Consolidated Investment Company, Ltd., took an option on the Beryl Rose beryl mine which had been closed in May 1962 because of the uneconomically low grade of its eluvial gravels.[12]

South Africa, Republic of.—Rare Minerals (Pvt.) and Johannesburg Consolidated Investment Co. concluded an option agreement to explore and develop the Portree tantalite mine owned by Rare Minerals. A drilling program was initiated to determine the extent of the deposit situated southwest of Odzi.[13]

OCEANIA

Australia.—Test drillings of the tin and tantalite deposits held by Aberfoyle Tin, N.L., development in the Greenbushes district of Western Australia determined a possible reserve of 36.7 million cubic yards containing an average of 0.62 pounds tin oxide and 0.063 pounds tantalum oxide per cubic yard. Two-thirds of the reported reserve should be recoverable by dredging operations while the remaining one-third is considered easily minable by opencut methods.[14] In November 1963, a bucket dredge was being assembled for working the deposit.[15]

TECHNOLOGY

A Bureau of Mines report evaluated the properties of columbium and tantalum alloys for use at elevated temperatures.[16] Alloys of collumbium-vanadium, tantalum-vanadium, tantalum-hafnium, and columbium–10 percent titanium modified with small additions of ZrO_2, TiO_2, ZrB_2, TiB_2, ZrC, and TiC were evaluated. Of the columbium alloys studied, the columbium–12 atomic percent vanadium alloy ex-

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[10] Murdock, Thomas G. Mineral Resources of the Malagasy Republic. BuMines Inf. Circ. 8196, 1963, pp. 98–100.
Bureau of Mines. Mineral Trade Notes. V. 58. No. 4, April 1964, pp. 6–7.

[11] Mine and Quarry Engineering (London). Niobium and Tantalum. V. 30, No. 1, January 1964, p. 5.

[12] Bureau of Mines. Mineral Trade Notes. V. 57, No. 4, October 1963, p. 57.

[13] Mining Journal (London). V. 261, No. 6683, Sept. 20, 1963, p. 265.

[14] Queensland Government Mining Journal (Australia). V. 64, No. 738, April 1963, p. 203.

[15] Mining Magazine (London). V. 109, No. 6, December 1963, p. 355.

[16] Babitzke, H. R., M. D. Carver, and H. Kato. Columbium and Tantalum Alloys Suitable for Use at High Temperatures. BuMines Rept. of Inv. 6390, 1964, 25 pp.

hibited the best properties. Because of their high strength and oxidation resistance, the following alloys are serviceable at elevated temperatures:

Columbium—10 to 15 atomic percent vanadium
Tantalum—20 atomic percent vanadium
Tantalum—33 atomic percent hafnium

A Bureau report describing a field test for columbium generated considerable interest.[17] The method described is suitable for detecting 1 percent of contained columbium oxide (Cb_2O_5) in a variety of mineral samples provided no tungsten is present.

A report presenting the engineering properties of columbium and 18 of the most promising columbium-refractory metal alloys was published.[18] Binary alloy systems of interest included Cb-Zr and Cb-V; ternary alloy systems included Cb-Ta-W, Cb-Ta-Zr, Cb-Ti-Zr, Cb-W-Zr, and Cb-W-Hf; quaternary alloy systems included Cb-Hf-Ti-Zr, Cb-Ta-W-Zr, Cb-Ti-Mo-C, Cb-W-Zr-C, Cb-W-Mo-Zr, and Cb-W-Ti-Mo.

It has been reported that unstrained (recrystallized) columbium alloys may be more creep resistant than the same alloys in the work hardened condition.[19] Alloy F48 (Cb-15W-5Mo-Zr-0.5C) was found to have superior strength. Columbium-tungsten and columbium-tantalum-tungsten alloys also had good high-temperature strength.

The engineering properties of tantalum and seven of its refractory metal alloys were compiled and published.[20] The alloy systems which were reported included Ta-W, Ta-Cb-V, Ta-W-Mo, and Ta-W-Hf.

Phase diagram studies of columbium and tantalum were reported and published.[21]

Improvements in the mechanical properties of columbium can be obtained by solid-solution strengthening and dispersion strengthening.[22] Strain hardening does not occur at temperatures above that of recrystallization.

When columbium pentachloride (Cb_2Cl_5) is exposed to moist air at temperatures approaching 100° C, the Cb_2Cl_5 reacts with the moisture to form a hydrated columbium pentoxide or columbic acid and hydrogen chloride.[23]

Because of the refractory nature of columbium and tantalum and their proposed usage at elevated temperatures, research was conducted on the evaluation of coatings and alloying additions to improve oxidation resistance.[24]

Advances in studies of the direct conversion of heat into electricity

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[17] McVay, T. H., and Annie G. Smelley. Field Test for Columbium. BuMines Rept. of Inv. 5898, 1962, 9 pp.

[18] Schmidt, F. F., and H. R. Ogden. The Engineering Properties of Columbium and Columbium Alloys. Battelle Memorial Inst., DMIC Rept. 188, Sept. 6, 1963, 237 pp.

[19] Bartlett, E. S., and J. A. VanEcho. Creep of Columbium Alloys. Battelle Memorial Inst., DMIC Memorandum 170, June 24, 1963, 92 pp.

[20] Schmidt, F. F., and H. R. Ogden. The Engineering Properties of Tantalum and Tantalum Alloys. Battelle Memorial Inst., DMIC Rept. 189, Sept. 13, 1963, 112 pp.

[21] English, J. J. Binary and Ternary Diagrams of Columbium, Molybdenum, Tantalum, and Tungsten. Battelle Memorial Inst., DMIC Rept. 183, Feb. 7, 1963, 131 pp.

[22] Briggs, D. C. A Survey of Niobium Alloys and their Strengthening Mechanisms. Canada Dept. Mines and Tech. Surveys (Ottawa), IC 153, July 1963, 26 pp.

[23] Ingraham, T. R., and B. J. P. Whalley. Kinetics of the Reaction of Niobium Pentachloride With Water Vapor. Canada Dept. Mines and Tech. Surveys (Ottawa), R 123, December 1963, 4 pp.

[24] Bliss, B. J., and J. J. Buchinski. Study of Ductile Coatings for the Oxidation Protection of Columbium and Molybdenum Alloys. Defense Documentation Center AD 419549, Washington, D.C., Sept. 30, 1963, 14 pp.

Gadd, J. D., and R. A. Jefferys. Advancement of High Temperature Protective Coatings have been made using magnets wound with superconducting columbium-zirconium wire.[25] During 1963 research was continued on the evaluation of columbium-tin and columbium-zirconium alloys and compounds for use at 4 to 18° K. Commercial development of columbium-base superconducting wire was announced by Superior Tube Co.[26] and Westinghouse Electric Corp.[27]

One proposed application of superconducting magnets was for use as a control for thermal fusion reactions for power production.[28]

Columbium and tantalum are finding increasing use as cladding materials in nuclear reactors.[29] Because of its low thermal neutron-capture cross section, columbium is used as a fuel cladding material in thermal reactors. Tantalum, which is insoluble in plutonium, is used as a cladding material in fast or breeder reactors. Tantalum has been proposed as a structural material in molten plutonium reactors. Fuel elements of columbium-uranium alloys, which resist radiation damage, corrosion, and thermal cycling, have been developed for use in thermal reactors.[30]

Impervious deposits of tantalum and columbium can be made by electroforming and electrocladding the metals onto an electrically conducting base material having a variety of shapes.[31] The base metal can be retained or removed chemically to produce a free-standing article of the refractory metal.

A nonconsumable electrode of columbium–8 percent cerium has been developed which is capable of sustaining a stable arc in a dynamic vacuum. When used as either a melting or welding electrode, high purity metal and columbium-base alloys were obtained.[32]

Refractory metals can be protected at high temperatures by the use of barrier metals placed between the refractory metal and the oxidation resistant coating. Barrier metals used successfully with tantalum include tungsten, rhenium, ruthenium, and iridium. Tungsten, rhenium, osmium, and zirconium were used as barrier metals with columbium.[33]

A continuous vacuum deposition process has been developed which

for Columbium Alloys. U.S. Air Force (Thompson Ramo Wooldridge Inc., Cleveland, Ohio), ASD–TDR–62–934, November 1962, 111 pp.
Huminik, John, Jr. High-Temperature Inorganic Coatings. Reinhold Publishing Corp., New York, 1963, 310 pp.
Kofstad, Per. Oxidation of Tantalum-10% Tungsten Alloy at 700–1,300° C. J. Inst. of Metals (London), v. 91, pt. 12, August 1963, pp. 411–412.
Metalworking News. Refractories Space Use Dependent Upon Coatings. V. 4, No. 168, Nov. 11, 1963, p. 19.
Sama, L. High-Temperature Oxidation-Resistant Coatings for Tantalum Base Alloys; ASD–TDR–63–160. U.S. Air Force (General Telephone Electronics Laboratories, Inc., Bayside, N.Y.). February 1963, 141 pp.

[25] American Metal Market. Columbium-Zirconium Super Magnets Seen as Key to Non-Dynamo Electric Power. V. 70, No. 8, Jan. 11, 1963, p. 13.
[26] American Metal Market. Ductile Superconductive Wire Made of Columbium-Tin With Monel Outer Tube. V. 70, No. 59, Mar. 27, 1963, p. 13.
[27] Westinghouse Electric Corp. Standard Niobium-Zirconium Superconducting Wire. Tech. Data Sheet 53–161, May 1963, 4 pp.
[28] Nucleonics. Superconducting Magnets—Vital to Controlling Fusion. V. 20, No. 5, May 1962, p. 105.
[29] American Metal Market. Refractory Metals Look Promising to Make Reactors More Efficient. V. 70, No. 36, Feb. 21, 1963, p. 15.
[30] DeMastry, John A. Refractory Metals in Nuclear Uses. Battelle Tech. Rev., v. 12, No. 2, February 1963, pp. 3–8.
[31] Chemical Week. A New Process for Electrocladding and Electroforming Refractory Metals. V. 93, No. 14, Oct. 5, 1963, p. 70.
[32] Aconsky, Simon S., and James R. Doyle. Development of a Cb-Ce Electrode for Melting and Welding Cb and Cb-Base Alloys in Vacuum. Electrochem. Tech., v. 1, Nos. 3–4, March–April 1963, pp. 116–122.
[33] Passmore, E. M., J. E. Boyd, and B. S. Lement. Investigations of Diffusion Barrier for Refractory Metals. Munlabs, Inc., Cambridge, Mass., July 1962, 87 pp.; OTS, AD 285569.

produces thin films of tantalum about 1,000 angstroms thick.[34] After deposition the tantalum is oxidized under controlled conditions to produce a tightly adherent, corrosion resistant oxide outer film.

Additions of 1 to 2 percent of zirconium and hafnium to tantalum-tungsten-molybdenum alloys produce pronounced strengthening at 1,925° C. Rhenium and ruthenium additions show little or no superiority to tungsten as solid solution strengtheners of tantalum alloys when both high- and low-temperature effects are considered.[35] A review of the present and projected uses of columbium [36] and tantalum [37] describing current alloys, present defense uses, current research and development programs, and future (1970) potential was published.

Studies of the weldability of three commercial grades of columbium base alloys were conducted. The alloys tested were B-66 (Cb–5% Mo–5% V–1% Zr), C-129 (Cb–10% W–10% Hf), and FS-85 (Cb–27% Ta–10% W–1% Zr). Tests conducted on base-metal samples showed that all three alloys met the required properties for base metal. However, tests of welded samples showed that only the FS-85 alloy possessed the properties desired for welded metal.[38]

Some columbium and tantalum alloys investigated and developed for high-temperature service during 1963 are listed in table 8.

TABLE 8.—Columbium and tantalum alloys developed in 1963

Developer	Designation	Composition, percent						
		Cb	Ta	Zr	Hf	W	Mo	Other
E. I. du Pont de Nemours & Co., Inc.	D-43	88.9		1		10		0.1 C
Stauffer Chemical Co.	SCb-291	80	10			10		
Do.	STa-880		87.5			12.5		
Do.	STa-900		90			10		
Westinghouse Electric Corp.	T-111		90		2	8		
Do.	T-222		87.99		2.4	9.6		0.01 C
Battelle Memorial Institute			92.5			5		2.5 Ru
Do.			90			5		5 Re
Do.			91.5	1		5	2.5	
Do.			90			5	2.5	2.5 Re
General Electric Co.	GE-473		89 to 90.5			7 to 8		2.5 to 3 Re

Interests in methods of producing and alloying columbium and tantalum were reflected by some of the patents issued in 1963.[39]

[34] Chemical Engineering News. Continuous Vacuum Process Deposits Thin Tantalum Films. V. 41, No. 16, Apr. 22, 1963, p. 50.

[35] Schmidt, E. F., E. S. Bartlett, and H. R. Ogden. Investigation of Tantalum and Its Alloys. Defense Documentation Center AD 406757. Washington, D.C., May 1963, 128 pp.

[36] Bartlett, E. S. The Current Status and 1970 Potential of Selected Defense Metals: Columbium. Battelle Memorial Inst., DMIC Memorandum 183, Oct. 31, 1963, pp. 10–15.

[37] Schmidt, F. F. The Current Status and 1970 Potential of Selected Defense Metals: Tantalum. Battelle Memorial Inst., DMIC Memorandum 183, Oct. 31, 1963, pp. 29–31.

[38] Kammer, P. A., and R. E. Monroe. Weldability Studies of Three Commercial Columbium-Base Alloys. Battelle Memorial Institute, DMIC Memorandum 169, June 17, 1963, 19 pp.

[39] Chang, Winston H., and Jack W. Clark (assigned to General Electric Co., New York). Columbium Base Alloy. U.S. Pat. 3,113,863, Dec. 10, 1963.

Downing, James H., Nelson B. Colton, and Cecil G. Chadwick (assigned to Union Carbide Corp., New York). Production of Columbium and Tantalum. U.S. Pat. 3,114,629, Dec. 17, 1963.

Egerton, L., and S. S. Flaschen (assigned to Western Electric Co., Princeton, New Jersey). Columbium-Potassium-Sodium-Ceramics. Canadian Pat. 663,021, May 14, 1963.

Hum, Jack K. Y., and Alfred L. Donlevy (assigned to Stauffer Chemical Co., New York). Multicomponent Columbium Alloys. U.S. Pat. 3,115,407, Dec. 24, 1963.

Jefferys, Ricard A., Warren I. Pollock, and Frederic J. Anders, Jr. (assigned to E. I. du Pont de Nemours and Co., Wilmington, Del.). Columbium Base Alloys. U.S. Pat. 3,086,859, Apr. 23, 1963.

Scheller, Walter, and Max Blumer (assigned to CIBA Limited, Basel, Switzerland). Process for the Manufacture of Metallic Niobium or Tantalum or Alloys Thereof. U.S. Pat. 3,110,585, Nov. 12, 1963.

Copper

By F. L. Wideman [1]

Contents

THE COPPER industry in the United States experienced a high rate of consumption, stable prices, increased imports, and slightly decreased production and exports. Domestic mine output was 1 percent less than in 1962, mainly because of continued voluntary production curtailments. The price of domestic copper remained 31 cents a pound throughout the year.

The United States returned to a net-importing nation in 1962, and this condition became even more pronounced in 1963. Imports increased 13 percent and exports of refined copper decreased 8 percent. Demand for copper continued high and consumption of refined copper rose 9 percent over 1962 to a new record.

World mine production of primary copper in 1963 increased 3 percent over that in 1962. Production gains in many countries, notably Northern Rhodesia, Peru, and South-West Africa more than offset decreased output in the United States and the Republic of the Congo. It was estimated that the production of the U.S.S.R. rose 50,000 tons. Free world consumption was 3 percent higher than in 1962. Usage reached new peaks in Australia, Canada, and some European countries.

[1] Commodity specialist, Division of Minerals.

LEGISLATION AND GOVERNMENT PROGRAMS

The Justice Department charged Kennecott Copper Corp. with violation of Section 7 of the Clayton Antitrust Act by its acquisition of the Okonite Company in 1958. A trial was held during November in the United States District Court for the Southern District of New York and no decision had been rendered.[2]

The 1.7 cent-per-pound excise tax on copper imports effective July 1, 1958, was unchanged.

TABLE 1.—Salient copper statistics

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Ore produced [1] thousand short tons	116,504	103,716	134,994	142,722	150,217	146,450
Average yield of copper percent	0.80	0.74	0.73	0.75	0.75	0.74
Primary (new) copper produced—						
From domestic ores, as reported by—						
Mines short tons	1,000,877	824,846	1,080,169	1,165,155	1,228,421	1,213,166
Value thousands	$669,162	$506,455	$693,468	$699,093	$756,707	$747,310
Smelters short tons	1,006,649	799,329	1,142,848	1,162,480	1,282,126	1,258,126
Percent of world total	27	19	23	23	24	23
Refineries short tons	994,313	796,452	1,121,286	1,181,015	1,214,146	1,219,342
From foreign ores, matte, etc., refinery reports short tons	366,429	301,795	397,641	369,124	397,584	377,009
Total new refined, domestic and foreign short tons	1,360,741	1,098,247	1,518,927	1,550,139	1,611,730	1,596,351
Secondary copper recovered from old scrap only short tons	449,200	471,007	429,365	411,110	415,674	421,843
Imports, general:						
Unmanufactured [2] short tons	575,002	570,891	524,344	457,669	478,851	540,533
Refined do	179,983	214,058	142,709	66,855	98,820	119,165
Exports:						
Metallic copper [3] [4] do	341,768	196,012	510,494	482,824	366,585	344,960
Refined do	273,953	158,938	433,762	428,718	336,525	311,479
Stocks Dec. 31: Producers:						
Refined short tons	59,000	18,000	98,000	49,000	71,000	52,000
Blister and materials in solution short tons	236,000	253,000	261,000	236,000	246,000	252,000
Total do	295,000	271,000	359,000	285,000	317,000	304,000
Withdrawals (apparent) from total supply on domestic account:						
Primary copper short tons	1,267,000	1,183,000	1,148,000	1,237,000	1,352,000	1,423,000
Primary and old copper (old scrap only) short tons	1,716,000	1,654,000	1,577,000	1,648,000	1,768,000	1,845,000
Price: Average cents per pound [5]	33.1	30.7	32.1	30.0	30.8	30.8
World:						
Production:						
Mine short tons	3,610,000	[6] 4,040,000	[6] 4,650,000	4,840,000	[6] 5,090,000	5,220,000
Smelter do	3,790,000	[6] 4,240,000	[6] 5,040,000	[6] 5,110,000	[6] 5,360,000	5,500,000
Price: London, average cents per pound	33.64	29.80	30.81	28.73	29.33	29.25

[1] Includes old tailings smelted or retreated. Not comparable with mine production figure shown, in that latter includes recoverable copper content of ores not classified as "copper."
[2] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering country under bond. Comprises copper in ingots, plates, and bars, ores and concentrates, regulus, blister, and scrap.
[3] Total exports of copper, exclusive of ore, concentrates, composition metal, and unrefined copper. Exclusive also of "Other manufactures of copper."
[4] Beginning Jan. 1, 1958, copper rods not separately classified; included in "Other copper manufactures."
[5] Exclusive of copper produced abroad and delivered in the United States.
[6] Revised figure.

[2] Kennecott Copper Corporation. Annual Report 1963. P. 5.

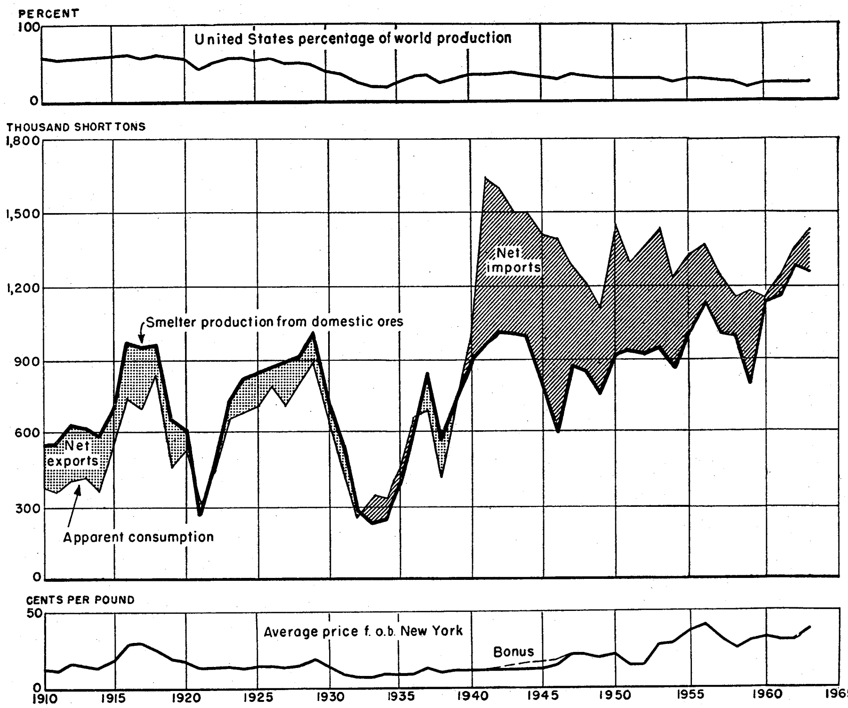

FIGURE 1.—Production, consumption, and price of copper in the United States, 1910–63.

DOMESTIC PRODUCTION

PRIMARY COPPER

Mine Production.—The downward trend in mine production, resulting from cutbacks that began in the last half of 1962, continued through July 1963. Although production turned upward in the last 4 months, output for 1963 was 1 percent less than in 1962.

Mine production in Arizona increased 3 percent and the State supplied 54 percent of the domestic output. The daily capacity of the concentrator of the Pima Mining Co., southwest of Tucson, was increased from 3,800 tons to 7,000 tons. Development and construction by Duval Corporation proceeded on schedule at the Ithaca Peak open-pit mine, north of Kingman, and production from the facilities was scheduled for the last half of 1964. Phelps Dodge Corporation authorized installation of new facilities at its Morenci Branch Reduction Works for the recovery of additional copper by a newly developed leach-precipitation-float process. The Anaconda Company explored properties of the Banner Mining Co. in Pima County by core drilling.

Utah continued to rank second among the major copper producing States, but output was 7 percent below 1962, and its share of the total output decreased from 18 to 17 percent. A $100 million expansion program began at the Utah Copper Division, Kennecott Copper Corp. Production from New Mexico and Nevada remained virtually unchanged and each State contributed about 7 percent of the Nation's total. Montana was in fifth place despite a sharp rise in production during the last 4 months of 1963. The increase in production was attributed to the beginning of operations at the new concentrator of The Anaconda Company at Butte. The facility was the fourth largest concentrator in the United States and the first to use autogenous grinding on a large scale. Michigan, ranking sixth produced about 6 percent of the Nation's total. Copper Range Company began treating stamp sands from the Atlantic property, and Calumet & Hecla, Inc., milled copper bearing waste rock piled near Ahmeek. Output in Tennessee remained virtually unchanged.

Classification of production by mining methods revealed that 74 percent of the recoverable copper and 81 percent of the ore came from open pits. Most domestic ore was treated by flotation at or near the mine of origin, and the resulting concentrate was shipped for smelting. Some copper ores were direct-smelted because of their high grade or fluxing qualtities.

The first 5 mines listed in table 6 produced 47 percent of the total U.S. production, the first 10 produced 72 percent, and the entire 25 supplied 97 percent.

TABLE 2.—Copper produced from domestic ores, by sources

(Short tons)

Year	Mine	Smelter	Refinery	Year	Mine	Smelter	Refinery
1959	824,846	799,329	796,452	1962	1,228,421	1,282,126	1,214,146
1960	1,080,169	1,142,848	1,121,286	1963	1,213,166	1,258,126	1,219,342
1961	1,165,155	1,162,480	1,181,015				

TABLE 3.—Copper and recoverable copper produced, by mining methods

(Percent)

Year	Open pit		Underground		Year	Open pit		Underground	
	Ore	Copper	Ore	Copper		Ore	Copper	Ore	Copper
1946	66	58	34	42	1955	83	77	17	23
1947	73	68	27	32	1956	78	73	22	27
1948	76	68	24	32	1957	77	72	23	28
1949	78	70	22	30	1958	76	71	24	29
1950	81	74	19	26	1959	79	74	21	26
1951	84	74	16	26	1960	80	75	20	25
1952	85	77	15	23	1961	80	74	20	26
1953	83	75	17	25	1962	81	75	19	25
1954	83	79	17	21	1963	81	74	19	26

TABLE 4.—Mine production of recoverable copper in the United States in 1963, by months [1]

Month	Short tons	Month	Short tons
January	102,358	August	96,938
February	94,594	September	99,291
March	105,255	October	109,935
April	105,402	November	106,349
May	105,162	December	108,545
June	93,094		
July	86,243	Total	1,213,166

[1] Monthly figures adjusted to final annual mine-production total.

TABLE 5.—Mine production of recoverable copper in the United States, with production of maximum year, and cumulative production from earliest record to end of 1963, by States

(Short tons)

State	Maximum production [1]		Production by years						Total production from earliest record through 1963
	Year	Quantity	1954–58 (average)	1959	1960	1961	1962	1963	
Alabama	1907	42							64
Alaska	1916	59,927	2	36	41	92			686,084
Arizona	1963	660,977	467,927	430,297	538,605	587,053	644,242	660,977	19,087,663
California	1909	28,644	706	663	1,087	1,382	1,162	916	640,848
Colorado	1938	14,171	4,476	2,940	3,247	4,141	4,534	4,169	311,875
Georgia	1917	465							1,117
Idaho	1958	9,846	6,972	8,713	4,208	4,328	3,861	4,172	183,247
Maine	1918	383							(2)
Maryland	1917	146							(2)
Massachusetts	1906	5							(2)
Michigan	1916	136,846	50,318	55,300	56,385	70,245	74,099	75,262	5,570,221
Missouri	1949	3,670	1,714	1,065	1,087	1,479	2,752	1,816	[3] 54,601
Montana	1916	176,464	83,902	65,911	91,972	104,000	94,021	79,762	7,857,743
Nevada	1942	83,663	74,771	57,375	77,485	78,022	82,602	81,738	2,895,076
New Hampshire	1908	[4] 94							(2)
New Mexico	1963	83,037	64,866	39,688	67,288	79,606	82,683	83,037	2,505,560
North Carolina	1930	6,695		(5)	(5)	(5)	(5)	(6)	(7)
Oregon	1916	1,791	10		6	(5)	(5)	(6)	(7)
Pennsylvania [8]	1942	6,410	5,414	6,604	7,907	8,934	6,108	4,434	(2)
South Carolina	1938	4							10
South Dakota	1918	32			1			1	108
Tennessee	1962	14,298	9,669	11,490	12,723	12,272	14,298	13,717	547,095
Texas	1928	224							1,384
Utah	1943	323,989	224,486	144,715	218,049	213,534	218,018	203,095	8,813,172
Vermont	1954	4,352	3,188						(2)
Virginia	1944	291							(2)
Washington	1940	9,612	2,454	49	78	66	41	[9] 70	121,892
Wisconsin	1914	5							(2)
Wyoming	1900	2,102	2			1			16,336
Total	1962	1,228,421	1,000,877	824,846	1,080,169	1,165,155	1,228,421	1,213,166	[10] 49,618,012

[1] For Missouri and States east of the Mississippi River, maximum since 1905.
[2] Data not available.
[3] Small quantity for Wisconsin included with Missouri.
[4] The 1908 volume of Mineral Resources credits this figure to Massachusetts and New Hampshire; the 1909 volume credits it to New Hampshire alone.
[5] Included with Pennsylvania to avoid disclosing operations of individual companies.
[6] Included with Washington to avoid disclosing operations of individual companies.
[7] Figure withheld to avoid disclosing individual company confidential data.
[8] Includes North Carolina for 1956–62 and Oregon for 1961–62 to avoid disclosing operations of individual companies.
[9] Includes North Carolina and Oregon to avoid disclosing operations of individual companies.
[10] Largely smelter production for States east of the Mississippi River except Michigan; includes 323,916 tons for States indicated by footnote 2.

TABLE 6.—Twenty-five leading copper-producing mines in the United States in 1963 in order of output

Rank	Mine	District or region	State	Operator	Source of copper
1	Utah Copper	West Mountain (Bingham)	Utah	Kennecott Copper Corp	Copper, gold-silver ores.
2	Morenci	Copper Mountain (Morenci)	Arizona	Phelps Dodge Corp	Do.
3	San Manuel	Old Hat	do	Magma Copper Co	Copper ore.
4	Butte Mines (includes Berkeley)	Summit Valley (Butte)	Montana	The Anaconda Company	Copper, silver-zinc ores.
5	Chino	Central	New Mexico	Kennecott Copper Corp	Copper ore.
6	Copper Queen-Lavender Pit	Warren (Bisbee)	Arizona	Phelps Dodge Corp	Do.
7	New Cornelia	Ajo	do	do	Copper, gold-silver ores.
8	Ray Pit	Mineral Creek (Ray)	do	Kennecott Copper Corp	Copper ore.
9	White Pine	Lake Superior	Michigan	White Pine Copper Co	Do.
10	Mission	Pima	Arizona	American Smelting and Refining Company.	Do.
11	Inspiration	Globe-Miami	do	Inspiration Consolidated Copper Co	Do.
12	Yerington	Yerington	Nevada	The Anaconda Company	Do.
13	Liberty Pit	Robinson (Ely)	do	Kennecott Copper Corp	Do.
14	Silver Bell	Silver Bell	Arizona	American Smelting and Refining Company.	Do.
15	Esperanza	Pima	do	Duval Corp	Do.
16	Copper Cities	Globe-Miami	do	Tennessee Corp	Do.
17	Bagdad	Eureka (Bagdad)	do	Bagdad Copper Corp	Do.
18	Magma	Pioneer (Superior)	do	Magma Copper Co	Copper, gold-silver ores.
19	Burra-Boyd	Polk County	Tennessee	Tennessee Copper Co	Copper-zinc ore.
20	Calumet & Hecla, Inc	Lake Superior	Michigan	Calumet & Hecla, Inc	Copper ore and tailings.
21	Daisy	Pima	Arizona	Pima Mining Co	Copper ore.
22	Pima	do	do	do	Do.
23	Christmas	Banner	do	Inspiration Consolidated Copper Co	Do.
24	Miami	Globe-Miami	do	Tennessee Corp	Copper precipitates.
25	Cornwall	Lebanon County	Pennsylvania	Bethlehem Cornwall Corp	Magnetite-pyrite-chalcopyrite ore.

TABLE 7.—Copper ore sold or treated in the United States in 1963, with copper, gold, and silver content in terms of recoverable metals [1]

State	Ore sold or treated (short tons)	Recoverable metal content				Value of gold and silver per ton of ore
		Copper		Gold (fine ounces)	Silver (fine ounces)	
		Pounds	Percent			
Arizona	80,615,132	1,217,337,700	0.76	121,177	4,494,239	$0.12
California	2,000	2,200	.06		16	.01
Colorado	20,900	1,190,000	2.85	4,166	423,751	32.91
Idaho	38,964	1,653,200	2.12	654	10,916	.95
Michigan [2]	9,437,516	150,524,000	.80		338,997	.05
Montana	8,139,535	153,463,900	.94	11,742	2,477,756	.44
Nevada	13,312,956	163,462,400	.61	39,598	165,834	.12
New Mexico	7,168,769	100,155,700	.70	6,418	106,782	.05
South Dakota	2	1,600	40.00			
Tennessee [3]	1,431,270	27,434,000	.96	137	107,913	.10
Utah	26,282,424	363,259,200	.69	254,610	2,183,632	.45
Washington [4]	72	14,900	10.35	35	61	18.10
Total	146,449,540	2,178,498,800	.74	438,537	10,309,897	.19

[1] Excludes copper recovered from precipitates as follows: Arizona, 91,236,600 pounds; Montana, 2,707,500 pounds; New Mexico, 64,468,500 pounds; Utah 37,533,600 pounds.
[2] Includes tailings.
[3] Copper-zinc ore.
[4] Includes Oregon to avoid disclosing individual company operations.

TABLE 8.—Copper ore concentrated in the United States in 1963, with content in terms of recoverable copper

State	Ore concentrated (short tons)	Recoverable copper content	
		Pounds	Percent
Arizona	[1] 80,146,922	[2] 1,133,197,600	0.71
California	2,000	2,200	.06
Colorado	3,283	138,200	2.10
Idaho	35,365	1,028,800	1.45
Michigan [3]	9,437,516	150,524,000	.80
Montana	8,139,180	153,438,100	.94
Nevada	[4] 8,995,644	[5] 112,169,300	.62
New Mexico	[6] 6,810,739	[7] 100,007,600	.73
Tennessee [8]	1,431,270	27,434,000	.96
Utah	26,282,400	363,251,700	.69
Total [9]	141,284,319	2,041,191,500	.72

[1] Includes 5,487,483 tons treated both by leaching and concentration.
[2] In addition 36,759,803 pounds of copper was recovered by leaching.
[3] Includes tailings.
[4] In addition 4,239,639 tons was treated by leaching.
[5] In addition 47,624,400 pounds of copper was recovered by leaching.
[6] In addition 310,000 tons was treated by heap leaching.
[7] In addition 103,000 pounds of copper was recovered by heap leaching.
[8] Copper-zinc ore.
[9] Excludes small quantities for Oregon. Bureau of Mines not at liberty to publish.

TABLE 9.—Copper ore shipped to smelters in the United States in 1963 with content in terms of recoverable copper

State	Ore shipped to smelters		
	Short tons	Recoverable copper content	
		Pounds	Percent
Arizona	468,210	35,445,400	3.79
Colorado	17,617	1,051,800	2.99
Idaho	3,599	624,400	8.67
Montana	355	25,800	3.63
Nevada	77,673	3,668,700	2.36
New Mexico	[1] 48,030	45,100	.05
South Dakota	2	1,600	40.00
Utah	24	7,500	15.63
Washington [2]	60	14,800	12.33
Total	615,570	40,885,100	3.32

[1] Primarily smelter fluxing material.
[2] Includes Oregon to avoid disclosing individual company operations.

TABLE 10.—Copper ores produced in the United States, and average yield in copper, gold, and silver

Year	Smelting ores		Concentrating ores		Total				
	Short tons	Yield in copper, percent	Short tons [1]	Yield in copper, percent	Short tons [1 2]	Yield in copper, percent	Yield per ton in gold, ounce	Yield per ton in silver, ounce	Value per ton in gold and silver
1954–58 (average)	827,782	4.17	112,720,080	0.78	116,503,987	0.80	0.0046	0.088	$0.24
1959	467,598	3.98	103,239,445	.72	103,715,843	.74	.0035	.066	.18
1960	669,502	3.26	134,306,380	.72	134,994,082	.73	.0040	.070	.20
1961	734,112	3.39	141,975,386	.74	142,721,798	.75	.0037	.073	.20
1962	598,519	3.25	145,580,048	.72	150,216,710	.75	.0032	.073	.19
1963	615,570	3.32	141,284,319	.72	146,449,540	.74	.0030	.070	.19

[1] Includes some ore classed as copper-zinc ore.
[2] Includes copper ore leached.

Smelter Production.—Recovery of copper from ores of domestic origin by smelters in the United States declined 2 percent. Copper produced from foreign material dropped 5 percent, but output from secondary sources rose 13 percent. Total output of the smelters decreased 1 percent.

Smelter production data are based on reports from domestic primary smelters handling copper-bearing material. Blister copper is accounted for in terms of copper content. Production of furnace-refined copper in Michigan is included in smelter and refinery output. Metallic and cement copper recovered from leaching solutions are included in smelter production.

Smelting was discontinued at facilities of the Phelps Dodge Refining Corp., at Laurel Hill, N.Y., in August. The plant continued to produce electrolytically refined copper.

TABLE 11.—Copper produced by primary smelters in the United States

(Short tons)

Year	Domestic	Foreign	Secondary	Total
1954–58 (average)	1,006,649	99,546	71,291	1,177,486
1959	799,329	42,466	54,895	896,690
1960	1,142,848	90,781	74,472	1,308,101
1961	1,162,480	44,874	78,377	1,285,731
1962	1,282,126	40,488	86,903	1,409,517
1963	1,258,126	38,574	97,986	1,394,686

Refinery Production.—Refined copper was produced from primary-source material at 15 plants, some of which also treated scrap material. Of the plants termed "primary refineries," 9 used the electrolytic-refining method exclusively. Three plants used only fire-refining methods (Lake copper refineries), and two used both electrolytic and fire-refining techniques. One western smelter fire-refined part of its blister copper and shipped the remainder to an electrolytic plant for refining. Inspiration Consolidated Copper Co. at Inspiration, Ariz., produced electrolytic copper from leaching solutions; a substantial part of this copper was shipped as cathodes to other refineries for melting and casting into commercial shapes.

United States Metals Refining Co. doubled the production capacity for oxygen-free copper at facilities at Carteret, N.J. The plant also produced special alloys using oxygen-free copper as a base.

TABLE 12.—Primary and secondary copper produced by primary refineries in the United States

(Short tons)

	1954–58 (average)	1959	1960	1961	1962	1963
Primary:						
From domestic ores, etc.:[1]						
Electrolytic	889,613	699,890	1,009,983	1,037,489	1,098,032	1,095,377
Lake	46,575	54,543	56,232	70,061	67,072	64,146
Casting	58,125	42,019	55,071	73,465	49,042	59,819
Total	994,313	796,452	1,121,286	1,181,015	1,214,146	1,219,342
From foreign ores, etc.:[1]						
Electrolytic	347,903	256,002	389,178	355,009	379,236	357,015
Casting and best select	18,525	45,793	8,463	14,115	18,348	19,994
Total refinery production of primary copper	1,360,741	1,098,247	1,518,927	1,550,139	1,611,730	1,596,351
Secondary:						
Electrolytic[2]	195,214	200,183	241,169	231,836	237,472	240,620
Casting	12,635	11,405	10,585	11,294	12,214	17,993
Total secondary	207,849	211,588	251,754	243,130	249,686	258,613
Grand total	1,568,590	1,309,835	1,770,681	1,793,269	1,861,416	1,854,964

[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	1962		1963	
	Thousand short tons	Percent	Thousand short tons	Percent
Billets	199	10	213	11
Cakes	182	10	170	9
Cathodes	164	9	182	10
Ingots and ingot bars	149	8	166	9
Wirebars	1,150	62	1,110	60
Other forms	17	1	14	1
Total	1,861	100	1,855	100

TABLE 14.—Copper smelting works in North America in 1963 [1] [2]

Country and company	Plant location	Annual capacity, tons of material
United States:		
American Metal Climax, Inc	Carteret, N.J	168,000
American Smelting and Refining Co	El Paso, Tex	420,000
	Hayden, Ariz	360,000
	Tacoma, Wash	600,000
The Anaconda Company	Anaconda, Mont	1,000,000
Inspiration Consolidated Copper Co	Miami, Ariz	360,000
Magma Copper Co.:		
Magma Division	Superior, Ariz	150,000
San Manuel Division	San Manuel, Ariz	360,000
Kennecott Copper Corp.:		
Nevada Mines Division	McGill, Nev	440,000
Chino Mines Division	Hurley, N.M	400,000
Ray Mines Division	Hayden, Ariz	400,000
Utah Mines Division	Garfield, Utah	1,225,000
Phelps Dodge Refining Corp.[3]	Laurel Hill, N.Y	200,000
Phelps Dodge Corp.:		
Douglas Reduction Works	Douglas, Ariz	1,250,000
Morenci Branch	Morenci, Ariz	900,000
New Cornelia Branch	Ajo, Ariz	300,000
Tennessee Copper Co	Copperhill, Tenn	90,000
Total		8,623,000
Calumet & Hecla, Inc	Hubbell, Mich	100,000
Quincy Mining Co	Hancock, Mich	12,000
White Pine Copper Co	White Pine, Mich	65,000
Total [4]		177,000
Canada:		
Falconbridge Nickel Mines, Ltd	Falconbridge, Ont	770,000
Gaspé Copper Mines, Ltd	Murdochville, Que	260,000
Hudson Bay Mining and Smelting Co., Ltd	Flin Flon, Manitoba	575,000
Noranda Mines, Ltd	Noranda, Que	1,600,000
The International Nickel Company of Canada, Ltd	Copper Cliff, Ont	5,600,000
The International Nickel Company of Canada, Ltd	Coniston, Ont	1,000,000
Total		9,805,000
Mexico:		
Compania Minera ASARCO, S.A	San Luis Potosi	300,000
Cia. Minera de Santa Rosalia, S.A	Santa Rosalia, Baja Calif	120,000
Compania Minera de Cananea, S.A. de C.V	Cananea, Sonora	290,000
Cia. Minera Macocozac S.A.[5]	Concepcion del Oro, Zacatecas	200,000
Total		910,000

[1] From 1962 and 1963 Yearbooks of American Bureau of Metal Statistics.
[2] The capacity of copper smelting works is stated in tonnage of capacity for smelting ore, including flux but not including fuel. Capacity in terms of copper product varies with the grade of ore charged. Ore and concentrate are metallurgically synonymous terms.
[3] Ceased operating August 1963.
[4] Tons of product.
[5] Idle.

TABLE 15.—Annual capacity of copper refineries in North America, in 1963 [1]

(Short tons)

Country and company	Electrolytic	Lake	Fire refined
United States:			
American Metal Climax, Inc., Carteret, N.J.	150,000	----------	125,000
American Smelting and Refining Co.:			
Baltimore, Md.	198,000	----------	----------
Barber, N.J.	168,000	----------	----------
Tacoma, Wash.	103,000	----------	----------
The Anaconda Company, Great Falls, Mont.	150,000	----------	----------
Calumet & Hecla, Inc., Hubbell, Mich.	----------	60,000	----------
Inspiration Consolidated Copper Co., Inspiration, Ariz.	45,000	----------	----------
International Smelting and Refining Company, Raritan, Perth Amboy, N.J.	240,000	----------	----------
Kennecott Copper Corp.:			
Garfield, Utah	204,000	----------	----------
Anne Arundel County, Md.	198,000	----------	----------
Hurley, N. Mex.	----------	----------	84,000
Lewin-Mathes Co., Div. of Cerro Corp., St. Louis, Mo.	42,500	----------	----------
Phelps Dodge Refining Corp.:			
El Paso, Tex.	290,000	----------	25,000
Laurel Hill, L.I., N.Y.	175,000	----------	----------
Quincy Mining Co., Hancock, Mich.	----------	12,000	----------
White Pine Copper Co., White Pine, Mich.	----------	65,000	----------
Total	1,963,500	137,000	234,000
Canada:			
Canadian Copper Refiners, Ltd., Montreal, East, Quebec	284,000	----------	----------
The International Nickel Company of Canada, Ltd., Copper Cliff, Ontario	168,000	----------	----------
Total	452,000	----------	----------
Mexico:			
Cobre de Mexico, S.A., Atzcapotzalco, D.F.	43,000	----------	----------
Casting capacity:			
United States [2]	2,094,400	137,000	[3] 234,000
Canada	462,000	----------	----------
Mexico	43,000	----------	----------

[1] From 1963 Yearbook of American Bureau of Metal Statistics.
[2] Total U.S. capacity is 2,465,400 short tons.
[3] In addition to capacity reported under Electrolytic.

Copper Sulfate.—Production and shipments of copper sulfate rose 4 and 2 percent, respectively. Shipments totaled 41,200 tons (40,300 in 1962) of which producers' reports indicated that 17,600 tons (17,800) was for agricultural uses, 22,100 tons (20,400) for industrial uses and 1,500 tons (2,100) for other purposes, 59 percent of which was for export. Stocks at yearend were 2 percent less than at the end of 1962.

TABLE 16.—Production, shipments, and stocks of copper sulfate

(Short tons)

Year	Production		Shipments	Stocks Dec. 31 [1]
	Quantity	Copper content		
1954–58 (average)	65,896	16,474	65,889	4,691
1959	40,292	10,073	42,100	2,500
1960	58,000	14,500	54,272	5,480
1961	48,584	12,146	46,544	6,740
1962	39,984	9,996	40,332	5,572
1963	41,636	10,409	41,188	5,480

[1] Some small quantities are purchased and used by producing companies, so that the figures given do not balance exactly.

Byproduct Sulfuric Acid.—Sulfuric acid produced from the sulfur content of sulfide ores at copper smelters totaled 358,500 tons, a decrease of 11 percent from 1962. The data include output from domestic and foreign materials and acid produced at a lead smelter.

TABLE 17.—Byproduct sulfuric acid[1] (100-percent basis) produced in the United States

(Short tons)

Year	Copper plants[2]	Zinc plants[3]	Total
1954-58 (average)	393,051	759,281	1,152,332
1959	282,461	803,578	1,086,039
1960	412,845	770,872	1,183,717
1961	362,630	776,109	1,138,739
1962	403,683	815,322	1,219,005
1963	358,503	861,763	1,220,266

[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.

SECONDARY COPPER AND BRASS

Recovery of copper in the United States, in alloyed and unalloyed form, from all classes of nonferrous scrap totaled 974,000 tons, 6 percent more than in 1962 and the largest quantity since 1955. Recovery from copper-base scrap rose 7 percent at brass mills, 5 percent at secondary smelters, 4 percent at primary producers, 9 percent at foundries, and 8 percent at chemical plants. New scrap furnished 57 percent of the copper recovered.

Consumption of purchased copper-base scrap rose 8 percent in 1963. Secondary smelters consumed 362,900 tons of copper scrap, of which 282,600 tons was old scrap. Primary copper producers used 233,800 tons of old scrap and 202,300 tons of new scrap. Of 448,400 tons used at brass mills, 434,900 tons was new scrap. Foundries and other plants consumed a total of 112,900 tons of scrap.

Primary copper refineries recovered 258,600 tons of refined copper, 4 percent more than in 1962. Production of brass-mill products and brass and bronze ingots rose 7 and 5 percent, respectively.

TABLE 18.—Secondary copper produced in the United States

(Short tons)

	1954-58 (average)	1959	1960	1961	1962	1963
Copper recovered as unalloyed copper	247,073	261,588	300,259	290,805	301,374	314,643
Copper recovered in alloys[1]	632,697	668,982	571,129	558,134	620,454	659,783
Total secondary copper	879.770	930,570	871,388	848,939	921,828	974,426
Source:						
New scrap	430,570	459,563	442,023	437,829	506,154	552,583
Old scrap	449,200	471,007	429,365	411,110	415,674	421,843
Percentage equivalent of domestic mine output	88	113	81	73	75	80

[1] Includes copper in chemicals, as follows: 1954-58 (average), 14,485; 1959, 10,061; 1960, 12,714; 1961, 10,708; 1962, 9,986; and 1963, 10,191.

TABLE 19.—Copper recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1962	1963	Form of recovery	1962	1963
New scrap:			As unalloyed copper:		
Copper-base	498,300	544,368	At primary plants	249,686	258,613
Aluminum-base	7,590	7,970	At other plants	51,688	56,030
Nickel-base	239	220			
Zinc-base	25	25	Total	301,374	314,643
Total	506,154	552,583	In brass and bronze	584,860	623,721
			In alloy iron and steel	2,956	2,141
Old scrap:			In aluminum alloys	22,470	23,465
Copper-base	410,475	416,493	In other alloys	182	265
Aluminum-base	4,579	4,808	In chemical compounds	9,986	10,191
Nickel-base	579	499			
Tin-base	22	23	Total	620,454	659,783
Zinc-base	19	20			
			Grand total	921,828	974,426
Total	415,674	421,843			
Grand total	921,828	974,426			

TABLE 20.—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	
	1962	1963	1962	1963	1962	1963
Recovered by—						
Secondary smelters	48,205	51,529	208,141	217,106	256,346	268,635
Primary copper producers	117,864	139,530	133,776	121,616	251,640	261,146
Brass mills	311,280	334,762	12,052	12,166	323,332	346,928
Foundries and manufacturers	19,562	17,338	51,014	59,379	70,576	76,717
Chemical plants	1,389	1,209	5,492	6,226	6,881	7,435
Total	498,300	544,368	410,475	416,493	908,775	960,861

TABLE 21.—Production of secondary copper and copper-alloy products in the United States

(Short tons)

Item produced from scrap	1962	1963
Unalloyed copper products:		
Refined copper by primary producers	249,686	258,613
Refined copper by secondary smelters	40,062	43,466
Copper powder	10,162	11,458
Copper castings	1,464	1,106
Total	301,374	314,643
Alloyed copper products:		
Brass and bronze ingots:		
Tin bronze	16,566	15,929
Leaded tin bronze	17,325	17,053
Leaded red bronze	82,510	85,745
Leaded semired brass	74,897	82,716
High-leaded tin bronze	14,750	13,835
Do	13,110	16,050
Do	4,554	4,895
Leaded yellow brass	9,092	11,038
Nickel silver Do	4,128	3,439
Low brass	3,001	2,661
Conductor bronze	615	638
Manganese bronze	12,740	12,369
Aluminum bronze	7,899	8,628
Silicon bronze	3,738	4,041
Copper-base hardeners and special alloys	11,625	11,415
Total	276,550	290,452
Brass-mill products	413,156	441,140
Brass and bronze castings	57,076	67,934
Brass powder	1,901	917
Copper in chemical products	9,986	10,191
Grand total	1,060,043	1,125,277

TABLE 22.—Composition of secondary copper-alloy production

(Short tons)

Year	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze production:[1]							
1962	217,649	13,798	17,907	26,921	212	63	276,550
1963	226,930	14,265	19,412	29,222	563	60	290,452
Secondary metal content of brass-mill products:							
1962	323,384	143	3,609	84,407	1,596	17	413,156
1963	346,917	151	4,063	88,219	1,786	4	441,140
Secondary metal content of brass and bronze castings:							
1962	44,742	2,436	6,157	3,653	18	70	57,076
1963	53,085	2,749	8,026	3,992	26	56	67,934

[1] About 95 percent from scrap and 5 percent from other than scrap.

TABLE 23.—Stocks and consumption of copper scrap in the United States in 1963

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts		Consumption				Stocks Dec. 31
		Purchased scrap	Machine shop scrap	Purchased scrap			Machine shop scrap	
				New	Old	Total		
Secondary smelters:								
No. 1 wire and heavy copper	2,835	35,240		2,926	32,358	35,284		2,791
No. 2 wire, mixed heavy and light copper	2,871	64,584		7,627	56,806	64,433		3,022
Composition of red brass	4,832	83,930		26,815	56,753	83,568		5,194
Railroad-car boxes	267	1,036			1,078	1,078		225
Yellow brass	5,870	56,674		7,268	49,526	56,794		5,750
Cartridge cases and brass	58	655			625	625		88
Auto radiators (unsweated)	3,181	51,246			50,876	50,876		3,551
Bronze	1,643	29,822		7,705	21,994	29,699		1,766
Nickel silver	641	3,774		313	3,377	3,690		725
Low brass	312	2,703		1,575	1,087	2,662		353
Aluminum bronze	137	451		103	319	422		166
Low-grade scrap and residues	4,299	33,872		25,977	7,779	33,756		4,415
Total	26,946	363,987		80,309	282,578	362,887		28,046
Primary producers:								
No. 1 wire and heavy copper	1,836	51,148		25,691	25,932	51,623		1,361
No. 2 wire, mixed heavy and light copper	6,676	132,227		87,881	45,257	133,138		5,765
Refinery brass	1,940	19,295		10,860	9,346	20,206		1,029
Low-grade scrap and residues	51,619	212,347		77,887	153,284	231,171		32,795
Total	62,071	415,017		202,319	233,819	436,138		40,950
Brass mills: [1]								
No. 1 wire and heavy copper	6,044	112,039		102,540	9,499	112,039		10,925
No. 2 wire, mixed heavy and light copper	4,302	48,040		47,999	41	48,040		3,522
Yellow brass	15,258	194,703		194,703		194,703		18,262
Cartridge cases and brass	2,001	49,285		45,357	3,928	49,285		2,824
Bronze	1,036	2,483		2,483		2,483		1,127
Nickel silver	3,595	8,133		8,133		8,133		3,293
Low brass	2,841	21,258		21,258		21,258		4,383
Aluminum bronze	344	261		261		261		342
Mixed alloy scrap	14,673	12,184		12,184		12,184		14,432
Total [1]	50,094	448,386		434,918	13,468	448,386		59,110
Foundries, chemical plants and other manufacturers:								
No. 1 wire and heavy copper	2,315	20,536	470	7,991	12,938	20,929	465	1,927
No. 2 wire, mixed heavy and light copper	1,456	16,636	2,134	5,326	11,283	16,609	1,920	1,697
Composition or red brass	1,716	3,784	17,091	1,733	2,528	4,261	16,802	1,528
Railroad-car boxes	2,058	41,483	1,857		41,431	41,431	1,817	2,150
Yellow brass	1,238	9,273	6,656	3,668	4,245	7,913	7,593	1,661
Auto radiators (unsweated)	385	7,097	598		6,746	6,746	2	1,332
Bronze	1,047	2,920	1,259	1,328	1,155	2,483	1,402	1,341
Nickel silver	35	81	90		84	84	102	20
Low brass	468	656	1,924	47	206	253	2,345	450
Aluminum bronze	265	457	204	186	268	454	211	261
Low-grade scrap and residues	1,493	12,326	2,775	2,115	9,573	11,688	2,740	2,166
Total	12,476	115,249	35,058	[2] 22,394	[2] 90,457	112,851	35,399	14,533

See footnotes at end of table.

TABLE 23.—Stocks and consumption of copper scrap in the United States in 1963—Continued

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts: Purchased scrap	Receipts: Machine shop scrap	Consumption: Purchased scrap: New	Consumption: Purchased scrap: Old	Consumption: Purchased scrap: Total	Consumption: Machine shop scrap	Stocks Dec. 31
Grand total:[3]								
No. 1 wire and heavy copper	13,030	218,963	470	139,148	80,727	219,875	465	17,004
No. 2 wire, mixed heavy and light copper	15,305	261,487	2,134	148,833	113,387	262,220	1,920	14,006
Composition or red brass	6,548	87,714	17,091	28,548	59,281	87,829	16,802	6,722
Railroad-car boxes	2,325	42,519	1,857		42,509	42,509	1,817	2,375
Yellow brass	22,366	260,650	6,656	205,639	53,771	259,410	7,593	25,673
Cartridge cases and brass	2,059	49,940		45,357	4,553	49,910		2,912
Auto radiators (unsweated)	3,566	58,343	598		57,622	57,622	2	4,883
Bronze	3,726	35,225	1,259	11,516	23,149	34,665	1,402	4,234
Nickel silver	4,271	11,988	90	8,446	3,461	11,907	102	4,038
Low brass	3,621	24,617	1,924	22,880	1,293	24,173	2,345	5,186
Aluminum bronze	746	1,169	204	550	587	1,137	211	769
Low-grade scrap and residues[4]	59,351	277,840	2,775	116,839	179,982	296,821	2,740	40,405
Mixed alloy scrap	14,673	12,184		12,184		12,184		14,432
Total[3]	151,587	1,342,639	35,058	739,940	620,322	1,360,262	35,399	142,639

[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, 933 tons of new and 4,189 old; copper-base alloy scrap, 1,748 tons of new and 9,502 old.
[3] Includes machine-shop scrap receipts and consumption for foundries, chemical plants, and other manufacturers.
[4] Includes refinery brass.

TABLE 24.—Consumption of copper and brass materials in the United States, by principal consuming groups

(Short tons)

Year and item	Primary producers	Brass mills	Wire mills	Foundries, chemical plants, and miscellaneous users	Secondary smelters	Total
1962:						
Copper scrap	400,425	419,925		101,047	343,904	1,265,301
Refined copper[1]		636,149	922,908	31,159	9,460	1,599,676
Brass ingot		6,998		[2] 265,299		272,297
Slab zinc		116,138		3,244	10,423	129,805
Miscellaneous		57		137	5,080	5,274
1963:						
Copper scrap	436,138	448,386		112,851	362,887	1,360,262
Refined copper[1]		673,907	1,036,162	30,552	3,652	1,744,273
Brass ingot		6,550	22	[2] 284,629		291,201
Slab zinc		117,331		3,370	7,536	128,237
Miscellaneous		1		127	8,766	8,894

[1] Detailed information on consumption of refined copper will be found in table 28.
[2] Shipments to foundries by smelters plus decrease in stocks at foundries

TABLE 25.—Foundry consumption of brass ingot, by types, in the United States

(Short tons)

Type of ingot	1954–58 (average)	1959	1960	1961	1962	1963
Tin bronze	13,477	11,257	9,689	11,152	9,677	8,295
Leaded tin bronze	25,123	24,868	23,818	22,876	27,034	25,655
Leaded red brass	148,549	162,798	142,817	149,405	158,047	163,153
High-leaded tin bronze	23,545	19,413	18,076	16,739	17,916	18,850
Leaded yellow brass	17,729	17,344	15,887	12,672	10,632	11,815
Manganese bronze	11,340	9,609	9,540	8,429	8,564	8,497
Hardeners	2,018	2,185	2,268	2,439	2,711	3,889
Nickel silver	3,248	2,921	2,732	2,792	3,303	2,789
Aluminum bronze	(1)	(1)	(1)	(1)	7,688	8,053
Low brass [2]	7,740	7,699	7,365	7,505	928	1,316
Total	252,769	258,094	232,192	234,009	246,500	252,312

[1] Included with low brass.
[2] Includes aluminum bronze for 1954–61.

TABLE 26.—Dealers' monthly average buying price for copper scrap and consumers' alloy-ingot prices at New York in 1963

(Cents per pound)

Grade	Jan.	Feb.	Mar.	Apr.	May	June
No. 2 copper scrap	21.69	22.37	22.30	22.64	22.37	22.37
No. 1 composition scrap	20.41	20.50	20.50	20.90	21.00	21.00
No. 1 composition ingot	32.00	32.00	32.00	32.00	32.00	32.00

Grade	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
No. 2 copper scrap	22.37	22.15	22.00	22.00	22.00	22.00	22.19
No. 1 composition scrap	21.00	20.85	20.75	20.75	20.75	20.75	20.76
No. 1 composition ingot	32.00	32.00	32.00	32.00	32.00	32.00	32.00

Source: Metal Statistics, 1964.

CONSUMPTION

Apparent withdrawals of primary copper rose to 1,423,000 tons in 1963. Demand for copper continued strong throughout the year, and consumption of new copper was the largest since 1953.

Actual consumption of refined copper rose 9 percent to 1,744,300 tons, the highest since compilation of the data was begun in 1945. These data are based on consumers' reports of quantities entering processing, with no adjustments for stock changes of material in process. Unlike table 27, in which only new copper is included as far as possible, table 28 does not distinguish between old and new copper, but includes all copper in refined form. Consumption in every month in 1963 exceeded that of the corresponding month in 1962. The use in September (160,000 tons) exceeded the previous high in December 1955 by 8,700 tons.

The pattern of uses for refined copper was virtually unchanged. Wire mills consumed 59 percent of the total, and brass mills consumed 39 percent.

TABLE 27.—Primary refined-copper supply and withdrawals on domestic account

(Short tons)

Supply and withdrawals	1954-58 (average)	1959	1960	1961	1962	1963
Production from domestic and foreign ores, etc	1,360,741	1,098,247	1,518,927	1,550,139	1,611,730	1,596,351
Imports [1]	179,983	214,058	142,709	66,855	98,820	119,165
Stock Jan. 1 [1]	59,000	48,000	18,000	98,000	49,000	71,000
Total available supply	1,599,724	1,360,305	1,679,636	1,714,994	1,759,550	1,786,516
Copper exports [1]	273,953	158,938	433,762	428,718	336,525	311,479
Stock Dec. 31 [1]	59,000	18,000	98,000	49,000	71,000	52,000
Total	332,953	176,938	531,762	477,718	407,525	363,479
Apparent withdrawals on domestic account [2]	1,267,000	1,183,000	1,148,000	1,237,000	1,352,000	1,423,000

[1] May include some copper refined from scrap.
[2] Includes copper delivered by industry to the government stockpiles.

TABLE 28.—Refined copper consumed, by classes of consumers

(Short tons)

Year and class of consumer	Cathodes	Wire bars	Ingots and ingot bars	Cakes and slabs	Billets	Other	Total
1962:							
Wire mills		913,131	8,964			813	922,908
Brass mills	113,402	42,799	97,090	184,085	198,676	97	636,149
Chemical plants			761			727	1,488
Secondary smelters	7,368		1,928	159		5	9,460
Foundries	5,760	41	8,417	30	327	1,083	15,658
Miscellaneous [1]	1,066	1	7,259	24	602	5,061	14,013
Total	127,596	955,972	124,419	184,298	199,605	7,786	1,599,676
1963:							
Wire mills		1,024,093	11,271			798	1,036,162
Brass mills	145,271	44,250	87,832	186,876	209,576	102	673,907
Chemical plants			726			512	1,238
Secondary smelters	1,906		1,731	11		4	3,652
Foundries	3,575	118	7,584	12	413	1,450	13,152
Miscellaneous [1]	1,163		9,114	23	572	5,290	16,162
Total	151,915	1,068,461	118,258	186,922	210,561	8,156	1,744,273

[1] Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and miscellaneous manufacturers.

STOCKS

Inventories of refined copper held by producers decreased from 71,000 tons at the beginning of 1963 to 44,800 tons by May 31. During the next 7 months, stocks of refined metal fluctuated and were 52,000 tons at yearend. Stocks of unrefined materials increased 2 percent during the year.

TABLE 29.—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]	Year	Refined copper [1]	Blister and materials in process of refining [2]
1954–58 (average)	59,000	236,000	1961	49,000	236,000
1959	18,000	253,000	1962	71,000	246,000
1960	98,000	261,000	1963	52,000	252,000

[1] May include some copper refined from scrap.
[2] Includes copper in transit from smelters in the United States to refineries therein.

Fabricators' stocks of refined copper were 475,000 tons December 31, an increase of 2 percent over those of the like date in 1962. Working stocks were 382,700 tons at yearend, slightly less than at the beginning of the year.

On December 31, inventories in Government stockpiles totaled 1,121,691 tons. Of this quantity, 1,008,255 tons was in the national (strategic) stockpile, 102,183 tons was in Defense Production Authority inventory, and 11,253 tons in the supplemental stockpile. Included in these data were 31,241 tons of oxygen-free high-conductivity copper in the national stockpile and 5,199 tons in supplemental stockpile. Also included were 2,149,758 pounds of beryllium-copper master alloy in the national stockpile and 12,623,973 pounds in the supplemental stockpile.

TABLE 30.—Stocks of copper in fabricators' hands Dec. 31

(Short tons)

Year	Stocks of refined copper [1] (1)	Unfilled purchases of refined copper from producers (2)	Working stocks (3)	Unfilled sales to customers (4)	Excess stocks over orders booked [2] (5)
1959	414,757	130,324	340,349	202,775	1,957
1960	456,094	75,222	370,055	126,260	35,001
1961	461,252	89,745	361,286	144,344	45,367
1962	465,592	81,297	385,239	138,089	23,561
1963	474,875	100,357	382,692	163,558	28,982

[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.

PRICES

Copper-selling agencies indicated that 1,329,480 tons of domestic refined copper was delivered to purchasers at an average price of 30.8 cents a pound. The average price for foreign copper delivered in the United States was 30.7 cents a pound.

December 31 marked the end of more than 30 months during which the primary producers' price for copper remained unchanged at 31 cents a pound, delivered. Custom-smelter prices and producers' prices were the same since May 1961. For this reason American Metal Market discontinued publishing custom-smelter price in July, a service that began in September 1955.

London Price.—The price of copper on the London Metal Exchange averaged £234 6s. 7d. per long ton in January. Monthly average prices varied from a high of £234 3s. 2d. in June to a low of £234 2s. 6d. in March and August–October. They began to rise in November and reached the year's high of £235 13s. 6d. (29.42 cents) for December. The average price for the year was virtually unchanged from 1962.

TABLE 31.—Average weighted prices of copper deliveries,[1] consumer plants

(Cents per pound)

Year	Domestic copper	Foreign copper	Year	Domestic copper	Foreign copper
1959	30.7	31.6	1962	30.8	30.6
1960	32.1	32.5	1963	30.8	30.7
1961	30.0	30.4			

[1] Covers copper produced in the United States and delivered here and abroad and copper produced abroad and delivered in the United States; excludes copper both produced and delivered abroad, whether or not handled by U.S. selling agencies.

TABLE 32.—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	1962				1963			
	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	30.82	30.600	28.060	28.92	30.82	30.600	28.433	29.32
February	30.82	30.600	28.620	29.53	30.82	30.600	28.439	29.30
March	30.82	30.600	28.600	29.51	30.82	30.600	28.400	29.27
April	30.82	30.600	28.598	29.43	30.82	30.600	28.404	29.28
May	30.82	30.600	28.545	29.40	30.82	30.600	28.405	29.26
June	30.82	30.600	28.571	29.35	30.82	30.600	28.396	29.27
July	30.82	30.600	28.538	29.33	30.82	30.600	28.397	29.28
August	30.82	30.600	28.564	29.31	30.82	30.600	28.409	29.26
September	30.82	30.600	28.588	29.28	30.82	30.600	28.390	29.24
October	30.82	30.600	28.529	29.29	30.82	30.600	28.389	29.24
November	30.82	30.600	28.488	29.29	30.82	30.600	28.380	29.25
December	30.82	30.600	28.466	29.30	30.82	30.600	28.515	29.42
Average	30.82	30.600	28.514	29.33	30.82	30.600	28.413	29.25

[1] American Metal Market.
[2] E&MJ Metal and Mineral Markets.
[3] Metal Bulletin (London).
[4] Based on average monthly rates of exchange by Federal Reserve Board.

FOREIGN TRADE

Imports.—Imports of unmanufactured copper rose for the third consecutive year and exceeded those of 1962 by 13 percent. Again Chile was the chief source of foreign copper, supplying 42 percent of the total. Peru regained second place with 18 percent of the total, and Canada was in third place with 17 percent of the total.

Imports of refined copper exceeded those of 1962 by 21 percent, mainly because of increased receipts from Belgium-Luxembourg, Chile, and Peru. Canada remained the chief source of refined copper, although shipments were 5 percent less than in 1962. Receipts of blister copper rose 11 percent because the increased supply from Peru and the Republic of South Africa more than offset a decrease from Chile.

Exports.—Refined copper was the principal class of export, and shipments were 8 percent less than in 1962. Total exports of copper scrap and brass and bronze scrap remained virtually unchanged from those of 1962. Japan, Spain, and Yugoslavia were the principal destinations of scrap copper in 1963. Japan received 91 percent of the scrap brass and bronze exported, compared with 90 percent in 1962.

Tariff.—As the price of copper remained above 24 cents per pound throughout 1963, the 1.7-cent-per-pound excise tax, effective July 1, 1958, was applicable to imported copper.

TABLE 33.—U.S. imports [1] of copper (unmanufactured), by classes and countries

(Short tons, copper content)

Year and country	Ore	Concentrates	Matte	Blister	Refined	Scrap	Total
1954–58 (average)[2]	11,598	98,659	6,476	271,116	179,983	7,170	575,002
1959	7,330	65,311	8,949	269,048	214,058	6,195	570,891
1960	9,982	65,536	5,049	298,373	142,709	2,695	524,344
1961	8,937	36,851	1,606	339,189	66,855	4,231	457,669
1962:							
North America:							
Canada	298	17,730	148	53	76,600	3,924	98,753
Mexico	148	96		23,473	8	54	23,779
Other			2			366	368
Total	446	17,826	150	23,526	76,608	4,344	122,900
South America:							
Chile	17	5		224,516	856		225,394
Peru	1,788	4,628	483	65,234			72,133
Other	211	1,369				28	1,608
Total	2,016	6,002	483	289,750	856	28	299,135
Europe:							
Finland					709		709
United Kingdom				1	845		846
Other			1		21	17	39
Total			1	1	1,575	17	1,594
Asia:							
Philippines	2	10,123	1				10,126
Other						35	35
Total	2	10,123	1			35	10,161

See footnotes at end of table.

TABLE 33.—U.S. imports [1] of copper (unmanufactured), by classes and countries—Continued

(Short tons, copper content)

Year and country	Ore	Concentrates	Matte	Blister	Refined	Scrap	Total
Africa:							
Rhodesia and Nyasaland, Federation of			(3)		18,997		18,997
South Africa, Republic of	1,682	4,069		18,409		300	24,460
Other					784		784
Total	1,682	4,069	(3)	18,409	19,781	300	44,241
Oceania:							
Australia	751						751
Other						69	69
Total	751					69	820
Grand total	4,897	38,020	635	331,686	98,820	4,793	478,851
1963: [4]							
North America:							
Canada	15,570		190	50	73,126	1,814	90,750
Mexico	275		126	21,885		58	22,344
Other			2			195	197
Total	15,845		318	21,935	73,126	2,067	113,291
South America:							
Chile	1,499			219,344	6,729	338	227,910
Peru	8,868		325	81,083	9,450		99,726
Other	1,462		65		23	50	1,600
Total	11,829		390	300,427	16,202	388	329,236
Europe:							
Belgium-Luxembourg					12,653	4	12,657
United Kingdom					815	249	1,064
Other					332	132	464
Total					13,800	385	14,185
Asia:							
Philippines	14,869		38				14,907
Other					47	43	90
Total	14,869		38		47	43	14,997
Africa:							
Rhodesia and Nyasaland, Federation of				10,910	11,191		22,101
South Africa, Republic of	4,946			31,309	94	19	36,368
Other				4,480	4,698		9,178
Total	4,946			46,699	15,983	19	67,647
Oceania:							
Australia	1,149						1,149
Other					7	21	28
Total	1,149				7	21	1,177
Grand total	48,638		746	369,061	119,165	2,923	540,533

[1] Data are "general" imports, that is, they include copper imported for immediate consumption plus material entering the country under bond.

[2] Some copper in "Ore" and "Other" from the Philippines is not separately classified and is included with "Concentrates."

[3] Less than 1 ton.

[4] Due to changes in classification ore and concentrates no longer separately classified. Matte and blister not strictly comparable to earlier years.

Source: Bureau of the Census.

TABLE 34.—U.S. imports [1] of copper (unmanufactured), by countries

(Short tons, copper content)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	102,494	112,318	117,641	78,354	98,753	90,750
Mexico	50,295	29,493	22,656	20,963	23,779	22,344
Other	18,083	11,219	6,758	308	368	197
Total	170,872	153,030	147,055	99,625	122,900	113,291
South America:						
Bolivia	3,914	1,790	1,346	905	1,580	1,520
Chile	233,298	241,392	208,167	226,971	225,394	227,910
Peru	33,694	28,725	91,624	90,435	72,133	99,726
Other	550	464	11	(2)	28	80
Total	271,456	272,371	301,148	318,311	299,135	329,236
Europe:						
Belgium-Luxembourg	481	8,504	2,673			12,657
France	1,311	1,125	526		1	125
Germany, West	2,626	24,342	8,739	14		2
Malta, Gozo and Cyprus	5,436	3,524				
Netherlands	543	727	506		23	334
Norway	2,360	50	248			
Sweden	1,006	3,428	2,789			
United Kingdom	4,926	13,436	781	1,316	846	1,064
Other	1,238	1	5,150	11	724	3
Total	19,927	55,137	21,412	1,341	1,594	14,185
Asia:						
Philippines	14,261	13,759	17,562	13,898	10,126	14,907
Turkey	2,677	1,094	547			
Other	230	41	2		35	90
Total	17,168	14,894	18,111	13,898	10,161	14,997
Africa:						
Congo, Republic of the, and Ruanda-Urundi [3]	13,640	4,335	196			
Rhodesia and Nyasaland, Federation of [4]	48,706	32,622	5,795	10	18,997	22,101
South Africa, Republic of [5]	19,395	30,981	28,228	23,474	24,460	36,368
Other	217	49	625	21	784	9,178
Total	81,958	67,987	34,844	23,505	44,241	67,647
Oceania:						
Australia	13,620	7,472	1,774	826	751	1,149
Other	1			163	69	28
Total	13,621	7,472	1,774	989	820	1,177
Grand total	575,002	570,891	524,344	457,669	478,851	540,533

[1] Data are "general" imports; that is, they include copper imported for immediate consumption plus material entering the country under bond.
[2] Less than 1 ton.
[3] Before July 1, 1960, classified as Belgian Congo.
[4] Before July 1, 1954, classified as Southern and Northern Rhodesia.
[5] Before Jan. 1, 1962, classified as Union of South Africa.

Source: Bureau of the Census.

TABLE 35.—U.S. imports for consumption of old brass and clippings from brass or Dutch metal [1]

Year	Short tons		Value (thousands)	Year	Short tons		Value (thousands)
	Gross weight	Copper content			Gross weight	Copper content	
1954-58 (average)	7,645	5,021	[2] $2,797	1961	608	390	$173
1959	2,054	1,257	698	1962	2,141	1,289	738
1960	566	309	184	1963	1,516	945	558

[1] For remanufacture.
[2] Data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 36.—U.S. imports for consumption of copper (copper content), by classes [1]

Year	Ore		Concentrates		Matte	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1954-58 (average) [2]	9,325	$5,394	88,256	$51,565	5,456	$3,477
1959	60	20	9,299	5,505	7,113	4,260
1960	3,503	2,016	20,935	12,391	185	80
1961	2,587	1,526	21,914	12,516	95	57
1962	116	202	2,206	1,212	22	12
1963 [3]	([3])	([3])	11,498	6,567	[4] 2,800	[4] 1,674

Year	Blister		Refined		Scrap		Total value (thousands)
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	
1954-58 (average)	245,388	$160,911	179,236	$119,475	6,886	$4,060	$344,882
1959	203	126	237,304	146,478	2,984	1,635	158,024
1960	486	311	171,021	109,490	1,836	1,106	125,394
1961	5,929	3,508	87,206	51,852	1,643	870	70,329
1962	1,119	669	[5] 130,197	[5] 76,995	3,846	2,242	[5] 81,332
1963	[4] 119,231	[4] 72,502	123,149	71,342	2,195	1,259	153,344

[1] Excludes imports for manufacture in bond and export, classified as "imports for consumption" by the Bureau of the Census.
[2] Some copper in "Ore" and "Other" from the Philippines is not separately classified and is included with concentrates.
[3] Figures for ore and concentrates are combined as of 1963.
[4] Due to changes in classification data not comparable to earlier years.
[5] Revised figure.

Source: Bureau of the Census.

TABLE 37.—U.S. exports of copper by classes and countries

(Short tons)

Year and destination	Ore, concentrates, matte, (copper content)	Refined	Scrap	Pipes and tubing	Plates and sheets	Wire and cable, bare	Wire and cable, insulated	Other copper manufactures
1954-58 (average)	11,223	273,953	40,684	1,401	322	7,755	17,653	1,156
1959	2,982	158,938	10,721	799	313	3,378	21,863	4,352
1960	11,111	433,762	58,860	726	500	3,278	13,368	5,181
1961	4,478	428,718	35,257	949	355	1,995	15,550	7,362
1962	1,916	336,525	12,608	864	349	2,875	13,364	6,768
1963:								
North America:								
Canada	84	4,130	283	129	141	243	1,420	460
Mexico	----------	160	----------	72	28	16	213	10
Other	----------	41	21	266	28	244	2,147	17
Total	84	4,331	304	467	197	503	3,780	487
South America:								
Argentina	----------	1,811	----------	1	(1)	3	47	2
Brazil	----------	5,117	----------	23	2	1	35	48
Colombia	----------	5	----------	10	4	59	276	1,417
Venezuela	(1)	82	----------	46	10	31	222	2,832
Other	----------	60	----------	40	2	72	1,199	9
Total	(1)	7,075	----------	120	18	166	1,779	4,308
Europe:								
Belgium-Luxembourg	----------	3,504	39	3	1	11	82	(1)
France	----------	38,039	----------	5	10	7	102	24
Germany, West	209	69,227	39	9	6	11	123	(1)
Italy	117	56,239	49	12	3	22	114	2
Netherlands	----------	7,973	38	1	----------	6	145	----------
Norway	----------	2,633	----------	4	1	----------	8	----------
Spain	----------	1,134	1,126	12	5	10	130	----------
Sweden	----------	4,507	30	2	----------	2	37	3
Switzerland	----------	4,451	----------	1	----------	----------	20	113
United Kingdom	335	33,082	----------	1	58	13	346	1
Yugoslavia	----------	551	3,727	4	----------	2	105	----------
Other	----------	2,823	----------	12	15	53	767	673
Total	661	224,163	5,048	66	99	137	1,979	816
Asia:								
India	----------	55,540	385	94	3	983	1,895	112
Japan	463	15,499	7,924	48	----------	20	81	33
Taiwan	----------	988	----------	8	----------	25	175	22
Other	2	1,928	29	309	15	469	4,770	30
Total	465	73,955	8,338	459	18	1,497	6,921	197
Africa	----------	853	----------	42	6	846	592	3
Oceania	----------	1,102	----------	4	(1)	1	94	(1)
Grand total	1,210	311,479	13,690	1,158	338	3,150	15,145	5,811

[1] Less than 1 ton.

Source: Bureau of the Census.

TABLE 38.—U.S. exports of copper by classes

Year	Ore, concentrates, and matte (copper content)		Refined copper and semimanufactures		Other copper manufactures		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1954-58 (average)	11,223	$7,652,924	341,768	$234,968,314	1,156	$966,458	354,147	$243,587,696
1959	2,982	1,808,289	196,012	128,577,107	4,352	3,280,116	203,346	133,665,512
1960	11,111	6,832,050	510,494	327,935,628	5,181	4,006,049	526,786	338,773,727
1961	4,478	2,474,679	482,824	295,397,080	7,362	5,260,315	494,664	303,132,074
1962	1,916	1,045,181	366,585	234,604,915	6,768	5,106,603	375,269	240,756,699
1963	1,210	638,177	344,960	225,648,628	5,811	4,273,403	351,981	230,560,208

Source: Bureau of the Census.

TABLE 39.—U.S. exports of copper-base alloy (including brass and bronze), by classes

Class	1962		1963	
	Short tons	Value	Short tons	Value
Ingots	343	$466,053	592	$639,883
Scrap and other forms	36,209	15,524,912	34,717	14,606,864
Bars, rods, and shapes	910	1,462,956	787	1,142,617
Plates, sheets, and strips	1,138	2,298,631	667	1,708,756
Pipes and tubing	1,763	2,496,430	2,119	3,254,869
Pipe fittings	1,376	3,384,113	1,129	2,859,190
Plumbers' brass goods	2,008	5,488,976	2,341	6,302,835
Welding rods and wire	785	1,844,610	973	1,993,378
Castings and forgings	933	2,353,930	569	1,254,468
Powder	519	576,257	541	678,012
Semifabricated forms, not elsewhere classified	46	126,858	59	146,414
Total	46,030	36,023,726	44,494	34,587,286

Source: Bureau of the Census.

TABLE 40.—U.S. exports of unfabricated copper-base alloy [1] ingots, bars, rods, shapes, plates, sheets, and strips

Year	Short tons	Value	Year	Short tons	Value
1954-58 (average)	2,209	$3,028,289	1961	1,705	$3,658,503
1959	1,471	2,874,206	1962	2,391	4,227,640
1960	1,920	4,235,521	1963	2,046	3,491,256

[1] Includes brass and bronze.

Source: Bureau of the Census.

TABLE 41.—U.S. exports of copper sulfate (blue vitriol)

Year	Short tons	Value	Year	Short tons	Value
1954-58 (average)	27,643	$5,981,766	1961	7,575	$1,542,212
1959	2,672	674,522	1962	1,916	455,665
1960	14,841	3,376,649	1963	851	227,758

Source: Bureau of the Census.

TABLE 42.—U.S. imports and exports of brass and copper scrap

(Short tons)

	1954-58 (average)	1959	1960	1961	1962	1963
Imports for consumption:						
Brass scrap (gross weight)	7,645	2,054	566	608	2,141	1,516
Copper scrap (copper content)	6,886	2,984	1,836	1,643	3,846	2,195
Exports:						
Copper-base alloy scrap (new and old)	57,643	29,406	122,175	116,654	36,209	34,017
Copper scrap	40,683	10,721	58,860	35,257	12,608	13,690

Source: Bureau of the Census.

TABLE 43.—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 (gross weight)		Unalloyed copper scrap		Copper alloy scrap	
	1962	1963	1962	1963	1962	1963	1962	1963
North America:								
Canada	3,136	1,450	1,503	1,133	181	283	179	292
Mexico	41	58	97	50	-------	(1)	20	36
Other	247	189	458	211	-------	21	25	-------
Total	3,424	1,697	2,058	1,394	181	304	224	328
South America	-------	1	-------	9	-------	-------	4	10
Europe:								
France	-------	-------	-------	-------	-------	-------	255	418
Germany West	-------	(1)	9	-------	-------	39	595	725
Italy	-------	-------	-------	-------	111	49	2,569	218
Netherlands	2	3	28	-------	440	38	52	2
Spain	-------	-------	-------	-------	4,428	1,126	124	61
Sweden	-------	-------	-------	1	-------	30	-------	765
United Kingdom	-------	249	-------	112	-------	-------	514	95
Yugoslavia	-------	-------	-------	-------	3,580	3,727	-------	-------
Other	15	7	-------	-------	241	39	28	120
Total	17	259	37	113	8,800	5,048	4,137	2,404
Asia:								
India	-------	-------	-------	-------	712	385	141	205
Japan	34	43	-------	-------	2,904	7,924	31,568	31,623
Other	1	-------	4	-------	11	29	135	145
Total	35	43	4	-------	3,627	8,338	31,844	31,973
Africa	300	174	-------	-------	-------	-------	-------	2
Oceania	70	21	42	-------	-------	-------	-------	-------
Grand total	3,846	2,195	2,141	1,516	12,608	13,690	36,209	34,717

[1] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW

World production of copper in 1963 increased 3 percent over that of 1962, thereby continuing the upward trend for the fifth consecutive year. New records were set in Australia, Canada, Chile, Northern Rhodesia, Philippines, Republic of South Africa, and South-West Africa. Notable increases in production were made in Mexico and Peru. Production in Yugoslavia increased 20 percent and an increase of 7 percent was indicated in the estimate of the output in the U.S.S.R. Mine production in the United States decreased 1 percent and output in the Republic of the Congo dropped 9 percent as a result of strife in January and local stoppages later in the year.

TABLE 44.—World mine production of copper (content of ore) recoverable where indicated, by countries [1] [2]

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada [3]	337,562	395,269	439,262	439,088	457,385	458,396
Cuba	17,766	9,942	[4] 13,058	[5] 5,500	[5] 6,100	[5] 6,600
Haiti	-----	-----	1,000	3,832	6,738	6,553
Mexico	63,914	63,134	66,502	54,359	51,945	61,576
Nicaragua	-----	1,001	5,398	6,919	8,016	8,028
United States [3]	1,000,877	824,846	1,080,169	1,165,155	1,228,421	1,213,166
Total	1,420,119	1,294,192	1,605,389	1,674,853	1,758,605	1,754,319
South America:						
Argentina	419	201	569	607	446	-----
Bolivia (exports)	4,054	2,460	2,503	2,294	2,646	3,300
Brazil [5]	[6] 1,100	1,200	1,200	1,900	1,800	1,700
Chile	493,762	602,108	591,330	607,233	653,613	662,565
Ecuador		149	110	111	174	423
Peru	52,662	[3] 54,914	[3] 200,313	[3] 218,315	[3] 183,854	195,521
Total	552,019	661,032	796,025	830,460	842,533	863,509
Europe:						
Albania [5]	950	2,200	2,400	2,600	2,800	2,800
Austria	2,811	2,726	2,188	2,105	2,190	2,078
Bulgaria [5]	7,000	11,000	12,000	19,600	21,500	20,300
Finland	26,103	32,400	31,100	37,500	38,700	37,400
France [7]	454	592	619	402	456	418
Germany:						
East [5]	20,300	20,800	20,900	27,600	28,100	30,900
West	1,540	1,963	1,960	2,393	2,202	2,443
Ireland	[8] 5,291	4,737	6,883	6,534	2,632	-----
Italy [9]	2,651	3,941	3,301	2,658	2,718	[5] 4,200
Norway	16,235	15,828	16,966	15,379	17,124	12,135
Poland [5]	7,200	9,900	11,600	12,900	15,100	14,600
Portugal	717	791	579	622	574	[5] 550
Spain [10]	8,141	12,136	8,785	20,029	20,580	26,275
Sweden	18,131	19,079	19,265	20,047	21,054	21,000
U.S.S.R. [5] [11] [12]	420,000	480,000	550,000	600,000	720,000	770,000
Yugoslavia	35,261	38,141	36,682	41,787	57,008	68,446
Total [5] [11]	573,000	656,000	725,000	812,000	953,000	1,014.000
Asia:						
Burma [5]	145	165	160	125	165	190
China [5]	16,000	55,000	77,000	88,000	99,000	99,000
Cyprus (exports)	[10] 35,204	39,979	39,096	31,586	27,734	29,000
India	8,752	8,929	9,700	9,700	10,913	11,034
Israel	-----	4,938	6,151	6,893	6,514	8,267
Japan	83,985	93,970	98,307	106,273	114,221	117,968
Korea:						
North	3,100	5,900	[5] 6,600	[5] 6,600	[5] 8,800	[5] 8,800
Republic of	916	370	454	351	474	678
Philippines	32,228	54,587	48,513	57,182	60,327	70,201
Taiwan	1,580	1,793	2,315	2,460	2,323	1,785
Turkey	28,188	30,551	30,110	31,793	31,115	28,305
Total [5] [11]	210,000	296,000	318,000	341,000	362,000	375,000

See footnotes at end of table.

TABLE 44.—World mine production of copper (content of ore) recoverable where indicated, by countries [1] [2]—Continued

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
Africa:						
Algeria	325	94	152	732	859	1,142
Angola	1,587	1,932	2,113	1,022	1,965	143
Congo, Republic of	----------	----------	----------	176	926	320
Congo, Republic of the (formerly Belgian) [12]	261,404	310,955	333,175	325,402	325,442	297,540
Morocco	881	1,306	1,389	1,915	2,752	2,011
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	440,174	598,835	635,326	633,139	619,856	648,239
Southern Rhodesia	3,013	12,016	15,128	15,243	15,146	18,489
South Africa, Republic of	50,541	54,066	50,847	51,743	45,638	60,793
South-West Africa	25,821	34,392	22,597	27,778	24,971	35,774
Tanganyika [13]	1,070	1,210	1,404	111	----------	----------
Uganda [12]	[14] 8,719	13,377	16,257	14,742	17,173	17,875
Total	793,535	1,028,183	1,078,388	1,072,003	1,054,728	1,082,326
Oceania: Australia	62,292	106,344	122,567	107,102	123,849	128,185
World total (estimate)	3,610,000	4,040,000	4,650,000	4,840,000	5,090,000	5,220,000

[1] Czechoslovakia, Iran, and Hungary also produce copper, but production data are not available. Kenya and Malaya also produce a small amount of copper. No estimates for these countries are included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Recoverable.
[4] Exports.
[5] Estimate.
[6] Average annual production 1955–58.
[7] Includes copper content of auriferous ores.
[8] One year only as 1958 was the first year of commercial production.
[9] Includes copper content of cupriferous pyrites.
[10] According to Yearbook of American Bureau of Metal Statistics. This data does not include content of iron pyrites, the copper content of which may or may not be recovered.
[11] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[12] Smelter production.
[13] Copper content of exports and local sales.
[14] Average annual production 1956–58.

TABLE 45.—World smelter production of copper, by countries [1]

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	304,720	365,366	417,029	406,359	382,502	378,911
Mexico	55,914	61,105	64,861	52,498	50,177	60,005
United States [2]	1,106,195	841,795	1,233,629	1,207,354	1,322,614	1,296,700
Total	1,466,829	1,268,266	1,715,519	1,666,211	1,755,293	1,735,616
South America:						
Brazil [3]	1,135	1,984	1,336	1,829	1,984	[4] 1,984
Chile	461,556	570,593	556,464	578,068	614,235	613,977
Peru	37,517	38,024	181,650	200,699	164,920	173,471
Total	500,208	610,601	739,450	780,596	781,139	789,432

See footnotes at end of table.

TABLE 45.—World smelter production of copper, by countries [1]—Continued

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
Europe:						
Albania	849	1,109	1,041	1,421	[4] 1,400	[4] 2,000
Austria	10,423	11,601	12,964	13,044	14,186	14,385
Bulgaria	4,916	12,236	17,747	20,834	21,385	22,622
Finland	27,048	35,941	34,140	37,800	37,400	41,664
Germany:						
East [4]	28,100	33,000	35,000	35,000	35,000	38,600
West [5]	279,809	310,729	340,695	335,488	339,778	333,799
Italy [6]	405	405	35	----------	----------	----------
Norway	16,636	21,218	23,825	24,218	21,051	19,734
Poland	17,953	19,127	23,961	24,504	26,608	32,665
Spain	6,389	12,136	9,041	20,029	20,580	26,275
Sweden	19,999	27,922	23,927	22,822	25,098	25,000
U.S.S.R. [4] [7]	420,000	480,000	550,000	600,000	720,000	770,000
Yugoslavia	34,249	38,858	39,384	34,027	50,421	54,048
Total [4] [7] [8]	867,000	1,004,000	1,112,000	1,169,000	1,313,000	1,381,000
Asia:						
China [4]	16,000	88,000	110,000	110,000	110,000	110,000
India	8,781	8,459	9,822	9,189	10,781	10,561
Japan	104,701	169,318	204,494	232,659	233,828	277,841
Korea:						
North (electrolytic)	2,910	5,480	[4] 9,000	[4] 8,800	[4] 11,000	[4] 11,000
Republic of	681	825	1,113	1,456	2,436	2,621
Taiwan	1,537	1,986	1,962	2,500	2,746	1,633
Turkey	26,461	27,599	28,674	22,040	28,412	27,326
Total [4] [7]	161,000	302,000	365,000	387,000	399,000	441,000
Africa:						
Angola	1,590	1,782	1,744	937	877	112
Congo, Republic of the (formerly Belgian)	261,184	310,955	333,175	325,402	325,442	297,540
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	424,742	595,094	625,942	627,144	603,783	634,946
Southern Rhodesia	----------	----------	----------	12,915	13,599	16,187
South Africa, Republic of	48,590	53,843	50,847	57,562	50,905	60,085
South-West Africa	----------	----------	----------	----------	1,338	22,904
Uganda	[9] 6,886	13,377	16,257	14,742	17,173	17,875
Total	742,992	975,051	1,027,965	1,038,702	1,013,117	1,049,649
Oceania: Australia	53,652	76,712	79,561	69,997	97,818	99,076
World total (estimate)	3,790,000	4,240,000	5,040,000	5,110,000	5,360,000	5,500,000

[1] This table incorporates some revisions. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[2] Smelter output from domestic and foreign ores, exclusive of scrap. Production from domestic ores only, exclusive of scrap, was as follows: 1954–58 (average), 1,006,649 short tons; 1959, 799,329; 1960, 1,142,848; 1961, 1,162,480; 1962, 1,282,126; and 1963, 1,258,126.
[3] Includes secondary copper.
[4] Estimate.
[5] Includes scrap.
[6] In addition Italy produced the following quantities of copper in cement copper in short tons: 1954–58, 5,315; 1959, 6,100; 1960, 5,100; 1961, 5,200; 1962, 4,600; and 1963, not available.
[7] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[8] Belgium reports a large output of refined copper which is believed to be produced principally from crude copper from Congo, Republic of the (formerly Belgian); it is not shown here, as that would duplicate output reported under latter country.
[9] Average annual production 1956–58.

NORTH AMERICA

Canada.—A record output was reported in Canada, where mine production was slightly larger than the previous peak established in 1962. Because of the continuation of curtailments at major producers, decreased production was reported in first and second ranking provinces of Ontario and Quebec. British Columbia was in third place with a record production of 64,000 tons, reflecting an increase of 17 percent over output for 1962. Production began in October at three new producers of copper and zinc in the Matagami Lake area of Quebec. McIntyre Porcupine Mines, Ltd., Timmins, Ontario began copper production in August.

The International Nickel Company of Canada, Ltd., Canada's leading producer, mined 13.6 million tons of ore from mines in Ontario and Manitoba, compared with 13.8 million tons in 1962. The lower output resulted from the continuation of curtailments begun in 1962. Deliveries of copper totaled 126,800 tons (133,600 in 1962), of which more than 90 percent was sold to customers in Canada, the United Kingdom, and other Commonwealth countries.

Falconbridge Nickel Mines, Ltd., delivered 2.1 million tons to treatment plants from company mines in 1963, compared with 2.4 million tons in 1962. The company delivered 14,300 tons of copper to customers, 15 percent less than in 1962.

Geco Mines, Ltd., produced 1.3 million tons of ore from its copper-zinc orebody in the Manitouwadge district, Ontario. The mill produced 87,500 dry tons of 26.12 percent copper concentrate that was shipped to the Noranda smelter. Copper production totaled 22,900 tons.

McIntyre Porcupine Mines, Ltd., began treatment of 800 tons of copper ore a day in August, and 1,000 tons a day were milled by yearend. During this period the concentrator treated 111,400 tons of ore.

Rio Algom Mines, Ltd., (R.A.) milled 258,500 tons of ore produced from the Pater mine. Copper production was 4,700 tons.

In Quebec, mine production of Canada's second ranking copper producer Gaspé Copper Mines, Ltd., subsidiary of Noranda Mines, Ltd., totaled 2.8 million tons of ore. Of the total, 34 percent came from the open-pit mine. The smelter treated 285,900 tons of copper concentrate, smelting, and fluxing ore, of which 75,000 tons was custom concentrate. Anodes produced contained 48,100 tons of copper.

The Horne mine of Noranda Mines, Ltd., produced 1.2 million tons of ore, averaging 1.82 percent copper. The mill treated 819,700 tons of ore and produced 158,000 tons of copper concentrates. A total of 1.6 million tons of ore and concentrates, including 600,000 tons of custom material, was smelted. Total output was 161,500 tons of copper, of which 23,100 tons came from ore and concentrates from the Horne mine.

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TABLE 46.—Canada: Copper production (mine output), by Provinces

(Short tons)

Province	1954-58 (average)	1959	1960	1961	1962	1963 (preliminary)
British Columbia	18,064	8,121	16,559	15,845	54,490	63,964
Manitoba	16,156	12,945	12,793	12,454	12,738	16,954
New Brunswick	1,221				3,674	8,150
Newfoundland	5,785	14,989	13,863	15,752	17,308	14,058
Northwest Territories	120	494	520	463	314	
Nova Scotia	484				204	321
Ontario	151,439	188,272	206,272	211,647	188,995	180,058
Quebec	110,221	134,912	157,470	149,007	147,431	145,019
Saskatchewan	34,072	35,536	31,785	33,479	32,017	30,211
Yukon Territory				441	214	
Total	337,562	395,269	439,262	439,088	457,385	458,735

Source: Dominion Bureau of Statistics, Department of Trade and Commerce, Government of Canada, Preliminary Report on Mineral Production, 1963

Canadian Copper Refiners, Ltd., a subsidiary of Noranda and one of the two electrolytic refineries in Canada, produced 262,000 tons of copper compared with 255,000 tons in 1962.

Normetal Mining Corp., Ltd., milled 345,300 tons of ore, averaging 2.65 percent copper and containing zinc and small quantities of gold and silver. Copper concentrate production of 35,800 tons was shipped to the Noranda smelter and contained 8,600 tons of copper.

In the 1962–63 fiscal year, Campbell Chibougamau Mines, Ltd., milled 772,500 tons of ore averaging 2.02 percent copper. The Henderson Division supplied 346,200 tons or 44.8 percent of the total ore produced. The Main Mine Division produced 202,800 tons compared with 48,400 tons in fiscal year 1961–62. Output at Kokko Creek was 55,000 tons and at Cedar Bay, 168,500 tons, a total drop of 75,300 tons from fiscal year 1961–62. Concentrate shipments totaled 60,100 tons and contained 14,800 tons of copper.

In addition to gold, silver, zinc, and pyrite concentrates, the mill of the Quemont Mining Corp., Ltd., at Noranda, Quebec, produced 52,400 tons of copper concentrates. The concentrates yielded 9,000 tons of copper, 86,850 ounces of gold, and 325,600 ounces of silver.

Sullico Mines, Ltd., a subsidiary of East Sullivan Mines, Ltd., mined 1.0 million tons of ore averaging 0.65 percent copper. Copper production was 6,000 tons.

Solbec Copper Mines, Ltd., a subsidiary of Hastings Mining and Development Co., Ltd., mined and milled 191,000 tons of ore, averaging 1.96 percent copper. The concentrate contained 3,300 tons of copper. Cupra Mines, Ltd., sunk its mine shaft to an ultimate depth of 2,250 feet.

Opemiska Copper Mines (Quebec) Ltd., mined and milled 737,500 tons of ore averaging 2.94 percent copper, compared with 544,500 tons of 2.95 percent copper ore in 1962. Copper in the concentrates was 20,800 tons (16,500 tons in 1962). Because production in 1961 and 1962 was interrupted by strikes, 1963 was the first complete fiscal year of production since 1960.

Vauze Mines, Ltd., milled 115,900 tons of ore from which 3,500 tons of copper was recovered.

Copper Rand Mines Division, The Patiño Mining Corp., milled

624,500 tons of copper ore averaging 2.47 percent copper. Of the total ore, the Copper Rand mine supplied 329,600 tons, Portage mine 210,200 tons, Bouzan mine 50,800 tons, and Jaculet mine 33,900 tons. Production at the Jaculet mine was recessed in July to permit shaft sinking. Copper concentrate contained 16,000 tons of copper.

Willroy Mines, Ltd., produced 483,800 tons of ore averaging 2.02 percent copper from its mine in the Manitouwadge district. Copper concentrate shipped to the Noranda smelter yielded 9,200 tons of blister copper.

Milling copper-zinc ores produced by new mines in the Mattagami Lake area of Quebec began in late 1963. The concentrator of Mattagami Lake Mines, Ltd., began production October 1 and reached its daily capacity of 3,000 tons by December. The plant treated 166,000 tons of ore which yielded 4,600 tons of concentrate averaging 17.7 percent copper. The concentrator of Orchan Mines, Ltd., began treating ore from New Hosco Mines, Ltd., in October and Orchan ore in November.

Production in Manitoba and Saskatchewan rose 5 percent over that of 1962, and these provinces contributed 10 percent of Canada's output. Stall Lake Mines, Ltd., near Snow Lake mined about 3,000 tons of copper-zinc ore a month and shipped it to Flin Flon for treatment.

Hudson Bay Mining & Smelting Co., Ltd., milled 1.6 million tons of ore, of which 57 percent came from the Flin Flon mine, 19 percent from the Chisel Lake, 18 percent from Coronation, 5 percent from Schist Lake, and 1 percent purchased ore. During the year 1,600 tons of development ore was shipped from the Stall Lake mine to the Flin Flon concentrator for test purposes. The smelter treated 370,700 tons of Hudson Bay concentrate and residue and 13,400 tons of custom concentrates. Blister copper output totaled 37,500 tons, and 37,300 tons of refined copper was produced. The main shaft at the Osborne Lake mine was advanced 1,319 feet to a depth of 2,015 feet below the surface.

Sherritt Gordon Mines, Ltd., mined and milled 1.3 million tons of nickel-copper ore. Copper concentrate smelted at Flin Flon contained 6,000 tons of copper (5,300 tons in 1962).

Production of copper in British Columbia continued to rise, and the province contributed 14 percent of Canada's output. Concentrates from the mills were exported for smelting. During fiscal year ended October 31, 1963, Craigmont Mines, Ltd., the largest producer of copper in British Columbia, milled 1.8 million tons of ore that yielded 111,900 tons of concentrate averaging 27.70 percent copper. Most of the concentrate was shipped to Japan and the remainder went to Tacoma, Wash. Bethlehem Copper Corp., Ltd., treated 1.3 million tons of ore that averaged 1.06 percent copper during the fiscal year that ended February 29, 1964, the first full year of operation. The concentrate contained 12,000 tons of copper and was shipped to Japan.

During the period May 1, 1962–May 31, 1963, Cowichan Copper Co., Ltd., produced 18,600 tons of concentrate averaging 25.04 percent copper from claims of Sunro Mines, Ltd. The concentrate was shipped to Japan under terms of a 4-year contract with Mitsui Metal and Smelting Co. and Nippon Mining Co., Ltd.

The Anaconda Company (Canada), Ltd., purchased the Britannia mine from Howe Sound Co. An exploratory and development program was conducted in the mine and 20,000 tons of concentrate was produced.

The Consolidated Mining & Smelting Co. of Canada, Ltd., treated 281,000 tons of ore from the mine of a subsidiary, the Coast Copper Co., Ltd. Concentrate was shipped to Japan for smelting.

Phoenix Copper Co., Ltd., a subsidiary of the Granby Mining Co., Ltd., treated 645,000 tons of ore averaging 0.69 percent copper. Production of saleable copper was 3,400 tons, virtually the same as in 1962.

In New Brunswick, the Consolidated Mining & Smelting Company of Canada, Ltd. (Cominco) mined 263,000 tons of ore at the Wedge mine in 1963. The ore was concentrated in facilities rented from Heath Steele Mines, Ltd. Output was shipped to Japan for smelting.

Production in Newfoundland dropped 19 percent, resulting from mining lower grade ore at two mines. Atlantic Coast Copper Corp., Ltd., milled 376,400 tons of ore yielding 3,200 tons of copper. Maritimes Mining Corp., Ltd., milled 831,600 tons of ore at the Tilt Cove mine. Copper production was 8,700 tons. Repairs were made to surface installations and equipment was installed at the Gullbridge mine to prepare it for production when the Tilt Cove mine ceases operating. American Smelting and Refining Company's McLean mine at Buchans began full production in January 1963. The company milled 376,000 tons of ore that contained 123,400 tons of combined copper, lead, and zinc.

Production of refined copper in Canada totaled 380,200 tons, down 2,300 tons from 1962. Consumption of refined copper rose to 169,400 tons, 17,900 tons more than in the previous peak year 1962.

Exports of copper in ore, concentrate, and matte totaled 92,900 tons, 3 percent less than in 1962. Of the total, 57,300 tons (46,200 tons in 1962) went to Japan, 15,700 (20,700) to the United States, 15,300 (17,200) to Norway, 1,800 (1,800) to the United Kingdom, and 1,000 tons to Belgium-Luxembourg, and 900 tons each to West Germany, and Portugal.

Exports of ingots, bars, and billets were as follows:

Destination:	Short tons 1962	Short tons 1963
United Kingdom	93, 693	98, 703
United States	76, 506	74, 098
India	3, 440	13, 834
Germany, West	11, 907	7, 013
France	13, 928	6, 112
Poland	4, 759	3, 807
Sweden	5, 376	3, 695
Belgium-Luxembourg	4, 951	2, 255
Italy	2, 160	1, 829
Australia	1, 288	448
Other countries	5, 035	3, 193
Total	223, 043	214, 987

In addition, 33,900 tons of rods, strips, sheet, and tubing was exported, of which 7,800 tons went to Norway, 4,700 tons to the United States, 4,700 tons to Switzerland, and 3,500 tons to Pakistan.

These shapes were shipped also to Denmark, New Zealand, the United Kingdom and Venezuela.

Mexico.—Compania Minera de Cananea, S. A. de C. V. produced 32,800 tons of copper, 3 percent less than in 1962. The material was shipped to Cobre de Mexico, Mexico City for refining.

SOUTH AMERICA

Chile.—Despite strikes and work stoppages at the Braden and El Salvador mines, mine production of copper reached a record high of 662,600 tons, a 1 percent increase over that in 1962. The large producers known collectively as the Gran Mineria produced 84 percent of the total.

The Chuquicamata mine of Chile Exploration Co., a subsidiary of The Anaconda Company, produced 303,000 tons of copper, compared with 304,000 tons in 1962. The mine output for the year totaled 47,239,000 tons of ore and waste.

Andes Copper Mining Co., another Anaconda subsidiary, produced 97,200 tons of copper (90,900 tons in 1962) from its El Salvador mine. Operations were interrupted by an 18 day strike.

La Africana mine of Santiago Mining Co., also a subsidiary of Anaconda, produced 27,700 tons of concentrate having a copper content of 27.45 percent, compared with 21,400 tons of concentrate with a copper content of 28.5 percent in 1962.

The Braden Copper Co., a subsidiary of Kennecott Copper Corp., mined and milled 9.4 million tons of ore from the El Teniente mine, compared with 11.5 million tons in 1962. The grade of ore mined was 1.93 percent copper (1.96 in 1962). Refined copper production was 154,900 tons, compared with 181,300 tons in 1962. The lower output was attributed to intermittent strikes and work stoppages.

During the year, the Foreign Investment Committee approved the following applications for foreign capital investment:[3]

Canadian Foreign Ore Development Corp.—US$5 million to develop the Santo Domingo copper mine in Antofagasta Province, including the construction of a 600-ton-per-day leaching plant.

Anaconda's Chile Exploration Co.—US$7.4 million primarily for additional machinery and equipment for the Chuquicamata mine.

Kennecott's Braden Copper Co.—US$1.4 million for additional mining machinery and equipment for the El Teniente mine.

According to a press release issued by the Minister of Mines, Cia. Minera Disputada de las Condes, S.A., requested authorization to invest US$10 million to improve facilities and expand production. The company controlled by the French Société Miniere et Metallurgique de Peñarroya, operated the Disputada and El Soldado mines and Chagres smelter. The investment would permit an increase in concentrate output of from 50,000 tons to 100,000 tons annually by 1968, and blister copper production at the Chagres smelter from about 11,000 (1962 output) to 20,000 tons a year.

In addition to the exports shown in table 47, 48,600 tons of copper in ore and concentrate was shipped; 14,900 tons went to Japan, 12,000 tons to Sweden, 6,400 tons to West Germany, 5,200 tons to Belgium, 4,100 tons to Spain, 3,500 tons to Poland, 1,400 tons to the United States, and 1,100 tons to Peru.

[3] Bureau of Mines. Mineral Trade Notes. V. 58, No. 6, June 1964, pp. 9, 10.

TABLE 47.—Chile: Exports of copper, by principal types

(Short tons)

Destination	1962 [1] Refined Electrolytic	1962 [1] Refined Fire refined	1962 [1] Blister	1962 [1] Total	1963 Refined Electrolytic	1963 Refined Fire refined	1963 Blister	1963 Total
Argentina	3,208	1,173		4,381	6,326	1,377		7,703
Belgium	111	2,273	8,577	10,961	111	2,353	7,376	9,840
Brazil	10,786	9,786		20,572	24,694	7,631	11	32,336
Czechoslovakia		1,343		1,343		225		225
France	10,447	1,053		11,500	8,028	5,708		13,736
Germany, West	27,732	12,534	39,263	79,529	24,006	10,422	41,824	76,252
Italy	16,570	19,448	770	36,788	19,703	15,311	111	35,125
Japan		969		969	110			110
Netherlands	52,297	1,962	84	54,343	40,093	1,510		41,603
Sweden	24,182	1,512	2,105	27,799	28,378	1,566	2,004	31,948
U.S.S.R.		673		673				
United Kingdom	36,021	29,826	44,841	110,688	32,758	38,341	42,924	114,023
United States	883		228,771	229,654	1,898		230,935	232,833
Other countries						45	330	375
Total	182,237	82,552	324,411	589,200	186,105	84,489	325,515	596,109

[1] Revised figures.

Peru.—Mine production of copper totaled 195,500 tons in 1963, an increase of 6 percent over that of 1962. Operations of the Cerro de Pasco Corp. (Cerro-Peru) were uninterrupted, and a new production record of 40,700 tons of copper was established. Purchased ores accounted for 37 percent of the total production (33 percent in 1962). Concentrating copper ore at the largest mine of Cerro-Peru was terminated and the full capacity of the Paragasha concentrator was applied to lead-zinc ore.

At Toquepala, Southern Peru Copper Corp., produced 11.3 million tons of ore, averaging 1.37 percent copper. Blister copper output was 131,000 tons, compared with 126,200 tons in 1962. The increase in production was attributed to a reduction in work stoppages. The grade of ore treated continued to decline as anticipated.

EUROPE

Finland.—Most of the copper, the major nonferrous metal produced in Finland, came from mines of Outokumpu Oy. Ore produced in the Nation totaled 2.7 million tons compared with 2.6 million tons in 1962. Copper production was as follows:

Mine	Ore (short tons)	Copper concentrate (short tons)	Copper (short tons)
Outokumpu	725,400	118,800	26,100
Ylöjärvi	350,200	11,400	2,300
Vihanti	512,100	10,900	3,000
Kotalahti	504,200	3,900	1,000
Pyhasalmi	622,400	25,900	5,000
Total	2,714,300	170,900	37,400

United Kingdom.—Consumption of primary and secondary copper in the United Kingdom (the free world's second largest copper-consuming country) totaled 615,100 tons, compared with 579,900 tons in 1962.[4] In addition 144,200 tons (147,300 in 1962) of copper in scrap was consumed. Of the total consumption of 759,300 tons, 596,300 tons of refined copper and 82,400 tons of scrap were consumed for semi-manufactured products, and 18,700 tons of refined copper and 61,900 tons in scrap were used for castings, copper sulfate, and miscellaneous products. Production of copper sulfate totaled 25,300 tons (25,600 in 1962).

TABLE 48.—United Kingdom: Imports of copper, by countries

(Short tons)

Source	1962			1963		
	Blister	Electro-lytic	Fire refined	Blister	Electro-lytic	Fire refined
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	43,194	213,078	1,540	55,396	193,813	113
Chile	50,250	36,541	29,215	41,831	30,000	38,760
Canada	----------	98,240	----------	----------	106,117	----------
United States	----------	53,275	1,063	----------	31,816	657
Peru	23,024	6,718	----------	14,118	16,505	----------
Australia	----------	3,196	----------	----------	5,720	----------
Germany, West	----------	22,789	----------	----------	755	4,502
Spain	----------	1,915	----------	----------	3,453	----------
Congo, Republic of the	----------	3,080	----------	----------	3,276	----------
Belgium	----------	772	----------	----------	2,392	----------
South Africa, Republic of	----------	----------	1,960	112	----------	1,400
Norway	----------	342	----------	----------	952	----------
Other countries	----------	171	275	----------	315	----------
Total	116,468	440,117	34,053	111,457	395,114	45,432

Source: British Bureau of Nonferrous Metal Statistics.

Exports and reexports of refined copper totaled 64,300 tons (136,000 in 1962). Blister copper had not been reexported since 1957.

TABLE 49.—United Kingdom: Exports and reexports, by countries

(Short tons)

Destination	1962	1963	Destination	1962	1963
Belgium	47,601	34,060	Argentina	2,768	945
Netherlands	7,936	4,724	Finland	----------	890
Egypt	2,498	4,420	Norway	----------	869
Germany:			Czechoslovakia	7,036	560
West	15,221	4,311	France	1,543	18
East	11,173	2,333	Hungary	2,107	----------
Poland	14,632	1,792	Rumania	1,960	----------
Sweden	4,095	1,285	Other countries	5,989	5,755
China	6,269	1,182			
U.S.S.R	5,132	1,120	Total	135,960	64,264

Source: British Bureau of Nonferrous Metal Statistics.

Yugoslavia.—Mine production in 1963 totaled 6.2 million tons of ore with grades between 0.3 and 2.8 percent. Smelter output was 54,000 tons (50,400 tons in 1962).

[4] British Bureau of Nonferrous Metal Statistics. World Non-Ferrous Metal Statistics. V. 17, No. 3, March 1964, p. 13.

It was reported that open-pit mining supplied the bulk of the production at Bor, but it was expected that production by underground methods will exceed that by surface mining in the future. Heterogeneity of ore deposits in underground mines required use of several mining methods.

ASIA

Cyprus.—Cyprus Mines Corp. mined a total of 869,100 tons of ore with an average grade of 2.47 percent copper, compared with 721,400 tons and 2.84 percent in 1962. The Mavrovouni mine produced 726,900 tons, and the Skouriotissa deposit yielded 142,200 tons in the later months of the year. Output in 1963 consisted of 81,300 tons of copper concentrate, 8,100 tons of cupreous pyrite, and 3,000 tons of precipitate. In addition 637,900 tons of pyrite concentrate was produced by flotation. Construction of a new plant for the recovery of copper and pyrite from old tailing was 80 percent complete at yearend.

India.—Production of copper ore totaled 500,000 tons averaging 2.23 percent copper. Refined copper output was 10,600 tons and was all produced at the Indian Copper Corp. refinery near Ghatsila.

Japan.—Mine production of copper rose to 118,000 tons, a 3 percent increase over that of 1962. Production of refined copper totaled 335,200 tons, of which 325,400 tons were electrolytically refined and 9,800 tons were fire refined.

Mitsubishi Group announced that a large copper refinery will be constructed near the Port of Onahama in northeastern Japan by Mitsubishi Metal Mining Co., Ltd., the Furukawa Denka Co., and copper users of the Mitsubishi industrial group.[5] The refinery, scheduled to be completed by September 1965, will have an initial capacity to refine about 5,000 tons a month, and this capacity will be doubled eventually.

Philippines.—Costs of production rose because of increased wages and higher costs of replenishing inventories at a less favorable rate of exchange. Output of copper contained in ore and concentrate totaled 70,200 tons (60,300 tons in 1962). Exports totaled 70,900 tons of contained copper, of which 15,400 tons was shipped to the United States and the remainder went to Japan.

Atlas Consolidated Mining & Development Corp., the largest producer, increased copper output from 25,600 tons in 1962 to 31,300 tons in 1963. The company was sinking a 1,300 foot shaft at the Lutopan orebody and built a pilot plant for leaching waste dumps.

Lepanto Consolidated Mining Co., Ltd., milled 463,500 tons of ore averaging 3.04 percent copper and produced 48,700 tons of concentrate averaging 27.67 percent copper. The output of copper was 13,500 tons (14,300 tons in 1962).

Turkey.—Production of copper declined slightly in 1963. Ore produced totaled 746,000 tons, with an average grade of 3.62 percent copper. Blister copper output was 27,300 tons compared with 28,400 tons in 1962.

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[5] American Metal Market. V. 70, No. 200, Oct. 16, 1963, p. 10.

AFRICA

Congo, Republic of the.—Copper production was about 28,000 tons less than in 1962, because operations of the Union Minière du Haut Katanga were interrupted by political and military disturbances in January. Normal working conditions were reestablished at the beginning of April, but local stoppages occurred after that. Mining was carried on throughout the year at Kipushi and at the Western Group of open-pit mines. However, the ore production rate at the Western Group mines was reduced after July because of a lack of skilled labor to maintain heavy equipment. The second stage of stripping overburden at the Kambove-West open-pit was on schedule and underground mining of the deposit reached its productive stage in August. Open-pit mining continued at reduced rates at Kakanda in keeping with available equipment and maintenance.

A total of 6.0 million tons of ore was produced (10.1 million in 1962). Large quantities of stocked ore were used to offset insufficiences of mine production. The Western Group produced 4.5 million tons of ore (Kamoto 1.5, Musonoi 1.5, Ruwe 1.2, and Kolwezi 0.3). The Kolwezi mine was closed in June after removing equipment and dismantling of installations. In the Southern Group, the Kipushi mine produced 1 million tons and the Ruashi mine produced 15,500 tons until July when work stopped. The Kambove-West open-pit mine in the Central Group produced 200,000 tons. The Kambove-West underground mine, which went into production in September, produced 100,000 tons of ore.

As in the case of the mines, production stopped at the concentrators during the military operations in January 1963. The Kolwezi mill treated 4.2 million tons of ore of which 3.6 million tons was siliceous oxide ore from Kamoto, Musonoi, and stockpiled ore. Musonoi supplied most of the 700,000 tons of mixed oxide-sulfide ore treated in the mill. Production of concentrate totaled 662,000 tons with an average copper content of 25.33 percent copper from oxide ore and 84,900 tons of concentrate with an average grade of 29.60 percent copper from mixed oxide-sulfide ore. The Kipushi concentrator treated 996,700 tons of copper-zinc ore from the Kipushi mine. Differential flotation produced 174,900 tons of 27.66 percent copper concentrate and 193,200 tons of 59.08 percent zinc concentrate. The Kambove concentrator treated 874,300 tons of mixed ore provided principally from stockpiles built in 1962. Production was 118,800 tons of 31.29 percent copper concentrate. A total of 121,000 tons of talcose ore from stockpiles was treated at the Kambove washery and 58,500 tons of product containing 7.18 percent copper was sent to the concentrator. The Kakanda mill treated 559,400 tons of siliceous ore, chiefly from stockpiles. The output was 58,400 tons of concentrate of 24.51 percent copper. The Ruwe washery produced 62,100 tons of concentrate containing 22.24 percent copper and 45,000 tons of 5.62 percent copper product that required further treatment. The Ruashi washing plant treated 68,800 tons of ore that yielded 10,900 tons of concentrate containing 18.87 percent copper and 7,300 tons of products for retreatment containing 7.30 percent copper. The plant was closed and dismantled at the end of August when stocks of ore were depleted.

Production of blister copper at the Lubumbashi smelter was resumed January 15. The Shituru plants reached their normal production at the end of February after a month's shutdown that was caused by military events in January. Operations were further interrupted by incidents in April and May. Operations resumed at the Luilu plants at the end of January and continued at normal capacity during the rest of the year. Total production was as follows:

	Short tons
Lubumbashi (blast furnaces and converters)	77, 014
Shituru (leaching, electrolysis, and refining)	118, 415
Luilu (leaching and electrolysis)	100, 621
Jadotville-Panda electric smelter (copper in cobalt-copper alloy)	196
Recoverable copper in zinc concentrates, and miscellaneous products	119
Total	296, 365

Rhodesia and Nyasaland, Federation of.—In Northern Rhodesia total production of electrolytic and blister copper increased 5 percent and rose to a record level. Growing production capacities and a decision made by producers late in the year to remove self imposed production or sales curtailments more than offset loss of production caused by a 10 week strike at Mufulira and a 55 day work stoppage at Nchanga. Production of electrolytic copper increased 1 percent, but output of blister rose 17 percent, thereby reversing the trend of recent years when blister production progressively decreased with the expansion of electrolytic capacity at the three refineries.

Nchanga's low-grade copper leaching plant operated the entire year, producing a low-grade scavenger oxide concentrate (2 percent copper). The concentrate was treated separately from the high-grade oxide concentrate (12 percent copper). Development of the Chambishi mine was well under way. From April through December, more than 7 million tons of material were removed from the pit which was more than 80 feet deep at yearend. Some production was scheduled for financial year 1964–65 and full output of 28,000 tons of copper was planned for the 1966–67 year.

Roan Antelope Division of Rhodesian Selection Trust, Ltd. (RST Group) produced 6.08 million tons of ore averaging 1.75 percent total copper and 0.17 percent oxide copper in the fiscal year ended June 30, 1963. Roan Extension provided 73.4 percent of the ore, and the remainder came from Roan Basin. A total of 85,700 tons of anode copper was produced and, except for 6,700 tons, was sent to the Ndola plant for electrolytic refining.

Chibuluma Mines, Ltd., mined 577,000 tons of ore averaging 4.27 percent copper in fiscal year ended June 30, 1963. Copper concentrate production totaling 73,400 tons were treated at smelters within the RST Group. Anode copper production was 22,400 tons of fire refinable grade. Output of copper increased 3,700 tons over that of fiscal year 1962, and the increase was attributed to the start of production from the western orebody.

In fiscal year ended June 30, 1963, Mufulira Copper Mines, Ltd., produced 5.09 million tons of ore, averaging 2.76 percent total copper of which 0.09 percent was oxide copper. Anode copper produced totaled 125,200 tons, compared with 127,200 tons in fiscal year 1962.

Nearly 82 percent of the year's output was sent to the refinery, and 98,700 tons of electrolytic copper was produced.

Ndola Copper Refineries, Ltd., produced 100,300 tons of refined copper of which 88.5 percent was for companies of the RST Group. This compares with 107,700 tons and 83 percent in fiscal year 1962.

Mines of Nchanga Consolidated Copper Mines, Ltd., produced 4.4 million tons of ore averaging 5.44 percent copper in the fiscal year ended March 31, 1963. Nchanga West supplied 3 million tons, Nchanga open-pit 1 million tons, and Chingola open-pit 400,000 tons. Ore milled totaled 4.3 million tons that yielded 213,100 tons of copper in concentrate. The flotation plant building was extended, and 80 additional flotation cells were installed. The low-grade oxide concentrate leaching section began operating in December 1962. Production of copper was 197,000 tons—18,000 tons of blister copper and 179,000 tons of electrolytic copper.

Rhokana Corporation, Ltd., mined and milled 5.6 million tons of ore in the fiscal year ending June 30, 1963. Concentrate production was 304,500 tons averaging 37.02 percent copper and 0.85 percent cobalt. The smelter produced 284,900 tons of anode and blister copper, compared with 306,100 tons in the fiscal year 1962. Of the total, 12,000 tons of blister copper and 95,500 tons of anodes were recovered from materials from Rhokana, 14,300 tons of blister and 114,800 tons of anodes for Nchanga and 48,300 tons of blister for Bancroft.

Bancroft Mines, Ltd., mined and milled 1.9 million tons averaging 3.22 percent total copper in fiscal year ended June 30, 1963. Concentrates treated at the Rhokana smelter yielded 48,300 tons of blister copper. Preparations were made during the year for scavenging low-grade oxide concentrate to be sent to Nchanga for leaching.

Rhodesia Copper Refineries, Ltd., produced 257,000 tons of refined copper in the fiscal year ended June 30, 1963, compared with 220,000 tons in fiscal year 1962. The output for fiscal year 1963 consisted of 25,000 tons of cathodes and 232,000 tons of refined shapes.

Copper produced in Southern Rhodesia came from mines of Messina (Transvaal) Development Co., Ltd., and its subsidiary M.T.D. (Mangula) Ltd. In the fiscal year that ended September 30, 1963, 85,100 tons of ore from Umkondo was milled, and 2,000 tons of copper was produced; concentrates from treating 183,400 tons of ore at Alaska contained 2,700 tons of copper. At the Mangula mine, 1.3 million tons of ore milled contained 12,700 tons of copper. Output of the Alaska smelter of the Messina Rhodesia Smelting and Refining Co., Ltd., was 13,400 tons of copper.

South Africa, Republic of.—Most of the copper production from the Republic of South Africa came from two widely separated properties, O'okiep mines near Springbok in Namaqualand and the Messina mine in Northern Transvaal near the Southern Rhodesia border.

O'okiep Copper Co., Ltd., milled 2 million tons of ore averaging 2.12 percent copper in the fiscal year that ended June 30, 1963. The smelter produced 40,800 tons of blister copper compared with 39,700 tons in 1962. Production from the Carolusberg mine and mill began in January and attained a production of 80,000 tons a month at the end of 1963.

The Messina (Transvaal) Development Co., Ltd., milled 1 million tons of ore in the fiscal year that ended September 30, 1963. The concentrate produced contained 12,800 tons of copper.

In August, Palabora Mining Co., Ltd., began construction of facilities to process 33,000 tons of ore a day from its copper deposit in Northeastern Transvaal. The property was expected to be in production in 3 years.

South-West Africa.—Tsumeb Corp., Ltd., mined and milled 658,700 tons, averaging 4.00 percent copper at Tsumeb, and 201,700 tons, averaging 3.79 percent copper at Kombat in the fiscal year that ended June 30, 1963. Sales of copper totaled 21,600 tons compared with 28,100 tons in the fiscal year 1962. Reduced copper sales were attributed to a build up of inventories of blister copper following the start up of the smelter in November 1962.

Uganda.—Kilembe Mines, Ltd., treated 993,400 tons of ore compared with 982,600 tons in 1962. Blister copper production was 17,900 tons (17,200 tons in 1962). Open-pit operations were completed at the Northern Deposit in September and at the Eastern Deposit in December. Deliveries of oxide ore to the mill ceased in September and the grinding units from the oxide mill were moved to the main concentrator.

OCEANIA

Australia.—During the fiscal year ended June 30, 1963, Mount Isa Mines, Ltd., Queensland, a subsidiary of American Smelting and Refining Company, increased production over that of 1962. Ore treated totaled 3.7 million tons (2.7 million in 1962). Refined copper output was 74,000 tons (43,600 tons of refined copper and 14,000 tons of copper in concentrates shipped for treatment overseas in 1962). During the year a new concentrator with a capacity of 1,680 tons was constructed to treat ore from an open-pit mine.

At Mount Morgan, Ltd., Queensland, mine production increased to 1.36 million tons, but the grade of ore declined 0.09 percent copper. As a result, blister copper production decreased to 8,100 tons, which contained 8,000 tons of copper.

The Mount Lyell Mining and Railroad Co., Ltd., Tasmania, mined 2.4 million tons of ore from open-pit and underground mines in the fiscal year ended June 30, 1963. Concentrates produced totaled 61,100 tons, a record high, resulting from a record tonnage treated, better recovery, and an increase in the average grade of ore milled from 0.648 percent copper in 1962 to 0.779 percent in 1963. Blister copper production was 14,900 tons, and electrolytic copper output was 13,100 tons.

TECHNOLOGY

The Bureau of Mines published results of research that demonstrated the feasibility of recovering copper from oxidized ores by the segregation process using a direct-fired, refractory-lined rotary kiln.[6]

[6] McKinney, W. A., and L. G. Evans. Segregation of Copper Ores by Direct-Firing Methods. BuMines Rept. of Inv. 6215, 1963, 15 pp.

Results of laboratory smelting of copper precipitator dust also were published.[7] Poorest results were effected in smelting dry charges and best results were obtained from smelting moist, self-fluxing pellets.

Other publications described a method of computing ore reserves, measurements of the subsidence of the surface above a block-caving mining operation, and a statistical analysis of churn-drill and diamond-drill sample data.[8]

Information was published on mining and concentrating methods used at an open-pit copper mine.[9] The two ore bodies being mined are 2 miles (airline) apart. From time to time it is necessary to move a power shovel from one pit to another and a system has been developed for loading and transporting the shovels on lowboy trailers.

The Copper Development Association was organized in 1963 with a membership that included copper mining companies, smelting and refining firms, fabricating mills, and foundries.[10] The new group assumed the responsibility of virtually all the activities of the Copper and Brass Research Association which ceased operating December 31, 1963.

A long range expansion program designed to offset the steady decline in the grade of copper ore mined began at the ore production and processing facilities of the Utah Copper Division, Kennecott Copper Corp.[11] The first activities of the program were directed toward the mine at Bingham Canyon, Utah, where waste removal from the upper two-thirds of the mine was being converted from rail to truck haulage. Excavation began on cuts 250 and 300 feet deep for haulage roads that will shorten the distance to new waste dumps on the east side of the Oquirrh Mountains.

More man-hours, expense, and auxiliary service vehicles were devoted to the maintenance of the diesel-truck fleet than to all the other equipment in the Berkeley open-pit mine of The Anaconda Company, Butte, Mont.[12] The Berkeley open-pit mine was the largest truck haulage operation in the domestic mining industry, and overseas was exceeded in size only by the Toquepala mine of the Southern Peru Copper Corp. Daily servicing and tire checks, 500-hour checkups, and 5,000-hour overhauls were practices of planned maintenance at the Berkeley pit. Detailed daily status reports were kept and summarized monthly as a truck availability report. Important trends were noted, and steps taken to improve on any of the maintenance practices.

Open-pit and underground mining operations of the Inspiration Consolidated Copper Co. at Miami and Christmas, Ariz., were

[7] Irwin, Mark L., and R. A. Marsyla. Laboratory Smelting of Copper Precipitator Dust. BuMines Rept. of Inv. 6336, 1963, 9 pp.

[8] Hazen, Scott W., Jr. Statistical Analysis of Churn-Drill and Diamond-Drill Sample Data from the San Manuel Copper Mine, Arizona. BuMines Rept. of Inv. 6216, 1963, 124. pp.

Hewlett, R. F. Computing Ore Reserves by the Triangular Method Using a Medium-Size Digital Computer. BuMines Rept. of Inv. 6176, 1963, 30 pp.

Johnson, G. H., and J. H. Soulé. Measurements of Surface Subsidence, San Manuel Mine, Pinal County, Ariz. BuMines Rept. of Inv. 6204, 1963, 36 pp.

[9] Hardwick, W. R. Open-pit Copper Mining and Concentrating Methods and Cost, Silver Bell Unit, American Smelting and Refining Co., Pima County, Ariz. BuMines Inf. Circ. 8153, 1963, 72 pp.

[10] American Metal Market. V. 70, No. 224, Dec. 23, 1963, p. 14.

[11] Skillings Mining Review. Kennecott Copper Corp. to Expand Capacity at Utah Copper by 50% in $100 Million Program. V. 52, No. 8, Feb. 23, 1963, pp. 12–13.

[12] Mining World. Maintenance Control Means Greater Availability for Berkeley Pit. V. 25, No. 12, November 1963, pp. 14–15

described.[13] At the open-pit mine, Inspiration was using a standard 40-ton, single rear axle truck capable of attaining speeds of 14 mph on plus 7 percent grades to counteract the effect of ever-increasing lengths of haul and vertical lifts. Inspiration revised its mining plan at the Christmas mine to include self-loading diesel haulage units as a result of a change in Arizona law that permitted use of diesel powered equipment underground.

Changes in methods of transportation were reported at two open-pit mines in the Southwest. Trolley-electric motors were replaced by diesel-electric motors at the New Cornelia Branch, Phelps Dodge Corp., at Ajo, Ariz.[14] Methods of transportation at the Chino Division, Kennecott Copper Corp., at Santa Rita, N. Mex., were described.[15] When the mine was operated by the Spaniards as early as 1800, Indians climbing chicken-ladders brought ore to the surface in leather buckets. Open-pit operations began in 1910, and several changes were made in haulage methods from then until the autumn of 1963 when rail haulage was phased out. Trucks of 25 ton capacity were added to the haulage system in 1951, and the capacities of the trucks increased to 40, 65, and 85 tons by 1963.

Improved mining techniques developed in 7 years of block caving on the first or 1,475-foot level were of great assistance in planning development and mining on the 2,075-foot (second) level at the San Manuel mine in Pinal County, Ariz.[16] A regular sequence was developed for repairing concrete drift lining broken by ground pressures of as much as 20,000 p.s.i. The first step was to drill through the concrete shell and install rock bolts to hold the large chunks of concrete in place. If weight increased, yieldable steel rings were installed and prestressed after installation to insure uniform loading. Cement grout was sometimes injected into the rock behind the concrete. If pressure continued, the drifts gradually squeezed closed and required reopening. Heavy yieldable sets were installed and used as forms when the drifts were reconcreted.

A mining program with production activities separated from development efforts enabled the White Pine Copper Co., in Michigan, to cut costs and improve the grade of ore mined.[17] A preventative maintenance schedule also reduced costs by increasing the availability rate of equipment.

An article described preparations for breaking a large pillar by a single underground blast at the Murray Mine of the International Nickel Company of Canada, Ltd., Sudbury District, Province of Quebec, Canada.[18] More than 2 million tons of ore were broken when charges were exploded in 5,800 blast holes, totaling more than

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[13] Anderson, T. M. Inspiration's Approach to the Grade Haul Problem. Min. Eng., v. 15, No. 3, March 1963, pp. 42–43 and 52.
Mackintosh, I. B. Inspiration Copper. Mine & Quarry Eng., v. 29, No. 8, August 1963.
Skillings, David N., Jr. New Christmas Mine of Inspiration Copper. Skillings Mining Review, v. 52, No. 30, July 27, 1963, front cover and pp. 4–5.
[14] Mining Congress Journal. V. 49, No. 4, April 1963, p. 86.
[15] Spivey, Rupert. Chino Completes Change Over To Trucks. Min. Eng., v. 16, No. 1, January 1964, pp. 33–35.
[16] Argall, George O., Jr. How San Manuel Used the First Level Experience To Improve Second Level Mining. Min. World, v. 25, No. 8, July 1963, pp. 18–21, 47.
[17] Mining World. White Pine Raises Ore Grade and Cuts Costs. V. 25, No. 9, August 1963, pp. 23–25.
[18] Smith, H. W., and A. R. H. Burford. Pillar Blasting at the Murray Mine. Can. Min. and Met. Bull. (Montreal, Canada), v. 46, No. 165, July 1963, pp. 552–557.

435,800 feet. Each of 10 crews of 2 men, loaded 50 cases of explosives a shift. Wiring the rounds began late in the second week and was completed in about a week.

Details were published concerning the Peterson shaft system and hoisting equipment at the Prain and No. 14 shafts of Mufulira Copper Mines, Ltd., Northern Rhodesia.[19] The Peterson shaft system consists of inclined, subsurface shafts, one for rock, one for rock and men, and one for men and materials. A cage, called the Hippophant, is used in the shaft for men and materials and has the capacity for 220 men. An extensive study showed that substantial savings would be made by using the inclined shafts rather than sinking subsurface vertical shafts or extending existing shafts. The main reasons for choosing inclined shafts were distances vertical shafts would be from the orebody (more than a mile on the 4,000-foot level) and to allow room for a crusher-conveyor system layout.

Operations began at completed divisions of the concentrator erected by The Anaconda Company at Butte, Mont.[20] High-speed conveyor belts moved ore from the primary crushing plant in the Berkeley open-pit mines to the secondary crusher. Grinding mills, 12½ feet in diameter and 22 feet long, were the first to use autogenous grinding on a big scale in the domestic copper industry. By grinding ore on ore, autogenous grinding replaces ball mills in which a heavy charge of steel balls are the grinding agents.

Tests of a flotation column were made on ore from Opemiska Copper Mines, Ltd. (Quebec, Canada).[21] The device is an air column of greater height than surface area and has no moving parts. Flotation reagents act on mineral particles in the same manner as in a conventional flotation cell. It was reported that concentrates were produced with a higher grade than those obtained by conventional methods.

Banner Mining Co. conducted research on recovery of copper from oxide ore in limestone.[22] The experiments were conducted in a 1-ton pilot plant using an alkaline leaching process on which the company holds several patents.

Two articles described salient features of leaching dumps at eight copper mines in Arizona, Nevada, New Mexico, and Utah.[23] The reports contained details on leaching procedures, precipitation plants, and pipe lines at the mines. Metallurgy, mechanics, and commercial application of precipitation of copper at the Weed Heights, Nev., operation of The Anaconda Company were discussed.[24] Composition and purity of the copper-bearing solution, type of iron precipitant

[19] Engineering and Mining Journal. Peterson Shaft Systems Gears for Large Tonnage at Mufulira. V. 164, No. 12, December 1963, pp. 72–76.
Hunt, D. L. Ward Winders at Mufulira Copper Mines. Assoc. Electrical Ind. Eng. (London), v. 3, No. 4, July/August 1963, pp. 181–189.

[20] Engineering and Mining Journal. Test Operations Begin at Butte Copper Concentrator. V. 1641 No. 9, September 1963, p. 108.
Mining World. Anaconda's New Butte Copper Flotation Mill in Operation. V. 25, No. 11, October 1963, p. 21.

[21] Canadian Mining Journal (Gardenvale, Quebec, Canada). The Flotation Column. V. 84, No. 8, August 1963, pp. 55–56.

[22] Skilling, David N., Jr. Serritas Copper Mining Area South of Tucson in Arizona. Skillings Min. Rev., v. 52, No. 32, Aug. 10, 1963, pp. 4–5, 12–13.

[23] Argall, George O., Jr. Leaching Dumps to Recover More Southwest Copper at Lower Cost. Min. World, v. 25, No. 11, October 1963, pp. 22–27; How Leaching Recovers Copper From Waste and Leach Dumps in the Southwest. Min. World, v. 25, No. 12, November 1963, pp. 20–24.

[24] Monninger, Frank M. Precipitation of Copper on Iron. Min. Cong. J., v. 49, No. 10, October 1963, pp. 48–51.

used, solution flow uniformity and velocity, and mechanical design of precipitation components were listed as variables that affect the quality of the precipitate. A new, low grade oxide leaching plant was placed in operation in Northern Rhodesia by Nchanga Consolidated Copper Mines, Ltd.[25] The new plant is part of an overall expansion of the leaching plant that is expected to be completed early in 1964, when productive capacity of the mine will be increased by 1,000 to 1,200 tons of copper a month.

General characteristics of porphyry copper ores in Iron Curtain countries are that they have a higher copper content but are more difficult to treat than domestic porphyry ores.[26] The copper content ranges from 1 to 1.5 percent but a substantial percentage is in the oxide form and difficult to recover. Some of the ores contain almost five times as much molybdenum as the best U.S. copper ore. Poorer recovery is made and lower grade concentrates are produced at Soviet plants, which is attributed to the oxidized condition of the ore or lack of certain reagents.

Czechoslovakian engineers obtained a patent (Czechoslovakian patent 91,406) for using ammonia as a source of hydrogen for scavenging oxygen from molten copper.[27] The use of reformed natural gas instead of wooden poles for scavenging oxygen began at a U.S. smelter in 1961. Advantages claimed for the use of ammonia were highly efficient reduction related to the nacent state of the hydrogen, agitation and purging of the metal by liberated nitrogen, consumption of one-fourth as much ammonia as natural gas, elimination of need for reforming natural gas, and freedom from contaminents. During operating trials, 0.3 percent ammonia by weight reduced the oxygen content of copper from 0.36 percent to 0.015 percent in 7 minutes. Reduction may take 5 to 20 minutes depending on the amount of ammonia, feeding method, and design of the furnace.

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[25] Rhodesian Mining and Engineering (Salisbury, Southern Rhodesia), Plant is Key to Copper Recovery From Waste. V. 28, No. 3, March 1963, p. 27.
South African Mining and Engineering Journal (Johannesburg), Nchanga's New Low-Grade Copper Leaching Plant. V. 74, Pt. 2, No. 3684, Sept. 13, 1963, pp. 801, 802, 804, 814.
[26] Crabtree, E. H. Porphyry Copper Operations in Communistic Countries, Metallurgical Practices, Mines Mag., v. 54, No. 1, January 1964, pp. 20–23.
[27] Chemical Engineering. Ammonia Improves Scavenging of Oxygen in Refining Copper. V. 70, No. 16, Aug. 5, 1963, pp. 48.

Diatomite

By Benjamin Petkof [1]

DOMESTIC diatomite production continued to increase during 1963 and exceeded the previous year's production by about 7 percent. The United States continued to be the world's leading producer of diatomite.

DOMESTIC PRODUCTION

California continued to lead the nation as the largest domestic producer of diatomite. Nevada ranked second with small quantities reported from Washington, Maryland, Arizona, and Oregon. Production was reported by 13 companies operating 15 plants, whereas during the previous reporting year there were 12 companies operating 14 plants. One new company with one plant was added to the list of active producers.

Mining rights to 1,200 acres of diatomaceous earth, located 35 miles southeast of McCloud, Calif., were leased by a private firm from the U.S. Forest Service. A 5-year contract was granted at $1,200 per year and a royalty payment of 50 cents per ton for material removed.[2]

TABLE 1.—Diatomite sold or used by producers in the United States, 3-year totals [1]

	1945–47	1948–50	1951–53	1954–56	1957–59	1960–62
Domestic production (sales)...short tons..	640,764	722,670	908,448	1,105,279	1,349,340	1,446,625
Average value per ton	$20.17	$25.55	$29.97	$39.21	$45.73	$50.08

[1] Annual figures are company confidential.

CONSUMPTION AND USES

Filtration continued to be the largest single use for diatomite, and the proportion sold or used for this purpose increased 4 percent in quantity over that of 1962. However, the share of the total diatomite for filtration decreased about 1 percent. Consumption of filler grade material increased almost 8 percent over the previous year; while the percentage of the total remained unchanged. The quantity used for insulation showed no increase, and its percentage of the total also remained the same. The quantity used in miscellaneous applications increased about 16 percent, but the percentage of the total quantity increased 1 percent. Miscellaneous uses included such items as abrasives, lightweight aggregates, pozzolans, absorbents, insecticides, and paints.

[1] Commodity specialist, Division of Minerals.
[2] California Mining Journal. F. S. Leases 1200 Acres Rare Earth at McCloud. V. 32, No. 8, April 1963, p. 25.

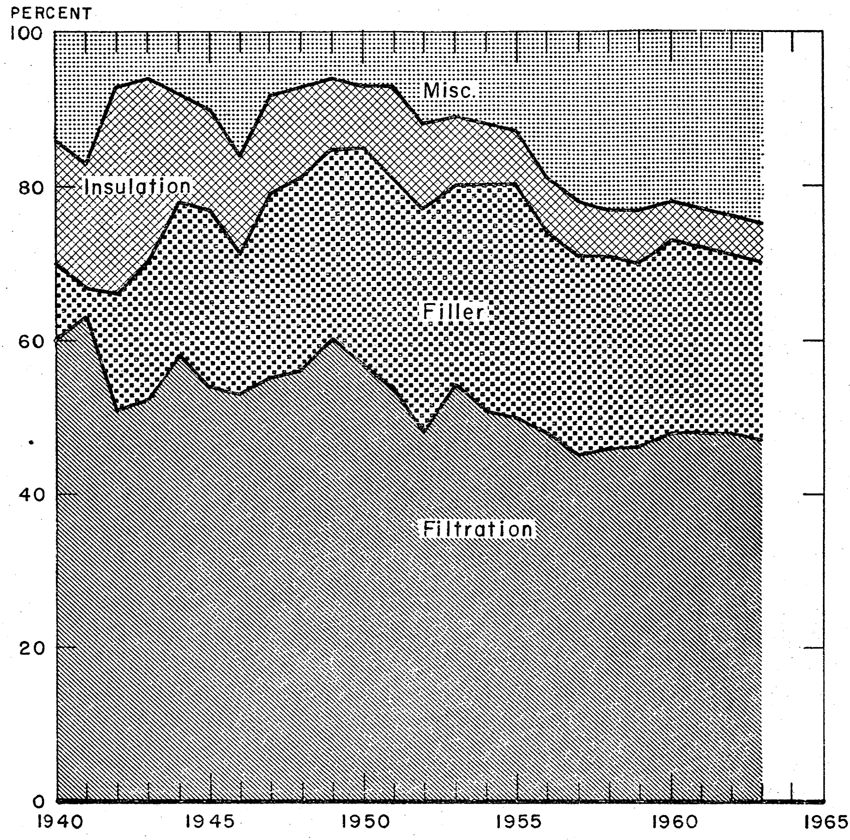

Figure 1.—Relative quantity of diatomite consumed in the United States for each principal class of use, 1940–63.

PRICES

Average prices increased for all grades of diatomite used for filtration insulation and miscellaneous purposes. The price of material used for abrasives remained steady; filler material declined slightly.

TABLE 2.—Average annual value per ton of diatomite, by uses

Use	1962	1963	Use	1962	1963
Filtration	$61.30	$62.26	Fillers	$51.69	$50.07
Insulation	45.13	49.91	Miscellaneous	26.45	30.20
Abrasives	137.00	137.00	Weighted average	50.06	50.72

FOREIGN TRADE

Crude or processed diatomite may be imported into the United States duty-free under current tariff regulations. Imports of diatomite were negligible. The U.S. Department of Commerce maintains no records of diatomite exports.

WORLD REVIEW

The United States continued to be the world's leading producer of diatomite. Other principal free world producers were France, West Germany, Italy, and Denmark.

Algeria.—Decreased diatomite production was anticipated for 1963. The number of workers engaged in the extraction of diatomite decreased from 285 at the beginning of 1962 to 181 at the end of 1962. By mid-1963 this number had been reduced to 77 workers. Exports increased slightly, changing from 17,000 tons in 1961 to 18,000 tons in 1962. Only about 3,700 tons of material were exported during the first half of 1963.[3]

TABLE 3.—World production of diatomite by countries [1] [2]

(Short tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	34	5	44	214	211	322
Costa Rica	2,860	2,425	2,425	717	827	[3] 2,000
Guatemala	17,576	------	------	------	------	------
Nicaragua	------	1,887	2,249	2,976	1,414	[3] 1,400
United States	400,968	[4] 449,789	[5] 482,202	[5] 482,202	[5] 482,202	[5] 482,202
South America:						
Argentina	4,233	4,829	117	1,286	180	[3] 1,000
Chile	117	------	------	------	------	------
Colombia	187	330	440	330	150	[3] 150
Peru	39	254	1,284	2,048	1,624	[3] 1,600
Europe:						
Austria	4,275	4,492	4,431	5,993	4,613	[3] 4,500
Denmark:						
Diatomite	15,895	18,200	17,600	21,500	22,000	[3] 22,000
Moler [3] [6]	193,500	205,000	204,300	212,900	230,800	220,500
Finland	2,030	1,520	1,457	805	1,323	[3] 1,300
France [7]	81,216	112,821	140,468	118,429	[3] 110,000	[3] 110,000
Germany, West [7] (marketable)	64,796	55,737	51,138	72,201	67,792	[3] 66,000
Italy	22,196	57,099	51,888	[3] 55,000	[3] 55,000	[3] 55,000
Portugal [7]	1,853	2,075	1,172	847	1,598	[3] 1,600
Spain [7]	13,138	11,561	13,840	19,351	13,352	[3] 13,000
Sweden	1,292	764	453	783	[3] 770	[3] 770
U.S.S.R.[3]	([8])	275,000	300,000	330,000	330,000	345,000
United Kingdom	25,409	[3] 19,000	16,553	24,920	[3] 24,900	[3] 24,900
Yugoslavia	[3] 4,400	[3] 5,000	[3] 5,000	[3] 5,000	4,500	[3] 4,500
Asia: Korea, Republic of	2,134	1,865	2,646	1,989	758	2,407
Africa:						
Algeria	29,280	38,087	24,266	34,315	30,534	[3] 9,000
Kenya	4,200	4,041	3,791	3,537	3,207	[3] 3,300
Mozambique	22	------	103	397	------	------
Rhodesia and Nyasaland, Federation of: Southern Rhodesia [7]	------	148	164	409	423	301
South Africa, Republic of	700	397	346	137	647	[3] 250
United Arab Republic (Egypt)	364	440	805	332	55	[3] 55
Oceania:						
Australia	5,988	5,700	5,218	6,067	8,189	[3] 4,700
New Zealand	2,167	8,152	6,992	3,961	2,099	[3] 2,200
World total (estimate)[1] [2]	1,235,000	1,480,000	1,550,000	1,635,000	1,630,000	1,610,000

[1] Diatomaceous earth is produced in Brazil, Bulgaria, and Japan, but data on output are not available; estimates are included in total. Hungary and Rumania may produce diatomaceous earth but data are not available, and no estimates are included in total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Average annual production 1957–59.
[5] Average annual production 1960–62.
[6] A clay-contaminated diatomite used principally for lightweight building brick.
[7] Includes Tripoli.
[8] Data not available; estimate included in total.

[3] Bureau of Mines. Mineral Trade Notes. V. 58, No. 2, February 1964, p. 11.

Iceland.—Investigation of Myvatn diatomite deposits have confirmed that high-grade diatomite can be produced in Iceland. The construction of a $2.3 million processing plant to produce about 11,000 tons per year was proposed. This production would increase the total annual value of Iceland's exports by an estimated $1.2 million.[4]

Kenya.—Two large deposits were worked by the East African Diatomite Syndicate in the Gilgil area of the Rift-Valley between Nairobi and Nakuru. Approximately 6 million tons of proved reserves are available with an additional 4 million tons estimated to be available. The material is claimed to be of exceptionally high quality. The mineral is selectively mined and is further treated by drying, milling, and air removal of any impurities.[5]

South Africa, Republic of.—Production during the first 9 months of 1963 was 180 tons of diatomite compared with 647 tons produced during 1962. No exports were reported for the first 9 months of 1963. Only one firm was producing this material.[6]

TECHNOLOGY

Diatomite of the Tallahatta formation, in Choctaw and Clarke Counties, Ala., was described in a report. The report provides information on the physical properties of the diatomite based on petrographic, chemical, X-ray diffraction, and differential thermal analysis studies. Possible uses for this material are: Lightweight concrete aggregate, pozzolanic material, filter aids, industrial filler, polishing powders and refractory products.[7]

Low-turbidity water was obtained from high-turbidity water by sedimentation and diatomite filtration to provide suitable river water samples for the isolation and measurement of contained organic refractories.[8]

The absolute age of the diatomite in the Lacustrine formation of the upper Quaternary of the eastern Niger was determined. Age determinations on seven samples by Carbon 14 dating methods gave ages of 6,900 to 21,000 years.[9]

A laboratory study of factors affecting the economical design of diatomite water filters was reported and a procedure was developed to calculate optimum diatomite filter design factors for large filter plants.[10]

The use of diatomite for removing iron from water supply systems was discussed and tests described. This type of filter has been found to be practical and can also be used for the removal of manganese.[11]

[4] Bureau of Mines. Mineral Trade Notes. V. 56, No. 6, June 1963, p. 13.

[5] Mine and Quarry Engineering (London). Screenings. V. 29, No. 1, January 1963, p. 17.

[6] Republic of South Africa, Department of Mines. Minerals. July–September 1963.

[7] Hastings, Earl L., and T. N. McVay. Tallahatta Diatomite, Choctaw and Clarke Counties, Ala. BuMines, Rept. of Inv. 6271, 1963, 12 pp.

[8] Myrick, H Nugent, and DeVere W. Ryckman. Considerations in the Isolation and Measurement of Organic Refractories in Water. J. Am. Water Works Assoc., v. 55, No. 6, June 1963, pp. 783–796.

[9] Chemical Abstracts. V. 59. No. 12. Dec. 9, 1963, p. 13728C.

[10] Bauman, E. Robert, and Robert L. LaFrenz. Optimum Economical Design for Municipal Diatomite Filter Plants. J. Am. Water Works Assoc., v. 55, No. 1, June 1963, pp. 48–58.

[11] Coogan, George J. Diatomite Filtration for the Removal of Iron and Manganese. J. Am. Water Works Assoc., v. 54, December 1962, pp. 1507–1517.

A thorough review of diatomite design criteria was presented describing the basic filtering system and outlining filter design requirements. Problem aspects such as body feed, precoating, and the quality of filtered and unfiltered waters were discussed.[12]

An equation was developed to describe the filtration of iron-bearing water under normal conditions of body feed, iron concentration, and filtration rate.[13]

Methods developed for defluorinating triple superphosphate use diatomite. One method requires addition of about 5 percent diatomite, heating to about 1,050 to 1,300° F for partial defluorination, and then heating to 1,800 to 2,000° F with the presence of calcium oxide or carbonate. The defluorinated material is suitable for use in animal feeds.[14]

Another method for defluorinating phosphate follows the same initial technique of adding diatomite and heating to the same temperature range. This is followed by hydrolization by steam or hot water to form a soluble calcium orthophosphate with high nutritional availability.[15]

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[12] Bell, George R. Design Criteria for Diatomite Filters. J. Am. Water Works Assoc., v. 54, October 1962, pp. 1241–1256.

[13] Bauman, E. Robert, John L. Cleasby, and Robert L. LaFrenz. A Theory of Diatomite Filtration. J. Am. Water Works Assoc., v. 54, September 1962, pp. 1109–1119.

[14] Malley, T. J., H. F. Cosway, and S. A. Giddings (assigned to American Cyanamid Co., New York). Low Temperature Defluorination of Phosphate Material. U.S. Pat. 3,101,999, Aug. 27, 1963.

[15] Malley, T. J., D. F. De Lapp, S. A. Giddings, and H. F. Cosway (assigned to American Cyanamid Co., New York). Production of Animal Feed Supplement of Low Fluorine Content. U.S. Pat. 3,102,000, Aug. 27, 1963.

Feldspar, Nepheline Syenite, and Aplite

By James D. Cooper[1]

FELDSPAR

DOMESTIC output of feldspar increased in 1963, partly because of the continued high demand from the glass and ceramic industries, and partly because of a decrease in production of aplite, a substitute material used in making amber glass. Continuing high construction activity and automobile production maintained the demand for plate and rolled glass, resulting in production at a rate about 11 percent over that of 1962 and a corresponding increase in demand for feldspar. Glass container production also increased despite heavy competition from plastics, metals and other container materials, and more feldspar was required by the container glass industry. Imports of feldspar were slightly less than those of 1962.

TABLE 1.—Salient feldspar statistics

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Crude:						
Sold or used by producers[1] long tons	521,064	548,390	502,380	496,808	492,476	548,954
Value thousands	$4,817	$5,372	$4,779	$5,120	$5,076	$5,524
Average value per long ton	$9.25	$9.79	$9.51	$10.31	$10.31	$10.06
Imports for consumption long tons	117	45	44	24	33	68
Value thousands	$7	$5	$5	$2	$1	$2
Average value per long ton	$56.73	$100.49	$106.95	$84.38	$39.55	$23.29
Consumption, apparent[2] long tons	521,181	548,435	502,424	496,832	492,509	549,022
Ground:						
Sold by merchant mills[3] short tons	549,214	560,105	528,348	541,626	527,347	598,706
Value thousands	$7,765	$7,659	$7,079	$6,694	$6,703	$7,353
Average value per short ton	$14.14	$13.67	$13.40	$12.36	$12.71	$12.28
Imports for consumption long tons	2,816	5,160	6,980	2,529	3,297	3,006
Value thousands	$51	$82	$110	$63	$87	$81
Average value per long ton	$18.10	$15.86	$15.69	$24.86	$26.45	$26.88
World: Production long tons	1,210,000	1,350,000	1,490,000	1,530,000	1,540,000	1,590,000

[1] See table 2 for distribution of feldspar by derivation.
[2] Measured by quantity sold or used by producers plus imports.
[3] See table 4 for distribution of feldspar by derivation.

[1] Commodity specialist, Division of Minerals.

DOMESTIC PRODUCTION

Crude Feldspar.—North Carolina, the leading feldspar producing State for many years, accounted for almost 50 percent of reported domestic production of crude feldspar in 1963. California and Connecticut ranked second and third in crude feldspar output, showing no change from 1962. Over 93 percent of the feldspar produced in North Carolina was flotation concentrate, an increase of 3 percent over that of the previous year. Flotation concentrate accounted for about 66 percent of total domestic feldspar production, the same as in 1962.

Hand-cobbed feldspar, flotation concentrate, and the feldspar content of feldspar-silica mixtures are all included in the crude feldspar data.

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)
1954-58 (average)	(3)	(3)	443,029	$4,133	78,035	$684	521,064	$4,817
1959	169,473	$1,508	293,356	3,114	85,561	750	548,390	5,372
1960	147,912	1,123	278,503	2,881	75,965	775	502,380	4,779
1961	116,503	788	307,468	3,580	72,837	752	496,808	5,120
1962	113,168	783	324,462	3,806	54,846	487	492,476	5,076
1963	93,488	643	364,676	3,885	90,790	996	548,954	5,524

[1] Partly estimated.
[2] Feldspar content.
[3] Included with flotation concentrate.

Ground Feldspar.—Ground feldspar was produced by 22 mills in 8 States, an increase of 1 mill from the previous year. The new mill is operated by Consolidated Quarries Division of The Georgia Marble Co., and produces a feldspar-silica mixture containing about 60 percent feldspar. Sales by merchant mills increased 13 percent in volume and 10 percent in value in 1963. The leading producing States in order of volume were North Carolina, California, Connecticut, Georgia, and South Carolina. Two thirds of the total domestic production of ground feldspar was from five southeastern States: Georgia, North Carolina, South Carolina, Tennessee, and Virginia.

TABLE 3.—Ground feldspar sold by merchant mills[1] in the United States

Year	Mills	Domestic feldspar: Short tons	Domestic feldspar: Value (thousands)
1954–58 (average)	24	[2] 549,214	[2] $7,765
1959	26	[3] 560,105	[3] 7,659
1960	24	[3] 528,348	[3] 7,079
1961	21	541,626	6,694
1962	21	527,347	6,703
1963	22	598,706	7,353

[1] Excludes potters and others who grind for consumption in their own plants.
[2] Includes Canadian feldspar, 1954.
[3] Includes Canadian feldspar.

TABLE 4.—Ground feldspar sold by merchant mills in the United States, by derivation[1] and uses

(Short tons)

Year	Hand-cobbed					Flotation concentrate				
	Glass	Pottery	Enamel	Other	Total	Glass	Pottery	Enamel	Other	Total
1954–58 (average)	(2)	(2)	(2)	(2)	(2)	226,055	181,126	23,305	32,058	462,544
1959	40,365	88,233	36,929	24,662	190,189	219,139	72,496	--------	10,558	302,193
1960	31,171	59,546	21,418	32,267	144,402	206,784	87,133	1,315	12,870	308,102
1961	23,248	56,875	17,160	26,083	123,366	232,365	88,170	4,012	12,135	336,682
1962	26,323	45,612	(3)	45,650	117,585	215,941	96,828	(3)	35,605	348,374
1963	6,863	58,497	(3)	39,128	104,488	240,783	(3)	(3)	151,777	392,560
	Feldspar-silica mixtures[4]					Grand total				
	Glass	Pottery	Enamel	Other	Total	Glass	Pottery	Enamel	Other[5]	Total
1954–58 (average)	79,133	2,135	--------	5,402	86,670	305,188	183,261	23,305	37,460	549,214
1959	55,809	5,323	--------	6,591	67,723	315,313	166,052	36,929	41,811	560,105
1960	56,727	5,872	2,416	10,829	75,844	294,682	152,551	25,149	55,966	528,348
1961	65,950	6,983	--------	8,645	81,578	321,563	152,028	21,172	46,863	541,626
1962	50,993	4,726	--------	5,669	61,388	293,257	147,166	27,391	59,533	527,347
1963	65,541	(3)	--------	36,117	101,658	313,187	195,510	24,068	65,941	598,706

[1] Partly estimated.
[2] Included with flotation concentrate.
[3] Included with "Other" to avoid disclosing individual company confidential data.
[4] Feldspar content.
[5] Includes soaps, abrasives, and other ceramic and miscellaneous uses.

CONSUMPTION AND USES

Crude Feldspar.—The larger feldspar producers process their crude material by grinding and, where necessary, by further treatment for removal of iron and other impurities. These producers, together with other merchant grinders, purchase and process the crude feldspar output of numerous small miners. Essentially all feldspar was ground prior to sale to ceramic and other manufacturers. However, some pottery, enamel, and soap producers purchased crude feldspar and ground it to meet their specifications.

Ground Feldspar.—In 1963 the glass, pottery, and enamel industries consumed 89 percent of the ground feldspar produced in the United States. The quantity used in glass increased by 20,000 tons in 1963, but represented only 52 percent of the total ground feldspar sold, compared with 56 percent of the total in 1962. Purchases by the pottery industry which accounted for 33 percent of the total ground feldspar sold in 1963, increased by 48,000 tons. This industry purchased only 28 percent of the total ground feldspar sold in 1962. The enamel industry purchased about 3,000 tons less than in 1962 and accounted for about 4 percent of the total feldspar sold in 1963, compared with 5 percent in 1962.

Ohio led in feldspar consumption in 1963, overtaking California which dropped to second place. Other States in order of consumption were New Jersey, Illinois, and Pennsylvania. These five States used 59 percent of the ground feldspar sold in the United States in 1963, compared with 55 percent in 1962. Consumption increased in all of these States except California, where a drop of less than 1,000 tons was indicated.

TABLE 5.—Ground feldspar shipped from merchant mills in the United States

(Short tons)

Destination	1959	1960	1961	1962	1963
California	87,332	91,452	99,149	79,075	78,164
Illinois	57,952	54,089	55,815	46,283	49,822
Indiana	34,212	28,426	39,700	19,139	20,688
Maryland	17,572	16,017	14,092	11,748	11,636
Massachusetts	4,229	5,101	6,235	4,603	4,231
New Jersey	28,577	25,989	38,245	53,640	62,336
New York	16,463	19,701	16,850	21,696	23,631
Ohio	71,293	67,324	67,304	76,287	122,242
Pennsylvania	56,332	60,907	55,947	34,843	40,567
Texas	22,057	21,440	22,994	22,502	(1)
West Virginia	51,965	36,216	27,384	(1)	18,714
Wisconsin	10,823	9,677	8,727	(1)	(1)
Other destinations [2]	101,298	92,009	89,184	157,531	166,675
Total	560,105	528,348	541,626	527,347	598,706

[1] Included with "Other destinations."

[2] Includes Alabama (1960–62), Arkansas, Colorado, Connecticut, Florida (1960–61), Georgia (1960 and 1963), Hawaii (1961), Kentucky, Louisiana, Maine (1959–60), Michigan, Minnesota, Mississippi, Missouri, Oklahoma, Rhode Island, South Carolina (1962–63), Tennessee, Utah (1960), Vermont (1960 and 1962–63), Virginia (1963), Washington (1959–62), shipments that cannot be separated by States, and shipments indicated by footnote 1. Also includes exports to Canada, Colombia (1961), Cuba (1959–60), England (1959 and 1962), Mexico, Panama, Philippines (1963), Puerto Rico (1959), Venezuela (1959–63), and small quantities to other countries.

PRICES

Crude feldspar prices were not quoted in the trade journals in 1963. The average value of crude feldspar in 1963 reported to the Bureau of Mines was $10.06 per long ton, a drop of 25 cents per ton from the previous year. The value per ton of flotation concentrate decreased significantly while that of feldspar-silica mixtures increased. The value per ton of hand-cobbed feldspar remained within a few cents of the 1962 value.

Ground feldspar sold for an average price of $12.28 per short ton, a decrease of 3 percent from the price of $12.71 in 1962. Illinois had the highest average price of $25.10 per short ton, followed by New Hampshire with $20.98, Tennessee with $20.41, and Virginia with $20.08. Feldspar for use in soaps and abrasives sold for the highest average price, $20.20 per ton.

Prices for ground feldspar were quoted in E&MJ Metal and Mineral Markets for December 30, 1963, as follows: North Carolina, bulk, 325 mesh, $18 to $22 per ton; 200 mesh, $17 to $21 per ton; 40 mesh, glass grade, $13.50 per ton; and 20 mesh, semigranular, $7.50 per ton. There was no change from prices quoted at the end of the previous year.

FOREIGN TRADE

Ground Feldspar.—Imports of feldspar, essentially all from Canada, decreased 8 percent in 1963. Ground feldspar exports decreased 44 percent from those in 1962, according to reports from grinders. Canada, Mexico, and several South American countries were the principal buyers.

Cornwall Stone.—A total of 23 tons of natural mineral fluxes, presumably Cornwall stone, valued at $1,400 was imported from England in 1963.

TABLE 6.—U.S. imports for consumption of feldspar [1]

Year	Crude		Ground		Year	Crude		Ground	
	Long tons	Value	Long tons	Value		Long tons	Value	Long tons	Value
1954–58 (average)	117	$6,660	2,816	$50,978	1961	24	$2,025	2,529	$62,859
1959	45	4,522	5,160	81,849	1962	33	1,305	3,297	87,205
1960	44	4,706	6,980	109,547	1963	68	1,584	3,006	80,795

[1] All from Canada, except 39 long tons ($1,724) of ground feldspar from Norway in 1963.

Source: Bureau of the Census.

WORLD REVIEW

World production of feldspar increased slightly compared with that of 1962. The production pattern has remained relatively stable for a number of years, except in the Republic of South Africa, where annual production has nearly quadrupled since 1959. The United States furnished about 35 percent of the world total in 1963 compared with 32 percent in 1962.

TABLE 7.—World production of feldspar by countries [1] [2]

(Long tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada (shipments)	16,650	16,030	12,376	9,381	8,923	7,640
United States (sold or used)	521,064	548,390	502,380	496,808	492,476	548,954
Total	537,714	564,420	514,756	506,189	501,399	556,594
South America:						
Argentina	5,125	4,922	8,418	11,474	4,853	[3] 4,900
Brazil	(4)	[3] 34,000	[3] 39,000	[3] 39,000	[3] 39,000	[3] 39,000
Chile	987	1,476	1,095	2,280	1,138	[3] 1,180
Colombia	4,527	14,800	14,800	14,800	15,250	[3] 15,300
Peru	----------	----------	236	992	287	309
Uruguay	302	352	713	877	692	282
Total [3]	31,000	56,000	64,000	69,000	61,000	61,000
Europe:						
Austria	2,510	3,445	4,573	3,907	4,976	2,077
Finland	10,817	9,114	9,158	13,303	14,822	12,795
France	71,032	78,737	83,658	96,453	119,089	[3] 98,000
Germany, West	156,790	175,353	264,204	265,450	269,770	[3] 270,000
Italy	50,103	59,990	85,076	93,204	91,126	100,211
Norway	43,335	39,252	53,337	68,895	54,132	[5] 50,000
Portugal	642	837	1,699	2,892	3,674	[3] 3,600
Spain	5,279	10,722	11,924	8,194	8,267	[3] 8,300
Sweden	49,477	46,159	54,517	56,002	[3] 56,000	[3] 56,000
U.S.S.R.	(4)	[3] 185,000	[3] 195,000	[3] 205,000	[3] 205,000	[3] 210,000
Yugoslavia	[6] 9,184	19,309	13,780	20,215	[3] 29,500	28,995
Total [1] [3]	570,000	635,000	780,000	840,000	860,000	845,000
Asia:						
Ceylon	----------	----------	32	106	56	109
Hong Kong	[7] 748	1,716	2,511	1,206	937	1,680
India	6,384	9,740	10,484	9,706	15,469	20,602
Japan [8]	40,161	60,196	91,454	50,986	46,991	[3] 47,000
Philippines	[9] 62	1,684	3,896	14,526	15,325	6,564
Viet-Nam, South	709	----------	----------	----------	----------	----------
Total	48,064	73,336	108,377	76,530	78,778	[3] 76,000
Africa:						
Eritrea	167	1,476	984	2,953	425	[3] 490
Kenya	30	----------	----------	1	----------	----------
Malagasy Republic	40	----------	----------	13	----------	----------
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	90	----------	----------	----------	----------	----------
South Africa, Republic of	7,754	10,447	15,600	23,290	28,209	41,372
South-West Africa	----------	----------	----------	89	465	2,197
United Arab Republic (Egypt)	----------	492	354	----------	----------	----------
Total	8,081	12,415	16,938	26,346	29,099	44,059
Oceania: Australia	14,336	6,750	8,414	8,209	8,513	[3] 7,600
World total (estimate) [1] [3]	1,210,000	1,350,000	1,490,000	1,530,000	1,540,000	1,590,000

[1] Feldspar is produced in China, Czechoslovakia, Republic of Korea, and Rumania, but data are not available; no estimates included in total except for Czechoslovakia.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Data not available; estimate by author of chapter included in total.
[5] Exports.
[6] Average annual production 1956–58.
[7] Average annual production 1955–58.
[8] In addition, the following quantities of aplite and other feldspathic rock were produced: 1954–58 (average), 72,871 tons; 1959, 88,451 tons; 1960, 91,339 tons; 1961, 132,041 tons; 1962, 168,543 tons; 1963, 211,172 tons.
[9] Average annual production 1957–58.

TECHNOLOGY

A comprehensive series of articles on the effect of particle size of feldspar and quartz on various processing characteristics and fired properties of porcelain bodies was completed.[2]

Two methods of separating potash and soda feldspars were patented. In one process a concentrate containing cationic reagents is treated to cause it to accept differential charges and is then separated electrostatically.[3] In the other, finely divided feldspar concentrate is pulped, conditioned with sodium chloride or sodium metasilicate, and then with a cationic collector. Froth flotation is used to float the high potash fraction and sink the high soda fraction.[4]

Patents were granted on feldspar-containing products, including a ceramic fiber made by extruding a viscous ceramic mixture,[5] and a porous ceramic material for use in disposal of radioactive waste. The waste-soaked ceramic mass is fired to vitrification.[6]

NEPHELINE SYENITE

DOMESTIC CONSUMPTION

Ceramic and glass grade nepheline syenite is obtained from Canada. Apparent consumption in 1963 was slightly above that of 1962. Principal consumers are glass manufacturers in the northeastern United States. Because of its high iron content, domestic nepheline syenite produced in Arkansas is suitable only for use as roofing granules and other similar applications. Production data are included in the Stone chapter of Minerals Yearbook.

PRICES

The approximate price of glass grade nepheline syenite was $9.00 per ton, f.o.b. plant, Ontario. A price of $28.50 per ton, bagged, carlots for the finest ground high-quality material was given in Canadian Chemical Processing for October 1962.[7]

FOREIGN TRADE

Ground nepheline syenite was imported from Canada, mostly for use in glass production. Imports increased slightly in quantity and value compared with that of 1962. Imports of crude nepheline syenite were small, but the average unit value was higher than that for the ground material.

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[2] Kato, Syozi, Ryuzo Naito, Ryuichi Yamamoto, and Yukio Nishimura. Effects of the Particle Size of Raw Materials in Porcelain Manufacturing. Pt. 5, Nagoya Kogyo Gijutsu Shikensho Hokoku, v. 11, No. 9, 1962, pp. 596–602; pt. 6, v. 11, No. 11, 1962, pp. 713–725; pt. 7, v. 11, No. 12, 1962, pp. 775–783; pt. 8. v. 12, No. 2, 1963, pp. 106–115; abs. in J. Am. Ceram. Soc.—Ceram. Abs., v. 46, No. 8, August 1963, p. 217.

[3] Snow, R. E. (assigned to International Minerals & Chemical Corp., Skokie, Ill.). Process for Beneficiating Potash Spar. U.S. Pat. 3,073,443, Jan. 15, 1963.

[4] Hall, D. J. Jr. (assigned to International Minerals & Chemical Corp., Skokie, Ill.). Process for Beneficiating Ores. U.S. Pat. 3,113,922, Dec. 10, 1963.

[5] Davies, F. W., and V. F. Freeth (assigned to General Electric Co., Ltd.). British Pat. 919,181, Feb. 20, 1963.

[6] Arrance, F. C. (assigned to Coors Porcelain Co., Golden Colo.). Method for Disposing of Radioactive Waste and Resultant Product. U.S. Pat. 3,093,593, June 11, 1963.

[7] Reeves, J. E. Nepheline Syenite (1962 Preliminary). Canada Dept. Mines and Tech. Surveys, March 1963, p. 4.

TABLE 8.—U.S. imports for consumption of nepheline syenite

Year	Crude		Ground		Year	Crude		Ground	
	Short tons	Value	Short tons	Value		Short tons	Value	Short tons	Value
1954-58 (average)	32	$539	135,951	[1] $2,037,358	1961	1,167	$20,224	186,297	$2,026,239
1959	808	18,652	184,464	2,403,079	1962	(2)	(2)	188,833	2,084,766
1960	900	18,585	195,166	2,370,040	1963	272	4,731	196,567	2,109,441

[1] Data known to be not comparable with other years.
[2] Revised to none.

Source: Bureau of the Census.

WORLD REVIEW

Canada.—Canada continued as the leading producer of nepheline syenite in the world in 1962, with an increase of 17 percent over that of 1961, according to preliminary data. Most of the processed material was exported to the United States. There are two producers, Indusmin Ltd. and International Minerals & Chemical Corp. (Canada) Ltd., both operating on the Blue Mountain deposit, Methuen Township, Peterborough County, Ontario. The two producers together have a plant capacity of about 1,200 tons per day.[8]

Norway.—Production started in 1960 on the Norwegian island of Stjerny and has increased rapidly. Output was about 8,000 short tons in 1961, and 20,000 tons in 1962.[9]

U.S.S.R.—Nepheline concentrate suitable for use as a constituent in green glass has been produced for a number of years in the Kola Peninsula near Kirovsk. The concentrate is a byproduct of large scale mining and processing of apatite-nepheline rock from the Khibiny deposits. The nepheline concentrate contains 29 percent aluminum oxide and has become important as an aluminum ore.[10]

Other Countries.—Potentially commercial deposits of nepheline syenite are known to occur in Belgium-Luxembourg, Finland, India, Republic of Korea, and Peru.

TECHNOLOGY

Evidence was presented which indicated that basic conditions are required in order to maintain uniformity of slip-casting compositions containing nepheline syenite. The proper additives necessary to achieve the requisite hydrogen-ion concentration under various conditions of initial acidity, were indicated.[11]

[8] Page 3 of work cited in footnote 7.
[9] The Mining Journal (London). Norway's Industrial Minerals. V. 261, No. 6679, Aug. 23, 1963, p. 170.
[10] Page 3 of work cited in footnote 7.
[11] Wilson, R. C., and C. J. Koenig. Stability of Forming Characteristics of Bodies Containing Nepheline Syenite—A Review. Am. Ceram. Soc. Bull., v. 42, No. 12, December 1963, pp. 752–755.

TABLE 9.—Canada: Production, exports, and consumption of nepheline syenite

	1961		1962[1]	
	Short tons	Value	Short tons	Value
Production (shipments)	240,320	$2,572,169	281,100	$3,383,700
Exports:				
Australia	455	21,571	239	6,597
Belgium and Luxembourg	2,692	44,058	560	12,040
Britain	10,170	144,436	11,263	130,090
Dominican Republic	250	11,331	595	7,259
Germany, West	392	7,559	250	5,160
Netherlands	774	13,810	286	5,865
Puerto Rico	1,450	21,665	1,000	12,305
United States	177,740	1,972,665	179,105	2,023,852
Other countries	675	12,253	360	7,666
Total	194,598	2,249,348	193,658	2,210,834
Consumption:				
Glass, glass fiber, and mineral wool	35,455	(2)		
Other ceramic products	4,054	(2)		
Other products	225	(2)		
Total	39,734	(2)		

[1] Preliminary figures.
[2] Data not available.

Source: Reeves, J. E. Nepheline Syenite (1962 Preliminary). Canada Dept. Mines and Tech. Surveys, March 1963, p. 2.

APLITE

Sales of ground aplite, primarily to producers of amber glass decreased in 1963, because of the closing of two of the four production plants. The selling price of aplite was considerably higher than that prevailing in 1962. Data on production and sales are withheld to avoid disclosing individual company confidential data.

The producing companies in 1963 were M & T Chemicals, Inc., Hanover County, Va., and Consolidated Feldspar Department, International Minerals & Chemical Corp., Nelson County, Va. Riverton Lime & Stone Co., Dominion Minerals Division, Amherst County Va., and Buffalo Mines, Inc., Nelson County, Va., had both ceased operations and the plant of the latter company had been dismantled by the end of 1962.

Production of aplite in Japan in 1963 was 227,067 short tons.

A method of processing aplite ore to produce high quality concentrate was described.[12] Iron oxide content was reduced to less than 0.1 percent by use of a high capacity 3-roll magnetic separator.

[12] Mining Journal (London). Reducing Iron in Aplite Alumina. V. 260, No. 6662, Apr. 26, 1963, p. 397.

Ferroalloys

By Gilbert L. DeHuff[1]

THE domestic ferroalloy industry in 1963 was faced with falling prices resulting from pressure of imports and competition among domestic producers. Worldwide overcapacity created similar problems elsewhere. Total domestic production of ferroalloys increased slightly over the quantity reported for 1962, and shipments increased 11 percent. The value of the 1963 shipments was slightly lower, however, than that for shipments in 1962.

DOMESTIC PRODUCTION

In 1963, 49 producers in 16 States made 2 million tons of ferroalloys in 52 plants; 38 of the plants were electric furnace, 8 were blast furnace, 5 were aluminothermic, and 1 used a fused-salt electrolytic process. Ohio was the leading producing State with 616,968 short tons; Pennsylvania was next with 428,694 tons. Production also was reported from Alabama, Florida, Idaho, Illinois, Iowa, Kentucky, New Jersey, New York, Oregon, South Carolina, Tennessee, Texas, Washington, and West Virginia.

Several companies planned to consolidate and modernize their facilities to better meet growing competition. Impending termination of long-term electric power contracts was one of the factors involved in consideration of possible plant closings.

As of September 1, 1963, the name of Union Carbide Metals Co. was changed to Union Carbide Corp., Metals Division. The Company announced plans to close out production of ferroalloys at its Niagara Falls, N.Y., plant in 1964.

The name of Reading Chemicals was changed to Reading Alloys Co., Inc.

Manganese Alloys.—Eleven companies produced ferromanganese in 1963 in 17 plants in 9 States. Manganese Chemicals Corp. began production of low-carbon ferromanganese by fused-salt electrolysis at a new plant at Kingwood, W. Va. Ferromanganese was made by conventional methods in 12 electric-furnace plants and 4 blast-furnace plants. The Graham, W. Va., electric furnaces of Vanadium Corporation of America, which did not produce ferromanganese in 1962, did produce in 1963. The Anaconda Company did not make

[1] Commodity specialist, Division of Minerals.

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TABLE 1.—Ferroalloys produced and shipped from furnaces in the United States

Alloy	1962				1963			
	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	528,183	76.76	483,181	$86,694	468,438	76.67	522,526	$77,965
Electric furnace	252,929	78.05	244,515	47,652	[2] 282,760	[2] 78.06	[2] 279,587	[2] 47,111
Total	781,112	77.18	727,696	134,346	751,198	77.19	802,113	125,076
Silicomanganese	136,197	65.82	129,925	25,429	151,590	65.83	154,836	24,910
Ferrosilicon	419,741	54.99	398,731	70,971	439,074	55.72	448,008	76,555
Silvery iron:								
Blast furnace	84,636	9.70	102,250	7,580	61,549	9.49	68,904	5,048
Electric furnace	133,751	15.76	136,589	11,513	132,628	17.34	133,172	11,005
Total	218,387	13.41	238,839	19,093	194,177	14.86	202,076	16,053
Chromium alloys:								
Ferrochromium [3]	191,302	65.08	173,959	63,111	231,741	66.08	235,374	63,962
Other chromium alloys [4]	70,257	39.93	71,004	17,957	82,469	38.85	79,352	18,260
Total	261,559	58.32	244,963	81,068	314,210	58.93	314,726	82,222
Ferrotitanium	2,572	22.55	2,440	1,727	2,889	26.27	3,058	2,536
Ferrophosphorus	96,655	24.08	51,650	2,735	102,028	23.93	77,827	2,877
Ferrocolumbium and ferrotantalum-columbium	1,351	58.25	1,342	5,285	1,356	58.11	1,256	4,990
Ferronickel	19,910	53.08	19,678	50,107	21,807	49.18	22,208	53,207
Other [5]	61,470	27.75	60,803		35,055	36.09	61,970	
Grand total	1,998,954	57.90	1,876,067	390,761	2,013,384	58.99	2,088,078	388,426

[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, ferromolybdenum, ferrotungsten, ferrovanadium, simanal, spiegeleisen, zirconium-ferrosilicon, ferrosilicon-zirconium, aluminum-silicon alloy, and other miscellaneous ferroalloys.

any ferromanganese in 1963, and the blast-furnace plant of E. J. Lavino & Co. at Reusens, Va. (Lynchburg), was open only for shipments from stocks. Production of ferromanganese decreased 4 percent below that of 1962, but shipments increased 10 percent. The average unit value of the ferromanganese shipped from electric furnaces was 10.7 cents per pound of contained manganese, compared with 12.5 cents in 1962.

Silicomanganese was made in 8 States by 8 companies in the same 13 electric-furnace plants as in 1962. Production increased 11 percent and shipments increased 19 percent over the quantities reported for 1962. The average value per pound of contained manganese decreased to 12.2 cents from 14.9 cents.

Spiegeleisen was made only by The New Jersey Zinc Co., Palmerton, Pa., and by Union Carbide Corp., Metals Division, Marietta, Ohio. The former completed conversion oi its spiegeleisen-production facilities from blast furnace to electric furnace, and began construction of a second electric furnace scheduled for completion in the spring of 1964.

Silicon Alloys.—Ten companies produced ferrosilicon at 22 electric-furnace plants in 10 States. There was no blast-furnace production. Output and shipments increased 5 and 12 percent, respectively.

Silvery Iron.—Silvery pig iron was produced by five companies employing four electric-furnace plants and three blast-furnace plants. Production decreased 11 percent and shipments decreased 15 percent from those of 1962. The unit value of the blast-furnace product decreased to 37 cents from 39 cents per pound of contained silicon; that for the electric furnace product decreased to 24 cents from 27 cents. Tennessee Products and Chemical Corp., a blast-furnace producer at Rockwood, Tenn., did not produce in 1963.

Chromium Alloys.—Eight companies produced ferrochromium and other chromium alloys at 14 electric-furnace installations in 7 States. Production and shipments, quantities of which were virtually the same, increased 20 and 28 percent, respectively, over those reported for 1962. The average unit value of the contained chromium dropped appreciably, from 28.6 cents to 22.1 cents per pound.

Molybdenum Alloys.—Two companies, Climax Molybdenum Co. and Molybdenum Corporation of America, produced ferromolybdenum. Both aluminothermic and electric-furnace methods were employed. The average unit value, $1.86 per pound of contained molybdenum, was little changed from that of 1962.

Titanium Alloys.—Four companies continued to produce ferrotitanium at three electric-furnace plants and one aluminothermic installation in three States.

Ferrophosphorus.—Eight companies made ferrophosphorus as a byproduct of the electric-furnace process for obtaining elemental phosphorus from phosphate rock. Production increased 6 percent. Shipments increased 51 percent but were still well below production.

Ferrocolumbium and Ferrotantalum-Columbium.—Five companies in three States produced ferrocolumbium at three electric-furnace and two aluminothermic facilities. Unit value of $3.43 per pound was virtually unchanged from that of 1962. Only one company, Shieldalloy Corp. at Newfield, N.J., reported production of ferrotantalum-columbium in 1963. Combined production of the two alloys was essentially the same as 1962, but shipments decreased 6 percent.

Ferronickel.—Hanna Nickel Smelting Co., Riddle, Oreg., continued to be the only producer of ferronickel.

Vanadium Alloys.—Ferrovanadium was made by the same four companies that produced in 1962. Three aluminothermic and three electric-furnace facilities were used; this was two more electric-furnace plants than in 1962. The product had an average vanadium content of 55 percent. The change in number of electric-furnace plants was due to production at the Niagara Falls, N.Y., plant of Union Carbide Corp., Metals Division, and at the Vancoram, Ohio, plant of Vanadium Corporation of America.

Zirconium Alloys.—Two companies reported production of zirconium alloys.

Ferroboron.—The same two electric-furnace plants that produced ferroboron in 1962 produced in 1963. Shieldalloy Corp., Newfield, N.J., also produced ferroboron by the thermic method. The average boron content of the 1963 product was 17.8 percent, compared with 17.6 percent in 1962. The average unit value of shipments continued to decrease; it was $6.63 per pound of contained boron in 1963 and $6.74 in 1962.

Tungsten Alloys.—The same two electric-furnace plants that produced ferrotungsten in 1962 were producers in 1963. Reading Alloys Co., Inc., Robesonia, Pa., used a thermic process to produce chromium-manganese-tungsten alloy. Production of tungsten alloys decreased 36 percent but shipments were off by only 3 percent. The average unit value of contained tungsten fell from $2.24 to $1.82 per pound.

CONSUMPTION AND USES

As reported to the Bureau of Mines, and shown in tables 3 and 4, a total of 1,963,000 tons of ferroalloys and ferroalloy elements was consumed in the United States, an increase of 11 percent over the quantity used in 1962. While the greater part of this quantity was taken by the steel industry, the figure also includes consumption by iron foundries and nonferrous metal, chemical, and miscellaneous industries. The American Iron and Steel Institute (AISI) reported consumption by the steel industry amounting to a gross weight of 1,659,000 tons. The AISI figure includes all those alloys reported to the Bureau of Mines plus additional alloying materials, including items for nickel, cobalt, sulfur, and graphite for recarburizing.[2]

Manganese.—Consumption of manganese alloys (including silicomanganese and manganese metal) increased 113,000 tons, or 11 percent, corresponding to an 11-percent increase in steel production. Consumption of silicomangangese relative to ferromanganese continued to grow. Additional information and end-use data for the individual manganese items will be found in the Manganese chapter.

Silicon.—Consumption of silicon alloys (including silvery pig iron and silicon metal) increased 55,000 tons, or 9 percent. Consumption of silvery pig iron increased at the same rate.

Titanium.—The downward trend in consumption of ferrotitanium, evident over the past 3 years, was halted when 1963 reporting showed an appreciable increase in use in the "other alloy steels" category, giving a slight overall gain in total consumption for the year.

Phosphorus.—Total consumption of ferrophosphorus declined for the third successive year.

Boron.—The quantity of ferroboron used in 1963, while continuing to be relatively small, was nevertheless significantly more than that used in 1962.

Chromium.—Consumption of chromium contained in alloys and metal increased 13 percent over that consumed in 1962. There was a 15-percent increase in that portion reported as used for stainless steels.

[2] American Iron and Steel Institute. Annual Statistical Report. 1963, pp. 18–19.

Molybdenum.—Consumption of ferromolybdenum (including calcium molybdate and molybdenum silicide) increased 7 percent.

Tungsten.—Consumption of ferrotungsten (and minor tungsten alloys) was almost identical with that reported for 1962.

Vanadium.—Ferrovanadium consumption increased 35 percent over that of 1962. If the tool steel categories reported in table 4 are taken collectively, most of the categories there tabulated for consumption in the production of steels increased appreciably. Tool steels, the only exception, increased only slightly. Use of ferrovanadium in the production of high-temperature alloys also increased.

Columbium and Tantalum.—The sharp rise of the last 2 years in ferrocolumbium consumption leveled off, and the relatively small increase reported for 1963 was more than balanced by a drop in ferrotantalum-columbium consumption. Ferrocolumbium reported as used in the production of carbon steel decreased 26 percent, but that consumed in the production of high-temperature alloys increased 79 percent.

STOCKS

Producer stocks decreased 10 percent and consumer stocks decreased 8 percent, compared with the 1962 figures. Among the major items, ferrophosphorus and ferrochromium were exceptions to the general trend; most of the decrease was expressed in the manganese items. Government inventories held no ferroalloy for Defense Production Act account.

TABLE 2.—Consumption by major end uses, and stocks, of silicon alloys in the United States in 1963

(Short tons, gross weight)

Alloy	Silicon content (percent)	Stainless steels	Other alloy steels [1]	Carbon steels	Tool steels	Steel mill rolls	Gray and malleable castings	Aluminum-base alloys	High-temperature alloys	Other nonferrous alloys	Miscellaneous uses	Total consumption	Stocks December 31
Silvery pig iron	5–13	1	731	731	----------	775	85, 970	----------	----------	1	1, 771	89, 980	6, 588
Do	14–20	1	6, 571	19, 258	----------	114	99, 668	----------	----------	51	[2] 6, 437	132, 100	12, 643
Ferrosilicon	[3] 21–55	6, 710	53, 783	85, 469	815	914	71, 527	44	189	2, 410	[4] 16, 941	238, 802	19, 366
Do	56–70	401	5, 468	13, 941	----------	----------	822	----------	----------	----------	[4] 4, 167	24, 799	1, 128
Do	71–80	8, 297	11, 148	5, 722	445	215	11, 294	----------	22	32	11, 014	48, 189	4, 386
Do	81–89	106	804	2, 165	----------	137	4, 307	----------	----------	18	11	7, 548	938
Do	90–95	25	1, 226	168	----------	45	277	2, 563	----------	61	7	4, 372	418
Silicon metal	96–99	11	120	55	10	----------	419	32, 913	568	734	[5] 7, 946	42, 776	2, 071
Ferrosilicon briquets	40–50	----------	144	320	----------	17	32, 426	----------	----------	----------	4	32, 911	3, 412
Miscellaneous silicon alloys [6]	----------	277	6, 025	5, 260	54	128	14, 228	107	68	53	3, 951	30, 151	2, 279
Total	----------	15, 829	86, 020	133, 089	1, 324	2, 345	320, 938	35, 627	847	3, 360	52, 249	651, 628	53, 229

[1] Includes quantities of carbon steels because some firms failed to specify individual uses.
[2] Used mainly in high-silicon iron, and to beneficiate ores.
[3] Mainly from 40 to 55 percent silicon.
[4] Used mainly in producing ferronickel.
[5] Used mainly in silicones and other chemical compounds.
[6] Includes calcium-silicon, calcium-manganese-silicon, silicon-manganese-zirconium, ferrocarbo (including briquets), Alsifer, and other miscellaneous silicon alloys.

TABLE 3.—Consumption by end uses of ferroalloys as additives in the United States in 1963

(Short tons, gross weight)

Alloy	Stainless steels	Other alloy steels [1]	Carbon steels	Tool steels	Gray and malleable iron castings	Miscellaneous uses	Total
Ferromanganese [2]	11,470	149,441	747,909	3,859	29,174	15,641	957,494
Silicomanganese	6,276	38,317	93,247	1,005	3,677	1,566	144,088
Silicon alloys [3]	15,829	88,365	133,089	1,324	320,938	92,083	651,628
Ferrotitanium	279	1,048	723	59	----------	146	2,255
Ferrophosphorus	15	3,461	8,036	----------	927	72	12,511
Ferroboron	7	46	146	----------	12	19	230
Total	33,876	280,678	983,150	6,247	354,728	109,527	1,768,206

[1] Includes steel mill rolls.
[2] Includes spiegeleisen, manganese metal, and briquets.
[3] Includes silicon metal and silvery iron. See table 2 for more detail.

TABLE 4.—Consumption by end uses of ferroalloys as alloying elements in the United States in 1963

(Short tons of contained element)

Alloy	Stainless steels	Other alloy steels	Carbon steels	High speed steels	Other tool steels [1]	Gray and malleable iron castings	High temperature alloys	Miscellaneous uses	Total
Ferrochromium [2]	127,766	[3] 45,550	--------	1,064	1,685	3,666	5,258	1,826	186,815
Ferromolybdenum [4]	1,027	[3] 1,007	--------	323	184	1,417	135	463	4,556
Ferrotungsten	---------	[5] 119	--------	306	145	----------	29	8	607
Ferrovanadium	32	[6] 1,500	246	279	184	17	16	28	2,302
Ferrocolumbium [7]	217	194	83	1	--------	----------	147	14	656
Ferrotantalum-columbium [7]	8	--------	--------	--------	--------	----------	4	5	17
Total	129,050	48,370	329	1,973	2,198	5,100	5,589	2,344	194,953

[1] Includes hot-work and die steels.
[2] Includes other chromium ferroalloys and chromium metal.
[3] Includes quantities believed used in producing high-speed and other tool steels and stainless steels, because some firms failed to specify individual uses.
[4] Includes calcium molybdate and molybdenum silicide.
[5] Includes stainless steels, steel mill rolls, and other alloy steels.
[6] Includes steel mill rolls.
[7] See table 5 for more detail on end uses.

TABLE 5.—Consumption by end uses of ferrocolumbium and ferrotantalum-columbium in the United States

(Pounds of contained columbium and tantalum)

Product	1962	1963	Product	1962	1963
Stainless steels	582,563	450,005	High-temperature alloys	213,331	301,915
Other alloy steels	300,554	388,676	Permanent-magnet alloys	2,827	2,976
Carbon steels	223,530	166,514	Miscellaneous uses	[1] 33,003	[2] 12,405
Tool steels	3,289	1,199			
Welding rods	36,212	21,696	Total	1,397,638	1,345,789
Gray and malleable castings	2,329	403			

[1] Includes 23,000 pounds of Cb and Ta chemicals.
[2] Includes 3,817 pounds used in capacitors.

TABLE 6.—Stocks of ferroalloys held by producers and consumers in the United States, Dec. 31

(Short tons)

Alloy	Producers		Consumers	
	1962, gross weight	1963, gross weight	1962, gross weight	1963, gross weight
Manganese ferroalloys [1]	[2] 244,271	170,691	167,819	154,311
Silicon alloys [3]	[2] 124,696	108,221	[4] 60,996	[4] 53,229
Ferrochromium [5]	[2] 70,338	70,173	15,802	18,263
Ferrotitanium	993	824	459	449
Ferrophosphorus	[2] 194,098	218,299	3,306	2,685
Ferroboron	[2] 179	109	26	38
Total	[2] 634,575	568,317	248,408	228,975
	1962 contained alloy	1963, contained alloy	1962, contained alloy	1963, contained alloy
Ferromolybdenum [6]	(7)	(7)	626	875
Ferrotungsten	(7)	(7)	121	150
Ferrovanadium	(7)	(7)	267	313
Ferrocolumbium	[2] 175	232	103	137
Ferrotantalum-columbium	(7)	(7)	8	7
Total	[2] 860	1,092	1,125	1,482

[1] Includes ferromanganese, silicomanganese, spiegeleisen, manganese metal, and briquets.
[2] Revised figure.
[3] Includes ferrosilicon, silvery iron, silicon metal, and miscellaneous silicon alloys.
[4] For more detail see table 2.
[5] Includes other chromium ferroalloys and chromium metal.
[6] Includes calcium molybdate and molybdenum silicide.
[7] Figures withheld to avoid disclosing individual company confidential data.

TABLE 7.—Government inventory of ferroalloys, Dec. 31, 1963

(Short tons)

Alloy	National (strategic) stockpile	CCC and supplemental stockpile	Total
Ferrochromium:			
High-carbon	126,000	257,000	383,000
Low-carbon	128,000	189,000	317,000
Ferrochromium-silicon, low-carbon	26,000	33,000	59,000
Ferrocolumbium	224		224
Ferrotantalum-columbium	70		70
Ferromanganese, standard high-carbon	143,000	704,000	847,000
Ferromolybdenum (contained molybdenum)	2,013		2,013
Ferrotungsten (contained tungsten)	826		826
Ferrovanadium (contained vanadium)	1,001		1,001

Source: Office of Emergency Planning. Statistical Supplement, Stockpile Report to the Congress. OEP-4, July-December 1963, pp. 31-32.

PRICES

The ferroalloy market in 1963 was marked by falling prices and nominal quotations with the decrease in actual prices keeping ahead of that for published prices.

Quoted prices for domestically produced standard high-carbon ferromanganese dropped from $190 to $170 (nominal) per short ton, f.o.b. furnaces. Imported alloy of the same grade continued to be quoted at $158 per long ton, delivered at Pittsburgh, qualified as nominal after March. Spiegeleisen prices (19 to 21 percent manganese grade) changed from $90 to $84 per long ton.

High-carbon ferrochromium, quoted at 24 cents per pound of contained chromium at the beginning of the year, delivered, carloads, bulk lump, was priced by at least one producer at 19 cents after April. Standard low-carbon ferrochromium, 67 to 73 percent chromium, maximum 0.025 percent carbon, was similarly priced after April at 22.5 cents per pound of contained chromium; quotations at the beginning of the year were 31 cents or more. Charge chrome containing 61 to 68 percent chromium, 5.25 percent carbon, and 3.00 percent maximum silicon was priced at 13.5 cents per pound of contained chromium, delivered, carloads, bulk lump, at yearend. This also represented a substantial decrease from the initial prices of the year.

The price of the 50-percent silicon grade of ferrosilicon changed less sharply to 12.1 cents per pound of contained silicon, delivered, carloads, bulk lump, while quotations for electric-furnace silvery pig iron, 15.51 to 16.00 percent silicon content, remained unchanged for the year at $85 per long ton.

Early in the year quotations for ferrovanadium containing 50 to 55 percent vanadium dropped to $2.85 to $3.05 per pound of contained vanadium, depending on the grade. These were in the $3.20 to $3.40 range when the year began. The price of ferrocolumbium containing 50 to 60 percent columbium, maximum 0.40 percent carbon, and maximum 8 percent silicon, fell appreciably, also. Quotations at yearend were $3.00 per pound of contained columbium, ton lots, 2-inch lump, packed and delivered; quotations were $3.45 at the beginning of the year.

FOREIGN TRADE

A new classification of imports for statistical purposes became effective September 1, 1963. This appears to have posed no serious problems in connection with the statistics for ferroalloy imports but did result in some changes in the collection and presentation of the statistics. The item identified as "ferrosilicon-aluminum and ferro-aluminum silicon and alsimin" was deleted. Apart from the change in classification, revision of 1962 data revealed the quantity and value reported in this category for that year was in error, as there were no imports.

Imports for consumption of ferromanganese, compared with those of 1962, increased 17 percent on a gross weight basis. The total being 149,000 short tons in 1963; almost all were for commercial account. Ferrovanadium imports were more than four times those of 1962. Ferrochromium and ferrosilicon imports for consumption were lower in 1963, but imports of manganese and chromium metal were appreciably higher. Ferromanganese exports of 678 tons were at 1960–61 levels, which were lower than those of other recent years. Total ferroalloy exports in 1963 were almost twice those of 1962, but below those of earlier years through 1955.

TABLE 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1962			1963		
	Gross weight (short tons)	Content (short tons)	Value	Gross weight (short tons)	Content (short tons)	Value
Calcium silicide	685	(1)	$200,163	[2] 560	(1)	[2] $159,575
Chromium metal	648	(1)	992,655	861	(1)	1,308,120
Chromium-nickel and chromium-vanadium	3	(1)	3,352			
Ferroboron	10	(1)	16,032	11	(1)	17,194
Ferrocerium and other cerium alloys	10	(1)	60,421	8	(1)	48,797
Ferrochrome and ferrochromium—						
Containing 3 percent or more carbon	[3] 12,442	[3] 7,685	[3] 2,126,286	6,532	3,961	1,043,275
Containing less than 3 percent carbon	[3] 24,084	[3] 17,229	[3] 7,718,646	22,511	15,984	5,763,649
Ferrochromium-tungsten, chromium-tungsten, chromium-cobalt-tungsten, tungsten-nickel, and other alloys of tungsten, n.s.p.f. (tungsten content)	(1)	21	47,044	(1)	21	40,290
Ferromanganese—						
Containing not over 1 percent carbon	1,040	940	[3] 442,434	628	560	252,070
Containing over 1 and less than 4 percent carbon	12,826	10,517	2,883,891	15,666	12,581	2,867,241
Containing not less than 4 percent carbon	111,748	85,585	[3] 13,430,508	132,336	102,236	13,854,429
Ferromolybdenum, molybdenum metal and powder, calcium molybdate, and other compounds and alloys of molybdenum (molybdenum content)	(1)	39	189,455	(1)	37	174,267
Ferrosilicon	16,329	2,573	975,892	13,357	2,376	743,765
Ferrotitanium	120	(1)	87,702	41	(1)	35,145
Ferrotungsten	329	267	531,071	546	441	608,589
Ferrovanadium	88	(1)	231,028	443	(1)	1,186,697
Manganese metal	(1)	[3] 1,504	[3] 670,601	[4] 2,631	(4)	943,902
Manganese silicon (manganese content)	(1)	17,153	[3] 3,049,113	(1)	14,429	2,318,003
Silicon metal (silicon content)	12	12	5,015			
Tungsten in combinations, in lump, grains, or powder (tungsten content)	(1)	249	937,950	(1)	42	163,024
Tungstic acid and other alloys of tungsten, n.s.p.f. (tungsten content)	(1)	(5)	890	(1)	19	80,595
Zirconium silicon	70	(1)	12,999	30	(1)	5,582

[1] Not recorded.
[2] Data known to be not comparable with earlier years.
[3] Revised figure.
[4] Effective Sept. 1, 1963, reported in gross weight. However, because gross weight and manganese content are almost the same, the total is tabulated here under gross weight.
[5] 356 pounds.

Source: Bureau of the Census.

TABLE 9.—U.S. imports for consumption of ferromanganese and ferrosilicon, by countries

Country	Ferromanganese (manganese content), excluding silicomanganese				Ferrosilicon (silicon content)			
	1962		1963		1962		1963	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:								
Canada	135	$29,127			2,396	$791,954	1,962	$667,616
Mexico	1,236	196,815	1,094	$146,476				
Total	1,371	225,942	1,094	146,476	2,396	791,954	1,962	667,616
South America:								
Brazil	4,231	637,856						
Chile	4,534	940,318	6,491	1,257,584				
Total	8,765	1,578,174	6,491	1,257,584				
Europe:								
Belgium-Luxembourg	[1] 3,751	[1] 590,946	6,764	1,020,077				
France	35,403	[1] 5,759,833	32,791	5,030,875	9	1,873	102	17,326
Germany, West	17,671	2,658,997	36,724	4,767,124	163	180,948	5	4,850
Italy	217	52,693	353	82,000			17	2,959
Norway	894	127,486			4	845	290	51,014
Spain			5,307	672,800				
Yugoslavia	2,089	324,450	173	21,796				
Total	[1] 60,025	[1] 9,514,405	82,112	11,594,672	176	183,666	414	76,149
Asia:								
India	5,702	1,166,690	2,196	278,298				
Japan	9,707	2,426,943	7,263	1,631,828				
Total	15,409	3,593,633	9,459	1,910,126				
Africa:								
Mozambique			840	107,850				
South Africa, Republic of	12,300	1,844,679	15,381	1,957,032	1	272		
Total	12,300	1,844,679	16,221	2,064,882	1	272		
Grand total	[1] 97,870	[1] 16,756,833	115,377	16,973,740	2,573	975,892	2,376	743,765

[1] Revised figure.

Source: Bureau of the Census.

TABLE 10.—U.S. exports of ferroalloys and ferroalloy metals

Alloy	1960		1961		1962		1963	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Ferrochrome	15,588	$5,248,750	7,844	$2,837,518	3,075	$1,182,382	2,354	$772,937
Ferromanganese	751	202,457	469	146,178	4,114	629,401	678	154,973
Ferromolybdenum	212	489,140	179	501,476	95	305,126	120	379,173
Ferrophosphorus	47,897	2,094,527	32,860	1,425,568	14,130	594,666	41,361	1,302,337
Ferrosilicon	5,501	867,140	34,764	6,104,913	4,101	1,348,661	3,130	947,773
Ferrotitanium and ferrocarbon-titanium	245	157,419	212	93,389	130	95,265	211	182,828
Ferrotungsten			(1)	1,569	6	26,136	1	2,927
Ferrovanadium	162	506,624	120	436,208	201	745,912	183	587,690
Other ferroalloys	3,845	846,888	4,839	1,234,682	[2] 348	[2] 233,591	430	262,985
Spiegeleisen	148	15,056	525	46,617	715	59,275	1,176	89,766
Total	74,349	10,428,001	81,812	12,828,118	[2] 26,915	[2] 5,220,415	49,644	4,683,389

[1] Less than 1 ton.
[2] Revised figure.

Source: Bureau of the Census.

WORLD REVIEW

SOUTH AMERICA

Venezuela.—Approximately 10,000 tons per year of various ferroalloys was expected to be consumed by the new Matanzas Steel Plant of the Government's Corporacion Venezolana de Guayana. The early 1963 supply, principally ferrosilicon, came from Europe and the United States.

EUROPE

Germany, West.—Antidumping duties on Japanese ferrochromium and ferromanganese were voted by the Federal Cabinet on February 20, 1963, but were suspended on February 28 when the Japanese Government offered to restrict the exports and to suggest to its exporters that their prices be increased.

Italy.—Interlake Iron Corp., Cleveland, Ohio, and Finanziaria Ernesto Breda, S.p.A., Milan, agreed to form a joint company to be known as Breda-Interlake, S.p.A., which will build a large plant to produce ferroalloys to supply Italy and the Common Market.[3] The Italian industry was adversely affected in 1963 by low-priced imports.

Norway.—Only 60 percent of Norway's capacity to produce ferroalloys was reported to be in use in early 1963.[4] This appeared to foreshadow more serious difficulties for the industry arising from Norwegian exclusion from the European Economic Community and from the competition low-cost Norwegian hydroelectric energy may expect to meet from new energy sources becoming available to the Community.

United Kingdom.—Barrow Haematite Steel Co., Ltd., announced that beginning July 1, 1963, production of ferromanganese in the United Kingdom was no longer controlled by the United Kingdom Ferro Manganese Co. Consequently, Barrow Haematite planned to resume production at its Darwen and Mostyn works.[5] In December, 500 tons of standard ferromanganese was exported from the United Kingdom to Luxembourg. This was the first significant shipment of this alloy outside the country for some years.[6] Ferroalloy imports for 1963 and 1962 were, respectively, ferrochromium, 39,000 and 28,000 short tons; refined ferromanganese, 20,000 and 19,000 tons; standard ferromanganese, 41,000 and 30,000 tons; ferrosilicon under 55 percent silicon, 37,000 and 39,000 tons; ferrosilicon over 55 percent silicon, 61,000 and 46,000 tons; silicomanganese, 31,000 and 28,000 tons; and silicochrome, 4,300 and 3,400 tons. None of these alloys came from the United States; all of the standard ferromanganese was from South Africa, all of the silicomanganese was from Norway, the greater portion of the lower grace ferrosilicon was from Canada, and more than half of the higher grade ferrosilicon came from Norway. Relatively small quantities of ferrochromium were imported from

[3] American Metal Market. V. 70, No. 181, Sept. 19, 1963, p. 15.
[4] Mining Journal (London). V. 260, No. 6671, June 28, 1963, p. 652.
[5] Steel and Coal (London). V. 187, No. 4958, July 26, 1963, p. 187.
[6] Metal Bulletin (London). No. 4872, Feb. 14, 1964, p. 16.

Czechoslovakia, the U.S.S.R., and Yugoslavia in both years, lower grade ferrosilicon came from East Germany, and higher grade ferrosilicon came from the U.S.S.R. and Czechoslovakia.[7]

ASIA

Japan.—Nippon Denko Co. was formed, effective December 20, as a merger of two of Japan's largest ferroalloy producers—Toho Denka Co. and Nippon Denki Yakin Kogyo.[8] Following West German charges of Japanese dumping of ferromanganese and ferrochromium, the Japanese Ministries of Trade and Foreign Affairs early in 1963 agreed with the Japanese ferroalloy industry to suspend exports to West Germany until June, after which shipments were to be resumed under a monthly quota of 100 tons.[9] To implement this decision, plans were underway by the ferroalloy industry to establish two export organizations, one for ferromanganese and one for ferrochromium, which would fix export quotas, exercise control over export prices, and minimize unnecessary competition among producers and exporters. Eight ferromanganese producers, including Tekkosha, the country's largest ferroalloy producer, planned to organize the ferromanganese group. The ferrochromium group would have six members, including Nippon Kokan and Showa Denko.[10] During the first 6 months of 1963, Japan imported 400 tons of standard ferromanganese and 300 tons of Simplex ferrochrome from the United States.[11]

The tariff on ferromanganese, 25 percent in the first quarter of 1963, was changed on April 1 to 20 percent effective until March 31, 1964, when it was scheduled to be cut again to 15 percent effective until March 31, 1965. At this time it would reach its basic rate of 10 percent, if the proposals of the Tariff Council are accepted by the Ministry of Finance, the Cabinet, and the Diet. These tariff cuts, in the face of increasing competition for Japanese exports in world markets, caused some concern for the future of the ferroalloy industry. In spite of this situation, however, a gap between Japanese ferrosilicon demand and production required importation of this alloy, and contracts were made for imports to be delivered in 1964.

TECHNOLOGY

In open-hearth steel operations, addition of ferroalloys to the furnace rather than to the ladle assures complete solution in the bath, and the turbulent mixing upon tapping provides uniform distribution. The advantages of ladle additions are better analytical control and higher alloy recoveries—both important factors in obtaining satisfactory costs and meeting tight specifications. Disadvantages are that if the addition to the ladle is too large, the solution is adversely affected by a large temperature drop, and segregation results from incomplete mixture with the bath. The

[7] Metal Bulletin (London). No. 4884, Mar. 26, 1964, p. 16.
[8] Metal Bulletin (London). No. 4859, Dec. 31, 1963, p. 19.
[9] American Metal Market. V. 70, No. 50, Mar. 14, 1963, p. 15.
[10] American Metal Market. V. 70, No. 99, May 23, 1963, p. 15.
[11] Metal Bulletin (London). No. 4831, Sept. 20, 1963, p. 19.

trend has been toward larger ladle additions utilizing mechanical feeders. With increased use of the basic-oxygen steelmaking process, this trend probably will continue, in order to take full advantage of timesaving features of the process. Although the basic-oxygen furnace attains higher bath temperatures than those normally reached in the open hearth, the temperature drop to the ladle is greater. If nitrogen generated in the reaction is not detrimental to the quality of the steel produced, the use of exothermic alloys may overcome this problem. Another problem arising from making all alloy additions to the ladle is that of achieving sufficient deoxidation. It has been suggested that this might be accomplished by the use of silicomanganese instead of ferrosilicon, ferromanganese, or aluminum. The theory is that the latter alloys have difficulty mixing with the heat because a high-melting stable oxide film forms. Other alloys, of which silicomanganese is one, form a low-melting liquid oxide film that breaks up and allows the alloy to diffuse readily.[12]

A 29,000-kilovolt-ampere transformer weighing 90 tons was provided for the highly automated ferroalloy furnace under construction in 1963 at the Beverly, Ohio, plant of Interlake Iron Corp.[13] The furnace has an automatic mix system for feeding the raw materials. Its electric energy requirements are electronically controlled by a computer, and each of its three 60-ton carbon electrodes is positioned automatically within fractions of an inch by another electronically controlled system. This insures steady operating conditions. The machinery for adjusting the electrodes is housed in an atmospherically controlled chamber.[14]

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[12] Van Voris, F. E. High Speed Process Spurs Search for Most Economic Way of Adding Alloys. Am. Metal Market, v. 70, No. 118, June 20, 1963, p. 20.
[13] American Metal Market. V. 70, No. 206, Oct. 24, 1963, p. 15.
[14] American Metal Market. V. 71, No. 21, Jan. 30, 1964, p. 16.

Fluorspar and Cryolite

By Paul M. Ambrose [1]

FLUORSPAR

DURING the year there was renewed effort on the part of fluorspar producers and processors to prevent further decline of domestic fluorspar production. Research was conducted on the recovery of fluorspar and barite, of marketable quality, from complex ores. Renewed efforts were made to increase the use of briquettes and a new process for pelletizing fluorspar fines was tested. The results of the investigation of the new agglomerating process were encouraging and a small commercial plant was being constructed.

Shipments of finished fluorspar from domestic mines in 1963 were 3 percent less than those in 1962, and imports for consumption decreased 7 percent. Consumption of fluorspar reached a record of 736,000 tons, 48,000 tons more than the previous record established in 1961. There was a considerable decrease in the price of imported fluorspar delivered to consumers in 1963.

TABLE 1.—Salient fluorspar statistics

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Production:						
Crude:						
Mine production..short tons..	775, 020	404, 900	575, 700	615, 075	623, 750	586, 158
Material milled or washed do....	734, 240	442, 000	558, 600	524, 400	586, 700	586, 400
Beneficiated material recovered short tons..	291, 160	195, 100	225, 900	185, 200	192, 000	188, 200
Finished (shipments)........do....	300, 654	185, 091	229, 782	197, 354	206, 026	199, 843
Value............thousands..	$14, 006	$8, 680	$10, 391	$8, 940	$9, 166	$8, 998
Imports for consumption..short tons..	433, 165	555, 750	534, 020	505, 759	595, 695	555, 123
Value...............thousands..	$10, 907	$13, 368	$14, 393	$13, 644	$15, 596	$14, 104
Exports.................short tons..	1, 168	1, 144	458	338	1, 308	1, 202
Value...............thousands..	$84	$69	$38	$30	$119	$157
Consumption...........short tons..	562, 181	589, 979	643, 759	687, 940	652, 888	736, 350
Stocks Dec. 31:						
Domestic mines:						
Crude............short tons..	186, 877	155, 534	137, 723	221, 961	277, 876	299, 197
Finished...............do....	20, 993	21, 417	16, 013	21, 001	14, 549	14, 954
Consumer plants...........do....	177, 470	179, 771	216, 330	188, 413	186, 772	181, 934
Importers.................do....	44, 893	46, 422	61, 578	75, 811	75, 303	68, 038
World: Production.................do....	1, 790, 000	1, 900, 000	2, 230, 000	2, 275, 000	2, 410, 000	2, 340, 000

[1] Commodity specialist, Division of Minerals.

LEGISLATION AND GOVERNMENT PROGRAMS

The General Services Administration offered 2,300 tons of acid-grade fluorspar for sale in November. The filter cake material had become slightly contaminated and was offered for sale in lots not less than 50 tons by competitive bidding. None of the material was sold.

In June the Food and Drug Administration terminated the permission to use fluorine compounds in dietary supplements for sale under the food additives law. The law provided that the addition of fluorine compounds should be limited to water and to items authorized by special regulations such as certain dentifrices and prescription sales.

DOMESTIC PRODUCTION

Fluorspar was mined in Colorado, Illinois, Kentucky, Montana, Nevada, and Utah in 1963. Shipments of finished fluorspar from mines totaled 200,000 short tons as follows: Acid grade, 126,000 tons valued at $6.5 million; ceramic grade, 42,000 tons at $1.7 million; and metallurgical grade, 32,000 tons at $819,000. Producers in Illinois, the leading producing State, supplied 66 percent of the domestic output.

Output of crude ore from domestic mines was 586,000 tons, about 6 percent less than in 1962. Of the total, 94 percent was obtained from six mines that produced over 20,000 tons each. Crude fluorspar marketed as mined totaled 12,441 tons, compared with 10,081 tons in 1962.

Producers in 1962 that did not report production in 1963 were Cave Masonic Lodge, Ulysses Ralph, and Wallace and Crabb, all in Hardin County, Ill.; and J. Willis Crider Fluorspar Co., Crittenden County, and Kentucky Fluorspar Co., Livingston County, both in Kentucky.

Producers in 1963 that did not operate in 1962 were James W. Patton & Sons and Shawnee Mining Co., both in Hardin County, Ill.; and C & L Fluorspar Co. and Mayfluor Corp., both in Crittenden County, and Nancy Hanks Mines, Inc., all three located in Kentucky.

TABLE 2.—Number and production of domestic crude fluorspar mines by size of operation

Annual production (short tons)	1962			1963		
	Mines	Short tons	Percent	Mines	Short tons	Percent
Less than 1,000 [1]	13	3,076	0.5	13	2,990	0.5
1,000 to 10,000	5	26,805	4.3	7	30,037	5.1
10,000 to 20,000	2	28,758	4.6			
Over 20,000	6	565,111	90.6	6	553,131	94.4
Total	26	623,750	100.0	26	586,158	100.0

[1] Includes prospects and reworked dumps and tailings of previous mining and milling operations.

TABLE 3.—Shipments of finished fluorspar, by States

State	1962			1963		
	Short tons	Value		Short tons	Value	
		Total	Average per ton		Total	Average per ton
Illinois	132,830	$6,391,673	$48.12	132,060	$6,547,149	$49.58
Kentucky	33,830	1,492,000	44.10	35,072	1,537,327	43.83
Utah	399	11,571	29.00	247	6,700	27.13
Other [1]	38,967	1,271,101	32.59	32,464	907,472	27.95
Total	206,026	9,166,000	44.49	199,843	8,998,000	45.03

[1] Includes Colorado, Montana, and Nevada to avoid disclosing individual company confidential data.

CONSUMPTION AND USES

Domestic fluorspar consumption amounted to 736,000 tons, compared with the previous record of 688,000 tons in 1961. Fluorspar consumption was reported in 38 States, but 10 States—New Jersey, Texas, Ohio, Pennsylvania, Louisiana, Illinois, West Virginia, Delaware, Kentucky, and Michigan—reported 79 percent of the total consumption.

Hydrofluoric acid producers consumed 414,000 tons of the total 736,000 tons of fluorspar used in the United States in 1963. The second largest user was the steel industry that reported using 243,000 tons of fluorspar in making open-hearth-, basic-oxygen-, and electric-furnace steel.

Fluorocarbons produced by Kaiser Aluminum & Chemical Corp. at Gramercy, La., were shipped to bulk depots at Dalton, Ill., Hillside, N.J., and Los Angeles, Calif., for distribution. The corporation established a new fluorocarbon technical service laboratory at Dalton to assist in the further development of fluorocarbons.

National Carbon Co. produced a fibrous graphite packing material that contained 85 percent graphite and 15 percent tetrafluoroethylene. The thermal conductivity and coefficient of expansion were about the same as those of stainless steel. It was expected to be used as soft packing material in valve- and pump-stuffing boxes.[2]

Bronze-filled Teflon, containing 70 percent bronze, was available from Liquid Nitrogen Processing Corp., Malvern, Pa. The material, which had almost three times the compressive strength of Teflon, could be made into bearings, bushings, and other nonlubricated parts. A free-flowing form could be used in high-speed press molding of thin-wall parts.[3]

A new plant in Buffalo, N.Y., using a computer to control color matching, began production of Tedlar, a polyvinyl fluoride film. The product was fire and abrasion resistant and provided protective insulation where corrosive chemicals were handled. Because of special properties it was useful as a finish for residential siding, architectural building panels, and industrial or commercial buildings.[4]

[2] Industrial and Engineering Chemistry. V. 55, No. 8, August 1963, p. 74.
[3] Chemical Engineering. V. 70, No. 9, Apr. 29, 1963, p. 78.
[4] Chemical Engineering. V. 70, No. 13, June 24, 1963, p. 142.
Keller, E. Polyvinyl Fluoride—Corrosion-Resistant Exterior Finish. Ind. Eng. Chem., v. 55, No. 8, August 1963, p. 16.

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A new fluorocarbon processing facility to formulate, fabricate, and test a wide variety of fluorocarbon materials was constructed. The plant used filtered air which was maintained under a slight pressure to prevent infiltration of contaminants.[5]

Antipathy of fluoridation of water lessened and more than 43 million people in 2,300 towns used fluoride-treated water.[6]

One, and possibly two, commercial units for the production of polyvinylidene fluoride and polytetrafluoroethylene were to be constructed by Pennsalt Chemicals Corp.[7]

TABLE 4.—Fluorspar shipped from mines in the United States, by grades and industries

Grade and industry	1962				1963			
	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	134,796	76.4	$6,687,677	$49.61	113,953	67.6	$5,924,092	$51.99
Glass	23,747	13.4	999,156	42.08	30,453	18.1	1,283,895	42.16
Ceramic and enamel	3,978	2.3	171,126	43.02	4,496	2.7	186,989	41.59
Nonferrous	2,684	1.5	115,548	43.05	2,687	1.6	114,589	42.65
Ferrous	2,401	1.4	98,208	40.90	11,650	6.9	469,265	40.28
Miscellaneous [1]	8,817	5.0	363,758	41.26	5,256	3.1	213,891	40.69
Total	176,423	100.0	8,436,000	47.82	168,495	100.0	8,192,000	48.62
Fluxing gravel and foundry lump:								
Nonferrous	38	--------	1,426	37.53	12	--------	480	40.00
Ferrous	19,533	66.0	607,060	31.08	21,518	68.7	667,165	31.00
Miscellaneous	10,032	34.0	121,386	12.10	9,818	31.3	138,282	14.08
Total	29,603	100.0	730,000	24.66	31,348	100.0	806,000	25.71
All grades:								
Hydrofluoric acid	134,796	65.4	6,687,677	49.61	113,953	57.0	5,924,092	51.99
Glass	23,747	11.5	999,156	42.08	30,453	15.2	1,283,895	42.16
Ceramic and enamel	3,978	1.9	171,126	43.02	4,496	2.2	186,989	41.59
Nonferrous	2,722	1.3	116,974	42.97	2,699	1.4	115,069	42.63
Ferrous	21,934	10.7	705,268	32.15	33,168	16.6	1,136,430	34.26
Miscellaneous [1]	18,849	9.2	485,144	25.74	15,074	7.6	352,173	23.36
Total	206,026	100.0	9,166,000	44.49	199,843	100.0	8,998,000	45.03

[1] Includes exports.

[5] Chemical Engineering. V. 70, No. 10, May 13, 1963, p. 106.
[6] Engineering News-Record. V. 170, No. 18, May 2, 1963, p. 13.
[7] Chemical & Engineering News. V. 41, No. 18, May 6, 1963, p. 28.

TABLE 5.—Fluorspar (domestic and foreign) consumed and in stock in the United States, by grades and industries

(Short tons)

Grade and industry	1962		1963	
	Consumption	Stocks at consumer plants Dec. 31	Consumption	Stocks at consumer plants Dec. 31
Acid grade:				
Hydrofluoric acid	366,298	39,778	414,500	46,066
Glass	3,113	510	6,728	695
Enamel	359	22	399	63
Welding rod coatings	1,350	83	1,193	95
Nonferrous	(1)	----------	(1)	(1)
Special flux }				
Ferroalloys }	2,182	822	2,448	823
Primary aluminum }				
Total	373,302	41,215	425,268	47,742
Ceramic grade:				
Glass	24,703	3,307	24,334	3,221
Enamel	4,807	599	5,117	642
Welding rod coatings	1,761	169	2,550	268
Nonferrous	302	78	280	81
Special flux }	6,870	970	6,429	1,656
Ferroalloys }				
Total	38,443	5,123	38,710	5,868
Metallurgical grade:				
Glass	1,059	97	403	49
Enamel	3	1	----------	----------
Welding rod coatings	455	68	(2)	(2)
Nonferrous	10,005	2,159	10,292	2,540
Special flux }				
Ferroalloys }	1,728	6,343	1,728	3,303
Primary magnesium }				
Iron foundry	13,454	3,538	17,125	4,776
Basic open-hearth steel	133,721	}	135,832	}
Basic oxygen steel	45,922	128,228	64,822	117,656
Electric-furnace steel	34,627	}	42,170	}
Bessemer steel	169	}	----------	}
Total	241,143	140,434	272,372	128,324
All grades:				
Hydrofluoric acid	366,298	39,778	414,500	46,066
Glass	28,875	3,914	31,465	3,965
Enamel	5,169	622	5,516	705
Welding rod coatings	3,566	320	3,743	363
Nonferrous	10,307	2,237	10,572	2,621
Special flux	5,543	899	5,088	1,494
Ferroalloys	2,172	594	2,010	503
Primary aluminum }	3,065	6,642	3,507	3,785
Primary magnesium }				
Iron foundry	13,454	3,538	17,125	4,776
Basic open-hearth steel	133,721	}	135,832	}
Basic oxygen steel	45,922	128,228	64,822	117,656
Electric furnace steel	34,627	}	42,170	}
Bessemer steel	169	}	----------	}
Total	652,888	186,772	736,350	181,934

[1] A small amount of acid grade is included with metallurgical grade in order not to reveal individual company operations.
[2] Included with ceramic grade in order not to reveal individual company data.

TABLE 6.—Production of steel and consumption and stocks of fluorspar (domestic and foreign) at basic open-hearth, basic oxygen, and electric-furnace steel plants

	1954–58 (average)	1959	1960	1961	1962	1963
Production of basic and acid open-hearth steel ingots and castings at plants consuming fluorspar thousand short tons	89,943	76,500	83,668	81,999	82,877	82,831
Consumption of fluorspar in basic open-hearth steel production thousand short tons	196	158	169	156	134	136
Consumption of fluorspar per short ton of basic open-hearth steel made pounds	4.3	4.1	4.0	3.8	3.2	3.3
Stocks of fluorspar at basic open-hearth steel plants at end of year thousand short tons	122	108	137	121	102	86
Production of basic oxygen steel ingots and castings at plants consuming fluorspar thousand short tons	(1)	[2] 1,864	[2] 3,346	[2] 3,967	5,471	7,361
Consumption of fluorspar in basic oxygen steel production thousand short tons [4]	-------	-------	-------	-------	[3] 46	65
Consumption of fluorspar per short ton of basic oxygen steel made pounds [4]	-------	-------	-------	-------	[3] 16.8	17.6
Stocks of fluorspar at basic oxygen steel plants at end of year thousand short tons [4]	-------	-------	-------	-------	15	20
Production of electric-furnace steel, ingots and castings at plants consuming fluorspar thousand short tons	7,544	7,953	7,883	8,187	[5] 9,223	[5] 11,015
Consumption of fluorspar in electric-furnace steel production thousand short tons	29	36	46	49	35	42
Consumption of fluorspar per short ton of electric-furnace steel made pounds	7.8	9.2	11.6	11.9	7.6	7.7
Stocks of fluorspar at electric-furnace steel plants at end of year thousand short tons	8	16	17	14	11	12

[1] Data not available.
[2] Data from American Iron & Steel Institute.
[3] Revised figure.
[4] Data not available prior to 1962.
[5] Includes bessemer converters.

TABLE 7.—Fluorspar (domestic and foreign) consumed in the United States, by States

(Short tons)

State	1962	1963	State	1962	1963
Alabama, Georgia, North Carolina, and South Carolina	19,919	11,604	Kentucky	50,941	41,183
Arkansas, Kansas, Louisiana, Mississippi, and Oklahoma	62,463	84,592	Maryland	5,648	8,257
California and Hawaii	44,055	30,195	Massachusetts	180	163
Colorado and Utah	19,260	21,221	Michigan	24,500	40,328
Connecticut	1,617	1,414	Missouri	2,476	2,313
Delaware and New Jersey	114,781	133,695	New York	14,612	14,114
Florida, Rhode Island, and Virginia	892	1,131	Ohio	55,008	65,198
Illinois	46,718	47,597	Oregon and Washington	904	1,477
Indiana	22,684	27,573	Pennsylvania	60,260	64,898
Iowa, Minnesota, Nebraska, South Dakota, and Wisconsin	3,618	3,857	Tennessee	2,069	2,600
			Texas	69,963	89,529
			West Virginia	30,320	43,411
			Total	652,888	736,350

TABLE 8.—Fluorspar in Government inventories as of Dec. 31, 1963

Fluorspar	Objective	National (strategic) stockpile	DPA inventory	CCC and supplemental stocks
Acid grade	280,000	458,089	17,317	668,684
Metallurgical grade	375,000	369,443	----------	42,800

TABLE 9.—Stocks of fluorspar at mines or shipping points in the United States, by States, Dec. 31

(Short tons)

State	1962		1963	
	Crude [1]	Finished	Crude [1]	Finished
Illinois	244,709	12,064	273,972	11,370
Kentucky	5,926		2,397	37
Colorado, Nevada,[2] Montana, and Utah	27,241	2,485	22,828	3,547
Total	277,876	14,549	299,197	14,954

[1] This crude (run-of-mine) fluorspar usually is subjected to some type of processing before it can be marketed.
[2] Crude only.

PRICES

There was a decline in most E&MJ Metal and Mineral Market prices for fluorspar. The following are beginning and yearend short-ton prices or ranges of prices of some principal materials:

	Per short ton	
	January 1963	*December 1963*
Domestic:		
Metallurgical grade, 72½ percent, effective CaF_2, f.o.b. Illinois	\$38.50 to \$39.50	\$37.00 to \$39.00
Acid grade concentrates, dry basis, 97 percent CaF_2, f.o.b. Illinois, carloads	45.00 to 49.00	45.00
Less than carloads, Illinois	50.00 to 51.00	50.00
Bags, extra	3.00	3.00
Ceramic grade, 95 percent CaF_2	45.00 to 47.00	43.00
European:		
Metallurgical grade, 72½ percent effective CaF_2, duty paid	30.00 to 33.00	30.00 to 33.00
Mexican:		
Metallurgical grade, 72½ percent, effective CaF_2:		
Border, all rail, duty paid	26.50 to 28.00	24.50 to 26.00
Brownsville, Tex., barge, duty paid	30.50 to 32.50	27.00 to 28.50
Tampico, Mexico, vessel cargo lots	21.00 to 23.50	17.00 to 19.00
U.S. Atlantic ports, cars, duty paid	34.00 to 36.50	31.00 to 34.00

FOREIGN TRADE

Imports.—Fluorspar imports for consumption totaled 555,000 tons valued at \$14.1 million, a decrease of 7 percent in quantity and 10 percent in value below those of 1962. The percent of imports from Mexico continued to increase. In 1963, 80 percent of imports for consumption came from Mexico, compared with 75 percent in 1962. Other principal sources of imports were: Spain, 12 percent; Italy, 6 percent; and France, 2 percent. There were decreases in imports from Spain and Italy, and there was an increase from France. Imports from Canada and West Germany were less than 500 tons.

TABLE 10.—U.S. imports for consumption of fluorspar, by countries and customs districts

Country and customs district	1962						1963					
	Containing more than 97 percent calcium fluoride		Containing not more than 97 percent calcium fluoride		Total		Containing more than 97 percent calcium fluoride		Containing not more than 97 percent calcium fluoride		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:												
Canada:												
El Paso	-	-	-	-	-	-	-	-	69	$1,389	69	$1,389
Washington	-	-	-	-	-	-	4	140	-	-	4	140
Total	-	-	-	-	-	-	4	140	69	1,389	73	1,529
Mexico:												
Arizona	8,446	$262,682	-	-	8,446	$262,682	-	-	-	-	-	-
Buffalo	-	-	14,075	$325,286	14,075	325,286	-	-	7,354	123,003	7,354	123,003
El Paso	38,832	967,926	34,475	740,305	73,307	1,708,231	69,630	1,652,974	40,420	808,124	110,050	2,461,098
Galveston	159	5,143	-	-	159	5,143	432	13,812	-	-	432	13,812
Laredo	154,544	4,670,692	82,598	1,576,615	237,142	6,247,307	135,754	4,003,566	78,876	1,566,334	214,630	5,569,900
Los Angeles	45	1,117	-	-	45	1,117	172	4,314	100	2,003	272	6,317
Maryland	-	-	-	-	-	-	-	-	6,608	110,450	6,608	110,450
Massachusetts	-	-	-	-	-	-	-	-	20	393	20	393
Michigan	3,875	116,000	16,877	355,093	20,752	471,093	-	-	14,849	277,721	14,849	277,721
Mobile	-	-	5,829	105,484	5,829	105,484	-	-	8,053	124,590	8,053	124,590
New Orleans	3,931	140,130	9,139	164,417	13,070	304,547	17,805	567,383	16,551	295,422	34,356	862,805
New York	-	-	-	-	-	-	-	-	40	1,015	40	1,015
Ohio	-	-	9,632	205,233	9,632	205,233	-	-	11,638	245,484	11,638	245,484
Philadelphia	36,515	1,150,926	26,440	525,206	62,955	1,676,132	27,801	956,549	7,225	123,154	35,026	1,079,703
Sabine	317	10,018	-	-	317	10,018	-	-	-	-	-	-
St. Louis	1,596	33,763	-	-	1,596	33,763	-	-	-	-	-	-
San Diego	-	-	-	-	-	-	78	2,419	-	-	78	2,419
Vermont	-	-	39	793	39	793	-	-	128	2,548	128	2,548
Total	248,260	7,358,397	199,104	3,998,432	447,364	11,356,829	251,672	7,201,017	191,862	3,680,241	443,534	10,881,258
Total North America	248,260	7,358,397	199,104	3,998,432	447,364	11,356,829	251,676	7,201,157	191,931	3,681,630	443,607	10,882,787
South America:												
Colombia	-	-	-	-	-	-	9	228	-	-	9	228

Europe:												
France:												
Michigan	-----	-----	-----	-----	-----	-----	6,160	121,185	-----	-----	6,160	121,185
New Orleans	-----	-----	-----	-----	-----	-----	3,388	86,063	-----	-----	3,388	86,063
New York	28	1,539	-----	-----	28	1,539	-----	-----	-----	-----	-----	-----
Philadelphia	7,923	229,881	-----	-----	7,923	229,881	-----	-----	-----	-----	-----	-----
Total	7,951	231,420	-----	-----	7,951	231,420	9,548	207,248	-----	-----	9,548	207,248
Germany, West:												
Philadelphia	3,273	147,388	-----	-----	3,273	147,388	-----	-----	-----	-----	-----	-----
Puerto Rico	199	13,064	-----	-----	199	13,064	399	25,075	-----	-----	399	25,075
Total	3,472	160,452	-----	-----	3,472	160,452	399	25,075	-----	-----	399	25,075
Italy:												
New Orleans	12,349	332,640	-----	-----	12,349	332,640	22,873	771,290	-----	-----	22,873	771,290
Ohio	8,951	291,799	-----	-----	8,951	291,799	-----	-----	-----	-----	-----	-----
Philadelphia	26,503	810,443	-----	-----	26,503	810,443	10,201	307,410	-----	-----	10,201	307,410
Total	47,803	1,434,882	-----	-----	47,803	1,434,882	33,074	1,078,700	-----	-----	33,074	1,078,700
Spain:												
Ohio	15,213	398,509	-----	-----	15,213	398,509	25,317	703,050	-----	-----	25,317	703,050
Philadelphia	67,656	1,911,723	-----	-----	67,656	1,911,723	43,006	1,203,209	-----	-----	43,006	1,203,209
Total	82,869	2,310,232	-----	-----	82,869	2,310,232	68,323	1,906,259	-----	-----	68,323	1,906,259
United Kingdom:												
El Paso	-----	-----	-----	-----	-----	-----	129	3,207	34	661	163	3,868
Puerto Rico	101	4,280	-----	-----	101	4,280	-----	-----	-----	-----	-----	-----
Total	101	4,280	-----	-----	101	4,280	129	3,207	34	661	163	3,868
Total Europe	142,196	4,141,266	-----	-----	142,196	4,141,266	111,473	3,220,489	34	661	111,507	3,221,150
Africa: South Africa, Republic of: Philadelphia	-----	-----	6,135	98,241	6,135	98,241	-----	-----	-----	-----	-----	-----
Grand total	390,456	11,499,663	205,239	4,096,673	595,695	15,596,336	363,158	10,421,874	191,965	3,682,291	555,123	14,104,165

Source: Bureau of the Census.

TABLE 11.—Imported fluorspar delivered to consumers in the United States, by uses

Use	1962			1963		
	Short tons	Selling prices at tidewater, border, or f.o.b. mill in the United States, including duty		Short tons	Selling prices at tidewater, border, or f.o.b. mill in the United States, including duty	
		Total	Average per ton		Total	Average per ton
Hydrofluoric acid	164, 904	$5, 944, 998	$36. 05	77, 865	$2, 288, 709	$29. 39
Glass, ceramic, and enamel	14, 427	665, 825	46. 15	4, 252	138, 510	32. 58
Ferrous	105, 270	2, 867, 167	27. 24	85, 400	2, 103, 251	24. 63
Nonferrous				232	7, 097	30. 59
Other	34, 605	1, 228, 642	35. 50	54, 587	1, 517, 279	27. 80
Total	319, 206	10, 706, 632	33. 54	222, 336	6, 054, 846	27. 23

TABLE 12.—U.S. exports of fluorspar

Year	Short tons	Value		Year	Short tons	Value	
		Total	Average per ton			Total	Average per ton
1954–58 (average)	1, 168	$83, 767	$95. 07	1961	338	$30, 419	$90. 00
1959	1, 144	69, 204	60. 49	1962	1, 308	118, 749	90. 79
1960	458	38, 250	83. 52	1963	1, 202	156, 898	130. 53

Source: Bureau of the Census.

WORLD REVIEW [8]

NORTH AMERICA

Mexico.—The Government of Mexico was planning a quota system to allocate production and exports of fluorspar among existing producers in proportion to their records as producers and exporters during the past 5 years. Export licensing controls were placed on fluorspar to prevent some producers from being forced to close because of price cutting by new producers and to assure that price levels be maintained.

The fluorspar deposits of northern Coahuila, from which over 1 million tons of fluorspar were mined in the past 15 years, were described. The mantos are approximately 100 feet wide and some are several hundred feet long. They range from 2 to 15 feet in thickness and are coarse grained. Typical deposits contain from 70 to 90 percent CaF_2 and have only calcite and celestite as gangue minerals.[9]

[8] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

[9] Temple, A. K., and R. M. Grogan. Manto Deposits of Fluorspar, Northern Coahuila, Mexico. Econ. Geol., v. 58, No. 7, November 1963, pp. 1037–1053.

TABLE 13.—World production of fluorspar by countries [1] [2]
(Short tons)

Country [1]	1954-58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	103,020	[3] 74,000	[3] 77,000	[3] 80,000	[3] 75,000	[3] 67,000
Mexico	338,128	362,456	404,487	439,286	553,642	530,893
United States (shipments)	300,654	185,091	229,782	197,354	206,026	199,843
Total	741,802	621,547	711,269	716,640	834,668	797,736
South America:						
Argentina	13,224	17,989	13,748	11,105	9,976	[3] 10,000
Bolivia (exports)	216	---	---	---	---	---
Total	13,440	17,989	13,748	11,105	9,976	[3] 10,000
Europe:						
France	99,490	110,425	149,345	214,936	237,200	248,000
Germany:						
East [3]	80,000	70,000	80,000	80,000	80,000	80,000
West (marketable)	161,880	135,956	143,474	133,515	116,592	95,942
Italy	131,379	174,091	178,957	172,582	171,474	137,232
Norway	267	---	---	---	---	---
Spain (marketable)	86,629	98,318	122,377	161,954	165,356	168,441
Sweden (sales)	2,546	2,995	3,212	3,560	3,900	[3] 3,900
United Kingdom [4]	96,508	93,078	109,249	99,868	79,525	75,121
Total [1] [3]	665,000	690,000	790,000	870,000	860,000	820,000
Asia:						
China [3]	120,000	220,000	275,000	220,000	220,000	220,000
Japan	7,206	5,684	10,108	16,326	17,120	22,993
Korea:						
North [3]	(5)	33,000	33,000	33,000	33,000	33,000
Republic of	6,349	6,748	20,834	30,790	36,343	43,855
Mongolia, Outer	[3] 25,900	[3] 37,000	44,400	42,000	[3] 44,000	[3] 58,000
Thailand	---	---	3,814	5,241	11,806	32,221
Turkey	22	75	359	42	640	719
U.S.S.R. [3] [6]	147,000	190,000	210,000	230,000	230,000	235,000
Total [3]	335,000	495,000	600,000	580,000	595,000	645,000
Africa:						
Morocco	273	---	---	869	546	7,000
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	328	10	19	---	20	343
South Africa, Republic of	33,651	70,317	113,550	95,862	111,683	57,761
South-West Africa	753	141	---	---	240	480
Total	35,005	70,468	113,569	96,731	112,489	65,584
Oceania: Australia	600	528	8	---	---	---
World total (estimate) [1] [2]	1,790,000	1,900,000	2,230,000	2,275,000	2,410,000	2,340,000

[1] Fluorspar is also produced in Bulgaria, data not available; estimate included in total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Includes fluorspar recovered from old lead and zinc mine dumps, production of which is reported as follows: 1954–58 (average), 12,790 tons; 1959, 10,064 tons; 1960, 13,552 tons; 1961–63, data not available.
[5] Data not available; estimate by author of chapter included in total.
[6] U.S.S.R. in Europe included with U.S.S.R. in Asia, as the deposits are predominantly in Asiatic U.S.S.R.

TABLE 14.—Production and trade of fluorspar in 1962, by major countries

(Short tons)

Exports, by countries of origin	Production	Exports	Exports by countries of destination								
			North America		South America	Europe		Asia		Africa	Australia
			Canada	United States		East	West	Japan	other		
North America:											
Canada	[1] 75,000	4					4				
Mexico	553,642	516,216	[2] 52,905	[2] 447,365	77		12,453	[2] 1,270	[2] 2,146		
United States	[3] 206,026	1,308	1,144		112		1	6	45		
South America: Argentina	9,976	637			637						
Europe:											
Bulgaria	(4)	[5] 2,342					[2] 1,306	[2] 1,036			
France	237,200	48,688		3,585			44,560			543	
Germany:											
East	[1] 80,000	[5] 4,652					[2] 4,652				
West	[6] 116,592	15,802		3,781	64		11,957				
Italy	171,474	54,142		51,095			[2] 2,456		591		
Spain	[6] 165,356	97,004		82,802			13,938		264		
Sweden	[7] 3,900	531					508		23		
United Kingdom	79,525	(5)									
Asia:											
China	[1] 220,000	[2] 119,009				[2] 62,832	[2] 22,302	[2] 29,231	[2] 4,644		
Japan	17,120	64							64		
Korea:											
North	[1] 33,000	[5] 4,525						[2] 4,525			
Republic of	36,343	26,027					166	24,641	1,220		
Mongolia, Outer	[1] 44,000	[2] 41,337				[2] 41,337					
Thailand	11,806	7,674						6,462	1,212		
Turkey	640	(5)									
U.S.S.R.	[1] [8] 230,000	5,512						5,512			
Africa:											
South Africa, Republic of	111,683	78,187	10,915		242	1,058	21,863	[2] 34,384	142	7,021	2,562
South-West Africa	240	115		1				1		113	
Other Africa	566										
Total	[4] [9] 2,410,000	1,023,776	64,964	588,629	1,132	105,227	136,166	107,068	10,351	7,677	2,562

[1] Estimate.
[2] Imports.
[3] Shipments.
[4] Fluorspar is also produced in Bulgaria, data not available; estimate included in total.
[5] Incomplete data.
[6] Marketable.
[7] Sales.
[8] U.S.S.R. in Europe included with U.S.S.R. in Asia, as the deposits are predominantly in Asiatic U.S.S.R.
[9] Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

EUROPE

Bulgaria.—A fluorspar mine with a concentrating mill was opened near Michalkovo in the Rhodope Mountains. With the opening of these facilities, production was expected to be quadrupled from 5,500 short tons to 22,000 tons per year.[10]

Germany, West.—Competition, particularly from France and China, caused some fluorspar prices to drop to less than $20 per ton. Production of marketable fluorspar decreased from 134,000 short tons in 1961 to 117,000 tons in 1962. The outlook for the next few years was for continued decreases in production and increases in both imports and consumption. The prediction was verified by the production of 96,000 tons produced in 1963.

Italy.—Overall labor costs for producing fluorspar increased about 25 percent since the approval of a new mining labor contract in November 1962. Other labor costs increased transportation and port handling charges, and it was difficult for Italian producers to compete with Spanish fluorspar in Italy and even more difficult to compete with Mexican fluorspar in the U.S. market. Production, total exports, and exports to the United States all decreased. However, various proposals were made for the relief of the Italian fluorspar industry.[11]

United Kingdom.—A 12-ton-per-hour plant using a ferrosilicon medium was installed at the Whiteheaps mine in Durham to concentrate ore from this property and also from the Groverake mine at Rookhope. The heavy medium plant replaced jigs and concentrating tables, and in addition to concentrating raw ore it was planned to recover fluorspar from existing tailings piles. Tailings containing up to 40 percent CaF_2 would be upgraded to 85 to 90 percent CaF_2. Most of the product was metallurgical grade for use in steel plants of Colvilles, Ltd., which also controls the Whiteheaps and Groverake mines through its subsidiary, Blanchard Fluos Mines. Production of some acid-grade spar was planned in a flotation mill from fines and from the float fraction from the heavy medium plant.[12]

Planning permission was granted for an underground fluorspar mine at Eyam near Sheffield in Derbyshire. The mine was to be developed to produce 100,000 tons per year. This would be one of the largest producers in the world.[13]

ASIA

India.—Reserves of fluorspar rock in the Amba Dongar area, Baroda district, in Gujarat were estimated at more than 1 million tons to a depth of about 10 feet. Twenty-six zones of reserves were mapped.[14]

Plans were made to mine 10,000 tons per year from a deposit in Chota Udaipur in Gujarat. The acid-grade concentrate was to be used in manufacturing cryolite.

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[10] Mining Journal (London). New Mining Projects in Bulgaria. V. 260, No. 6669, June 14, 1963, p. 600.
[11] Bureau of Mines. Mineral Trade Notes. V. 58, No. 1, January 1964, pp. 15–16.
[12] South African Mining and Engineering Journal (Johannesburg). Media Separation Plant for Fluorspar. V. 74, No. 3688, October 1963, pp. 1029–1030, 1041.
[13] Mining Journal (London). U.K. Fluorspar Mine. V. 261, No. 6680, Aug. 30, 1963, p. 195.
[14] Mining Journal (London). Indian Fluorspar Deposits. V 261, No 6680, Aug 30, 1963, p. 195.

Japan.—The output of hydrogen fluoride, mostly for fluorocarbon and aluminum manufacture in 1962, was 12,000 tons.[15] A new company, Nitto Fluorochemicals Co., formed by Nitto Chemical Industry of Japan and E. I. du Pont de Nemours & Co., Inc., planned to produce 16,500 short tons of fluorine gas and 135 tons of fluorine resin annually.[16] Another firm, Osaka Kinzoku Kogyo Co., made 5 tons per month of a fluorine resin that was highly resistant to acids and heat. The resin was strong and light and was used for molding, insulation, and bearings.[17]

Korea, Republic of.—In March, Korea Tungsten Mining Corp. opened a custom fluorite concentrating plant at Kumsan, Cholla Pukto Province. About 10,000 short tons of plus 95-percent concentrate, with eventual concentration to more than 97 percent CaF_2 was to be produced for export.[18]

Thailand.—Production of fluorspar in Thailand started in August 1960 and increased from 5,241 short tons in 1961 to 11,806 tons in 1962. Exports through 1962 were 13,363 tons valued at $20 per ton.[19]

AFRICA

Morocco.—Continental Ore Corp. planned to investigate and exploit fluorspar deposits in Morocco. Deposits exist about 30 miles south of Meknes near Agourai.[20]

Mozambique.—Reconnaissance and prospecting had indicated fluorspar deposits in the Maringué-Macossa-Canxixe region, District of Manica e Sofala, Mozambique. The Portuguese Government invited proposals for prospecting and exclusive exploration of a 2,000-square-kilometer area in that region.[21]

South Africa, Republic of.—A fluorocarbon aerosol and refrigerant chemicals plant was planned by African Explosives as part of a chemical complex near Sasolburg, Republic of South Africa. African Explosives is a joint venture of Imperial Chemical Industries and De Beers Industrial Corp.[22]

Expansion of fluorspar activities in the Zeerust/Marico area, Republic of South Africa, was planned. This area produced a large proportion of the metallurgical-grade fluorspar for export and also for local use. Encouraging results were being obtained in concentrating low-grade ore into acid-grade concentrate.[23]

Markets for metallurgical-grade fluorspar produced in the Republic of South Africa were in the Netherlands and Japan. Japan and Canada were the largest markets for ceramic-grade spar.[24]

A large deposit of fluorspar 6 miles from Naboomspruit in the Transvaal was acquired by General Mining in February 1963. Acid-

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[15] Chemical Trade Journal and Chemical Engineer (London). Demand for Hydrogen Fluoride. V. 152, No. 3957, Apr. 12, 1963, p. 602.
[16] Oil, Paint and Drug Reporter. Fluorine Venture in Japan Is Planned by Nitto, du Pont. V. 183, No. 11, Mar. 18, 1963, p. 5.
[17] Oil, Paint and Drug Reporter. Japanese, U.S. Firms in Deal on Fluorine Resin Process. V. 183, No. 14, Apr. 8, 1963, p. 5.
[18] Bureau of Mines. Mineral Trade Notes. V. 57, No. 1, July 1963, p. 23.
[19] Bureau of Mines. Mineral Trade Notes. V. 58, No. 3, March 1964, p. 13.
[20] Engineering and Mining Journal. V. 164, No. 4, April 1963, p. 160.
[21] Bureau of Mines. Mineral Trade Notes. V. 56, No. 1, January 1963, p. 17.
[22] Chemical Week. Polyethylene Plans Firm Up in Africa and Russia. V. 92, No. 8, Feb. 23, 1963, pp. 35–36.
[23] South African Mining and Engineering Journal (Johannesburg). Cons. African Mines' Results. V. 73, pt. 2, No. 3644, Dec. 7, 1962, p. 1329.
[24] Bureau of Mines. Mineral Trade Notes. V. 57, No. 6, December 1963, pp. 17–20.

grade fluorspar was produced, from the property, at the rate of 500 tons per month.[25]

OCEANIA

Australia.—The Chillagoe deposits of fluorspar, which represent the biggest known concentration of the mineral, were being explored. Australia acquires from 2,000 to 2,500 tons of fluorspar annually from China, Federation of Rhodesia and Nyasaland, Republic of South Africa, and the United Kingdom. The drilling program was undertaken in anticipation of expansion of home markets.[26]

TECHNOLOGY

An analytical-control method for the determination of fluorine, particularly in partly defluorinated residues from high-temperature pyrohydrolysis, was developed. Fluorine was liberated from metal fluorides of aluminum, zirconium, and rare-earth elements by steam distillation at 155° C from a sulfuric-phosphoric acid solution of a sodium carbonate fusion of the sample. Fluorine in the distillate was determined by the established thorium nitrate titration.[27]

The fluorine content of glass-rich volcanic rocks of rhyolitic or rhyodacite composition was reported.[28]

Fluorspars that fluoresce were described at length. Sources were given in the United States and in Europe and new equipment for detecting fluorescence was mentioned.[29]

Lanthanum fluoride monocrystals doped with either neodymium or praseodymium, available in rods up to 0.5 inch in diameter, were suggested for laser and maser research.[30]

The Bureau of Mines completed research on the recovery of acid-grade fluorspar and barite, suitable for use in drilling mud, from complex barite-fluorspar ores from Arizona and Kentucky. The ore from Arizona contained 24.8 percent CaF_2 and 24.3 percent $BaSO_4$. Although the barite and fluorspar minerals had micron-size inclusions of gangue, flotation, using a sodium fluoride lignin-sulfonate-fatty reagent combination to float the fluorspar and a sodium cetyl sulfate to float the barite from the fluorspar tailings, produced concentrate analyzing 97 percent CaF_2 with an 82-percent recovery and barite concentrate containing 94 percent $BaSO_4$ with a 71-percent recovery. The millfeed was ground in a ball mill prior to flotation. More than 80 percent of the ground ore passed a 400-mesh screen. Using essentially the same reagent combination to float the fluorspar, and barium chloride, sodium silicate, sodium carbonate, and petroleum sulfonate to recover the barite, two barite-fluorspar ores from Kentucky were successfully concentrated. The minerals were liberated by grinding to minus 65-mesh in a rodmill. Concentrates containing slightly more

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[25] South African Mining and Engineering Journal (Johannesburg). General Mining Acquires Fluorspar Deposit. V. 74, pt. 1, No. 3669, May 31, 1963, p. 1273.
[26] Queensland Government Mining Journal (Australia). Fluorspar Drilling Programme. V. 64, No. 737, March 1963, p. 132.
[27] Blake, Henry E., Jr. Fluorine Analyses—Control Method for Various Compounds. BuMines Rept. of Inv. 6314, 1963, 29 pp.
[28] Economic Geology. Distribution of Fluorine in Unaltered Silicic Volcanic Rocks of the Western Conterminous United States. V. 58, No. 6, September–October 1963, pp. 941–951.
[29] Jones, Robert W., Jr. Collecting Fluorescent Minerals. Rocks and Minerals, v. 38, Nos. 11–12, November–December 1963, pp. 603–605.
[30] Chemical Week. Trivalent Monocrystals. V. 93, No. 11, Sept. 14, 1963, p. 131.

than 97 percent CaF_2 and over 94 percent $BaSO_4$, with recoveries of 82 and 85 percent, respectively, were obtained from ores containing from 25.6 to 32.6 percent CaF_2 and 71.0 to 47.4 percent $BaSO_4$.[31]

A method was developed and tested for agglomerating fluorspar concentrate into pellets for use as metallurgical fluorspar. Fluorspar moistened to 10 to 15 percent moisture with a water solution of sodium silicate was pelletized on a rotating disk mounted about 60° from the horizontal. The pellets were dried and baked above 500° F. Increasing the baking temperature to 700° or 750° F produced pellets that were highly resistant to breakage after being immersed in water for 60 hours. It was stated that commercial pellets and briquets would have certain advantages over lump metallurgical-grade fluorspar. Among the advantages were: A higher effective CaF_2 content, more uniform composition, easier handling, and a minimum content of fines and impurities.[32]

A new process for the recovery of anhydrous HF from hydrous wastes was being developed at Harwell, England, on a pilot scale of 50 pounds of acid per day. Dilute acid was concentrated to 38 percent HF by fractional distillation. This hydrous acid was contacted with trinonyl amine. Waste water was withdrawn from the reactor and the amine hydrofluoride was decomposed by fractional distillation in two successive, heated vertical evaporator tubes. Vapor from the first tube was mostly water and that from the second was passed through two partial condensers which recovered the amine and some water as a condensate to be recirculated. The residual vapor containing more than 99 percent HF was liquefied in a final condenser. Most principal units of the pilot plant were made of monel.[33]

Processes were announced for recovering byproduct hydrofluoric acid from phosphate rock operations.[34]

Fluorocarbon chemistry was being furthered by intensified study and dissemination of information on aromatic or ring fluorine compounds that showed promise of use in dyestuffs, heat, and radiation stable polymers, and biologically active compounds. Previously attention had been centered on aliphatic or open-chain fluorocarbons that found extensive use as refrigerants, propellents, plastics, and were used for a multitude of other purposes.[35]

The first book on aryl fluoride chemistry, a monograph, was released and other extensive information on fluorine became available.[36]

A test program was underway to determine how well fluorine could

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[31] Browning, James S., W. H. Eddy, and Thomas L. McVay. Selective Flotation of Barite-Fluorspar Ores From Kentucky. BuMines Rept. of Inv. 6187, 1963, 15 pp.
Bloom, P. A., W. A. McKinney, and L. G. Evans. Flotation Concentration of a Complex Barite-Fluorspar Ore. BuMines Rept. of Inv. 6213, 1963, 16 pp.

[32] Jackman, H. W., R. J. Helfinstine, and Josephus Thomas, Jr. Pelletizing Illinois Fluorspar. Illinois State Geol. Survey, Industrial Miner. Notes, No. 17, December 1963, 3 pp.

[33] Morris, J. B. Recovery of Hydrogen Fluoride. Chem. Trade J. and Chem. Eng. (London), v. 153, No. 3985, Oct. 25, 1963, pp. 635–636.

[34] Cunningham, G. L. (assigned to W. R. Grace & Co., New York). Production of Silica Free Hydrogen Fluoride. U.S. Pat. 3,101,254, Aug. 20, 1963.
Hinkle, J. H., Jr. (assigned to Hooker Chemical Corp., New York). Process for the Recovery of Hydrogen Fluoride and Silica From Waste Gases. U.S. Pat. 3,110,562, Nov. 12, 1963.

[35] European Chemical News (London). The Industrial Future of Aromatic Fluorocarbons. V. 3, No. 70, May 17, 1963, p. 32.

[36] Chemical and Engineering News (London). A "Must" for Fluorine Chemists. V. 41, No. 29, July 22, 1963, p. 70.
Stacey, M., J. C. Tatlow, and A. G. Sharpe (eds.). Advances in Fluorine Chemistry. Butterworth & Co., Ltd. (London), v. 3, 1963, 281 pp.

be used as an oxidizer ingredient in spacecraft. More than 200,000 pounds of fluorine have been burned in rocket engine tests. The purpose of this program was to learn more about the compatibility of 30 percent liquid fluorine in oxygen with loading equipment, valves, and oxidizer tankage of the Atlas launch vehicle. According to previous tests, use of this mixture would permit increases in payloads ranging from 30 to 88 percent.[37]

A laminated fabric suit was made of Teflon fibers and Teflon film was covered with solid gold. The suit which weighed 5.5 pounds protected the worker from chemical and temperature hazards in handling rocket fuels.[38]

A method was developed for bonding an inert slippery fluorocarbon to other materials, including ceramics, wood, metal, glass, pastic, and rubber. Etching with metallic sodium and anhydrous ammonia, under a protective atmosphere of nitrogen, removed fluorine atoms from the surface and exposed bondable carbon atoms. Etching produced a film ranging from light tan to dark brown or black. If the color was too light, it was an indication of underetching, and if the plastic was overetched it was extremely dark. One of several epoxy resins was the bonding agent. No single resin was suitable for all bonding applications. The development of the process opened possibilities of using relatively costly polymerized fluorocarbons for many new uses where it could be applied as a protective or friction-reducing coating.[39]

A process was developed for making fluorocarbon objects much larger than was previously possible. It was stated that part sizes were limited only by the size of the available ovens for curing the finished product. Facilities were available for making homogenous parts up to 5 by 5 by 10 feet.[40]

Teflon-aluminum laminate in sheets up to 4,500 feet long and 18 inches wide were produced with a new heat-pressure bonding process. The laminate which consisted of 0.1-inch-thick aluminum coated with Teflon (TFE) 1 mil to 0.125 inch thick could be processed with conventional metalworking techniques. The Teflon cold flow rate of 10 percent per 1,000 hours was reduced to 1 percent per 100,000 hours. More effective performance under heavy loads such as in bearings was expected. Predicted uses included chemical vessels, instrument cases, bearings, electrical and structural components, and antistick, anticorrosion, and antiwear surfaces.[41]

Announcement was made of a new fluorocarbon grease useful between 0° and 200° F. It was reported to be resistant to oxidizing agents and to be useful as a lubricant for missile couplings.[42]

CRYOLITE

The only commercial cryolite deposit in the world was operated by the Danish company, Kryolitselskabet Oresund Ald, at Ivigtut,

[37] Chemical Engineering. Fluorine Is Wooed by Aerospace Tests. V. 70, No. 23, Nov. 11, 1963, p. 138.
[38] Steel. New Teflon Uses. V. 153, No. 17, Oct. 21, 1963, p. 35.
[39] Schmidt, J. E., A. L. Mathews, and W. J. Hornblower. At Last, a Way To Stick the Unstickable Bond Teflon With Epoxies. Product Eng., v. 34, No. 11, May 27, 1963, pp. 43–46.
[40] Iron Age. Fluorocarbon Parts Get Bigger. V. 191, No. 21, May 23, 1963, p. 78.
[41] Chemical Engineering. Plastics-Metal Laminates. V. 70, No. 20, Sept. 30, 1963, p. 58.
[42] Chemical Week. Fluorocarbon Grease. V. 93, No. 13, Sept. 28, 1963, p. 82.

Greenland, through a concession from the Danish Government. Part of the mine output was exported to Pennsalt Chemicals Corp., Philadelphia, and was concentrated in a plant at Natrona, Pa.

Cryolite was reclaimed by Aluminum Co. of America at Point Comfort, Tex.; Kaiser Aluminum & Chemical Corp. at Chalmette, La., Spokane, Wash., and Ravenswood, W. Va.; and by Reynolds Metals Co. at Listerhill, Ala., and Longview, Wash.

Aluminum fluoride and cryolite for the production of aluminum in the $16 million plant at Veracruz in the State of Veracruz, Mexico, was supplied by Aluminum Co. of America's plant at Point Comfort, Tex.[43]

During 1963, 7,678 short tons of artificial cryolite in Defense Production Act Inventory was sold for $1,138,456. The warehouse in which the material was stored was to be evacuated by June 30, 1965.

PRICES

Cryolite quotations reported by the Oil, Paint and Drug Reporter of December 23, 1963, 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.

FOREIGN TRADE

Natural cryolite from Greenland constituted 80 percent of the cryolite imported in 1963.

Exports have been increasing for several years from a normal quantity of less than 200 short tons to 1,109 tons in 1962 and 3,719 tons in 1963. Prior to 1962 Canada was the principal outlet for cryolite from the United States. In 1962 Australian industries became major users. Principal exports from the United States in 1963 were: Australia, 1,747 tons; Mexico, 1,711 tons; and Canada, 223 tons. Lesser quantities in descending order were sent to Republic of South Africa, Brazil, Switzerland, Vietnam, and Jamaica.

TABLE 15.—U.S. imports for consumption of cryolite

Year and country	Short tons	Value
1954–58 (average)	24,628	$2,928,189
1959	22,102	1,994,473
1960	17,246	1,669,841
1961	13,814	1,193,840
1962:		
North America:		
Greenland [1]	9,464	424,175
Europe:		
Denmark	111	5,838
France	684	109,029
Germany, West	22	3,942
Italy	2,191	390,027
Total	3,008	508,836
Grand total	12,472	933,011
1963:		
North America:		
Canada	2	$515
Greenland [1]	21,412	837,863
Total	21,414	838,378
Europe:		
Germany, West	44	14,118
Italy	5,457	955,233
Total	5,501	969,351
Grand total	26,915	1,807,729

[1] Crude natural cryolite.

Source: Bureau of the Census.

[43] Chemical & Engineering News. V. 41, No. 28, July 15, 1963, p. 25.

Gem Stones

By Benjamin Petkof [1]

PRODUCTION of gem materials and mineral specimens was estimated at $1.4 million, an increase of 9 percent from the previous year. Production of these materials still remained largely in the hands of individual collectors.

DOMESTIC PRODUCTION

The Bureau of Mines collected production data by direct canvass of known amateur and professional gem stone producers. All producers are not known to the Bureau and the data presented are based on a partial survey.

For the third consecutive year, production of gem material and mineral specimens was reported from 45 States. California, Oregon, Texas, Arizona, Wyoming, and Nevada, the leading producing States, accounted for almost 62 percent of the total production in value.

Crystals of beryl, ranging in size from 1/16 inch in diameter and length to 2 feet in diameter and 4 feet in length, have been found in Coosa County, Ala. Much of the material is gem quality, and colors range from white to green, brown, and yellow. Most of the crystals are fractured and weathered, but fragments have been cut and polished into attractive gem stones.[2]

Emeralds of beautiful color and good quality have been found in Montana. The emeralds are very bright green and are similar to those of Chivor, Colombia. While most of the crystals are opaque, some have clear green portions.[3]

The Four Peaks amethyst mine was expected to begin production. The mine is located over a mile up on the western slope of the Four Peaks mountain range in Arizona. Mining equipment and construction material have been transported to the site by helicopter, and the amethyst crystals will be brought out in the same way.[4]

Agate.—Production of almost 106 tons of agate valued at $92,000 was reported in 23 States. Production included moss, turritella, fire, and other miscellaneous varieties of agate. Wyoming, New Mexico, Utah, and Arizona were the principal producers, in decreasing order of production.

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[1] Commodity specialist, Division of Minerals.
[2] Mining World. V. 25, No. 6, May 1963, p. 40.
[3] California Mining Journal. A.H. Welling Finds Valuable Emerald Deposits Near Superior, Montana. V. 33, No. 2, October 1963, p. 7.
[4] Mining World. V. 25, No. 3, March 1963, p. 38.

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Diamond.—Production was reported only in Arkansas. The recovery of 100 carats valued at $38,000 was reported.

Jade.—Jade production of 45,000 pounds valued at $90,000 was reported in five States. Wyoming and California accounted for 92 percent of the total production. Smaller quantities were produced in Nevada, Alaska, and North Carolina.

Mineral Specimens.—Production of various materials for mineral specimens was reported at almost 203,000 pounds valued at about $63,000. Production in varying quantities was reported from 31 States. The largest producing States, in decreasing order of rank, were California, Colorado, Michigan, Utah, and South Dakota. Production of copper mineral specimens, not included in the previously quoted total, was reported as 19,500 pounds valued at $8,800. The bulk of the production came from Michigan.

Obsidian.—Production of over 85,000 pounds valued at over $29,000 was reported in five States. Arizona, California, and Utah were the largest producers, accounting for 96 percent of total production.

Petrified Wood.—Petrified wood production of all varieties was reported as 115 tons valued at $78,000. Of this total, 1,400 pounds was petrified palm wood. The major producers of this commodity, in decreasing order, were Utah, Wyoming, and Arizona. These States were responsible for about 75 percent of total production. Eleven other States produced petrified wood.

Quartz Crystal.—Arizona and South Dakota provided 62 percent of total quartz crystal production, which was reported as 81,000 pounds valued at $30,000. Twenty other States also reported some production, but seven of these produced under 100 pounds of quartz crystal each. Approximately 4,000 pounds of the total production was of the smoky and rose quartz varieties.

Tourmaline.—About 220 pounds of tourmaline valued at almost $12,000 was produced. Half of this originated in Maine. The next largest producer was Minnesota, with lesser quantities from Alabama, California, Colorado, and South Carolina.

Turquoise.—The greatest quantity of turquoise was produced in Arizona. Wisconsin, California, Colorado, Wyoming, Nevada, and New Mexico produced lesser quantities. Total production was 14,750 pounds valued at $81,600.

Miscellaneous Gem Material.—Production of jasper was 36,600 pounds valued at $20,158, with Arizona and California producing two-thirds of the total. Opal production was about 7,400 pounds valued at almost $8,300. In addition, 12 pounds of fire opal valued at $180 was produced. New Mexico was the leading producing State with 3,100 pounds valued at $2,033. Garnet production was 4,800 pounds valued at $4,300. Coral production was primarily from Hawaii, with smaller quantities from a few other States. Total production was 9,100 pounds valued at $40,000. Peridot production occurred primarily in Arizona. About 1,500 pounds valued at $4,000 was produced.

The quantities and values of other gem and ornamental materials, for which production was reported, were amethyst, 470 pounds, $560; beryl specimens, 1,400 pounds, $1,480; feldspar gems, 7,400 pounds, $4,000; fluorite, 2,200 pounds, $800; fossils, 17,900 pounds, $8,900;

geodes, 1,500 pounds, $4,000; idocrase, 2,300 pounds, $4,700; marcasite, 620 pounds, $580; onyx, 68,500 pounds, $19,100; ornamental stone, 46,700 pounds, $10,300; rhodonite, 42,800 pounds, $11,200; sapphire, 18 pounds, $140; topaz, 470 pounds, $420.

CONSUMPTION

Consumption of gem diamond was valued at $224 million, an increase of about $32 million over 1962; imported imitation and synthetic gem stones was $5.1 million, an increase of $0.8 million over 1962; and natural and cultured pearls was $17.9 million, $1 million less than 1962.

Apparent consumption (domestic production plus imports, minus exports and reexports) of gem materials in the United States was $170 million, compared with $167 million in 1962.

PRICES

Prices ranges of cut and polished unmounted diamonds rose, compared with those of the previous year, because of increased demand. Estimated price ranges were 0.25 carat, $72 to $340; 0.5 carat, $220 to $600; 1 carat, $575 to $1,650; 2 carats, $1,380 to $5,000; 3 carats, $2,880 to $9,900.

FOREIGN TRADE

Imports.—Total precious and semiprecious gem stone imports were valued at about $256 million. About 2.8 million carats of rough

TABLE 1.—U.S. imports for consumption of precious and semiprecious stones, exclusive of industrial diamond

Stones	1962		1963	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Diamonds:				
Rough or uncut, suitable for cutting into gem stones, duty-free carats	[1] 1,421,143	[1] $102,548	1,749,641	$129,870
Cut but unset, suitable for jewelry, dutiable carats	982,278	89,188	1,017,620	93,977
Emeralds: Cut but not set, dutiable do	196,649	2,798	190,933	2,081
Pearls and parts, not strung or set, dutiable:				
Natural	(2)	737	(2)	479
Cultured or cultivated	(2)	18,198		17,427
Other precious and semiprecious stones:				
Rough or uncut, duty-free	(2)	1,765	(2)	1,708
Cut but not set, dutiable	(2)	[1] 5,102	(2)	5,183
Imitation, except opaque, dutiable:				
Not cut or faceted	(2)	61	(2)	28
Cut or faceted:				
Synthetic number	1,176,058	457	754,236	398
Other	(2)	[1] 3,730	(2)	4,487
Imitation, opaque, including imitation pearls, dutiable	(2)	18	(2)	154
Marcasites: Real and imitation, dutiable	(2)	(3)	(2)	(3)
Total	(2)	[1] 224,602	(2)	255,792

[1] Revised figure.
[2] Quantity not recorded.
[3] Less than $1,000.

Source: Bureau of the Census.

(uncut) and cut gem diamonds was imported and represented almost 88 percent of total imports by value.

Rough diamonds were principally imported by quantity from the following countries: United Kingdom, 52 percent; British West Africa, 18 percent; and Republic of South Africa, 6 percent. Cut but unset diamonds, by quantity, were imported principally from Belgium-Luxembourg (51 percent) and Israel (37 percent). Average values per carat of cut but unset diamond imports were Belgium-Luxembourg, $96.78; Israel, $79.42; Netherlands, $110.06; Republic of South Africa, $174.83; United Kingdom, $163.32; West Germany, $76.11.

Over 92 percent, by weight, of the cut but unset emeralds imported were from India. Of the remainder, 7 percent was imported from Switzerland, Belgium-Luxembourg, Colombia, and France. Twelve other countries supplied varying small amounts. The average values per carat of emerald imports from principal exporting countries were India, $9.11; Switzerland, $16.21; and Belgium-Luxembourg, $15.43.

Japan supplied almost the entire quantity of imported cultured pearls. Natural pearl imports were primarily from India (66 percent), Japan (14 percent), and Switzerland (7 percent); the remainder were from France, Iran, Hong Kong, Venezuela, and West Germany.

In addition, about $6.9 million of other precious and semiprecious stones, both rough and cut but unset, were imported. However, no classification information on varieties was available.

Exports.—Precious and semiprecious gem stone exports were valued at $40.5 million, compared with $18.8 million in 1962. Doubling of exports of cut but unset diamonds accounted for the increase. Cut but unset diamonds accounted for 81 percent of total exports. The value of gem stones, other than diamond, was over $5 million.

Reexports of all varieties of gem stone were valued at $46.7 million, compared with $40.0 million in 1962. Diamonds in the rough but uncut category accounted for 84 percent of total reexports.

TABLE 2.—U.S. imports for consumption of diamond (exclusive of industrial diamond), by countries

Country	1962				1963			
	Rough or uncut		Cut but unset		Rough or uncut		Cut but unset	
	Carats	Value (thousands)	Carats	Value (thousands)	Carats	Value (thousands)	Carats	Value (thousands)
North America:								
Canada	5,128	$655	217	$16	9,110	$918	847	$66
Mexico			198	22			12	3
Total	5,128	655	415	38	9,110	918	859	69
South America:								
Brazil	996	39	1,469	121	1,911	191		
British Guiana	9,852	346	133	10	1,011	43	84	6
Columbia					124	6		
Venezuela	128,264	4,025			55,905	1,971		
Total	139,112	4,410	1,602	131	58,951	2,211	84	6
Europe:								
Austria			130	13				
Belgium-Luxembourg	39,877	2,381	478,795	45,721	33,537	3,282	522,383	50,555
France	4,902	413	14,291	1,459	7,169	633	16,746	1,775
Germany, West	2,144	59	75,301	5,394	7	(1)	46,015	3,502
Gibraltar							7	(1)
Ireland			1	(1)				
Italy			201	66			152	103
Malta and Gozo			169	16	519	14	660	56
Netherlands	22,367	1,652	23,786	2,463	26,539	1,583	19,299	2,124
Portugal			12	1			105	14
Spain			7	5				
Switzerland	503	95	526	66	37,402	1,549	501	205
U.S.S.R.			2,640	262			411	23
United Kingdom	[2] 753,533	[2] 67,176	5,901	765	906,340	86,977	4,280	699
Total	[2] 823,326	[2] 71,776	601,760	56,231	1,011,513	94,038	610,559	59,056
Asia:								
Hong Kong			46	12			227	50
India			38	50			207	16
Iran			74	6				
Israel	20,001	949	351,306	27,881	69,671	3,404	374,199	29,719
Japan			831	70	283	5	4,381	321
Lebanon							15	4
Malaya, Federation of			7	10				
Thailand					3	(1)		
Total	20,001	949	352,302	28,029	69,957	3,409	379,029	30,110
Africa:								
British West Africa and Sierra Leone	125,407	4,622			320,845	8,725		
Cameroon, Federal Republic of	2,218	28	321	38				
Congo, Republic of the, and Ruanda-Urundi	34,945	1,309			8,811	368		
Ghana	23,962	253			1,993	49		
Liberia	10,456	1,211			19,051	1,395		
Nigeria	778	190			4,329	135		
South Africa, Republic of	[2] 120,285	[2] 12,268	25,878	4,721	112,448	11,558	27,089	4,736
Western Africa, n.e.c.[3]	57,030	2,772			71,096	4,148		
Western Equatorial Africa, n.e.c.[3]	58,495	2,105			61,537	2,916		
Total	[2] 433,576	[2] 24,758	26,199	4,759	600,110	29,294	27,089	4,736
Grand total	[2] 1,421,143	[2] 102,548	982,278	89,188	1,749,641	129,870	1,017,620	93,977

[1] Less than $1,000.
[2] Revised figure.
[3] Not elsewhere classified.

Source: Bureau of the Census

WORLD REVIEW [5]

SOUTH AMERICA

Brazil.—A large emerald deposit, claimed to be the largest in South America, has been located at Polao Arcado, in the State of Bahia. Shafts have been sunk and exploitation has begun.[6] About 503,000 pounds of semiprecious gem stone material was exported during the year. The material consisted primarily of agate, with lesser amounts of amethyst, citrine, garnet, aquamarine, tourmaline, and topaz. A valuation cannot be placed on these materials due to the wide variation of Brazilian currency during the year.

Chile.—Lapis lazuli was produced by only one company during 1962. Compañía Minera Caren mined the stone from a deposit high in the Andes Mountains in Coquimbo Province. Exports of about 22,000 pounds were reported for 1962. The bulk of the exports went to the United States, with smaller quantities going to West Germany, France, Japan, and Italy.[7]

TABLE 3.—World production of diamonds, by countries

(Thousand carats)

Country	1962		1963	
	Gem	Industrial	Gem	Industrial
Africa:				
Angola	[1] 762	[1] 319	759	325
Central African Republic	80	185	121	282
Congo, Republic of the	256	14,400	296	14,468
Congo, Republic of [2]	[1] 158	[1] 2,471	341	5,343
Ghana	628	2,580	536	2,142
Guinea, Republic of	[3] 140	[3] 210	[4] 22	[4] 32
Ivory Coast	102	182	63	117
Liberia [5]	225	680	249	508
Sierra Leone	[1] 707	[1] 1,200	555	833
South Africa, Republic of:				
Pipe mines:				
Premier	425	1,260	522	1,565
De Beers Group [6]	883	750	921	754
Others	36	84	37	86
Alluvial mines	290	190	294	196
South-West Africa	800	227	1,076	119
Tanganyika	[1] 323	324	276	313
Other regions:				
Brazil [3]	175	175	175	175
British Guiana	60	40	60	40
India	1	----------	1	----------
Venezuela	94	83	38	31
U.S.S.R.[3]	[1] 200	[1] 2,300	240	2,760
World total [7]	[1] [8] 6,347	[1] [8] 27,659	[8] 6,572	30,089

[1] Revised figure.
[2] Probable origin, Republic of the Congo.
[3] Estimate.
[4] Data known to be low, no sure basis for an upward revision.
[5] Exports, most production from adjacent nations.
[6] Includes some alluvial diamond from De Beers' properties.
[7] Countries producing minor quantities of gem diamonds not included.
[8] Data do not add to total because of rounding.

[5] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[6] Mining Journal (London). V. 261, No. 6681, Sept. 6, 1963, p. 218.
[7] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, p. 13.

Venezuela.—Production of gem diamond increased from 60,495 carats in 1961 to 93,970 carats in 1962. Exports of all qualities of diamond in 1962 totaled 82,189 carats, valued at $2.6 million. The major portion of exports was destined for the United States and Bermuda, with quantities consigned to Israel, the United Kingdom, and West Germany.[8] Production of gem diamond for 1963 was 38,400 carats.

EUROPE

Belgium.—Cuttable diamond imports increased 8 percent, from about 3.4 million carats in 1961 to about 3.7 million carats in 1962. Polished diamond imports decreased from 221,000 carats in 1961 to 212,000 in 1962. Israel and the Republic of South Africa were the principal suppliers. Exports during 1962 of cuttable and polished diamonds totaled 1.1 million carats and were valued at $120 million. Slightly over 500,000 carats of this material valued at about $53.8 million was sent to the United States.[9]

ASIA

Afghanistan.—The Afghan Ministry of Mines and Industries announced that about 3,600 pounds of lapis lazuli was produced in the year ending March 1962. About 1,800 pounds valued at $250,000 was exported.[10]

Burma.—The jade mining industry in the Kachin State has been nationalized by the Kachin State Affairs Council. Nationalization primarily affected Chinese nationals who own more than half of the 1,000 jade mines in the area. Chinese-owned mines have stopped operations, and the unemployed workers have been informed by the Council that they may have these mines if they work them on a collective or cooperative basis.[11]

India.—During the financial year of 1963–64, India's exports of precious stones were expected to reach a value of about $30.5 million. The Ramkheria mine in the Panna area was not in operation because of lack of equipment and was expected to be in operation in 1964. The Majhgawan, in the same area, was expected to be operative at the end of 1963. By December 1962, 1,070 carats were discovered.[12] The Indian State Geological Survey investigated diamond deposits and sampled pipe rocks of Vajrakarpur, in the Anantapur district of Andhra Pradesh.[13] Production of crude and dressed emeralds during 1962 was reported as about 306,000 and 52,700 carats, respectively, valued at about $12,000 and $37,800, respectively. India imported emeralds valued at about $2 million.

Israel.—Exports of $103 million worth of polished diamond in 1963 made Israel the world's second largest processor of diamond.[14] During 1962, about 838,000 carats of polished diamond valued at about

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[8] Bureau of Mines. Mineral Trade Notes. V. 56, No. 6, June 1963, p. 13.
[9] Bureau of Mines. Mineral Trade Notes. V. 56, No. 6, June 1963, pp. 8, 11.
[10] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, p. 13.
[11] Bureau of Mines. Mineral Trade Notes. V. 56, No. 5, May 1963, pp. 14–15.
[12] Mining Journal (London). V. 260, No. 6661, Apr. 19, 1963, p. 373.
[13] Mining Journal (London). V. 260, No. 6653, Feb. 22, 1963, p. 184.
[14] Mining Journal (London). V. 262, No. 6699, Jan. 17, 1964, p. 55.

$82.3 million were exported, compared with about 699,000 carats valued at about 26 percent less in 1961.[15]

Japan.—The Japanese cultured pearl industry has formed an organization to supervise the quality of exports. One of the aims of the 19-member group is to prevent very thinly coated pearls from reaching the consumer market.[16]

AFRICA

Angola.—A newly formed company has been granted a concession to exploit stone deposits containing precious and semiprecious stones. This company will concern itself primarily with rubies, sapphires, topazes, and aquamarines that occur in the riverbeds of southern and southeastern sections of the country. Previously, the only large-scale concessionaire, the Companhia de Diamantes, exploited only high-value precious stones.[17] Diamond production in 1963 was about 1.1 million carats, of which 70 percent was gem variety.

Central African Republic.—The Central African National Assembly enacted legislation to establish a State-owned diamond-mining firm, to be known as the Société Nationale de Recherches et d'Exploitations Minières. This legislation was expected to increase diamond production and to control the activities of non-Central African diamond buyers. Within the next 2 years this organization plans to establish several small diamond-mining centers in the southwestern section of the Nation. These centers will be staffed with 2 to 3 mining engineers and 15 to 30 laborers. Villages will be established with such facilities as retail stores and licensed buying offices. It is expected that these centers will attract the large number of "diggers" scattered throughout the area, and that licensed buying offices will purchase their production. These offices will resell to buying offices in Bangui. The Government will sell its production directly to buying offices in Bangui.

The Israel-Central African Republic diamond export monopoly was dissolved on December 31, 1963.[18]

Diamond production during 1963 was reported as 403,000 carats, of which 30 percent was gem quality.

Gabon.—A Government decree issued November 16, 1963, stopped exploitation of diamond resources by all persons, except those of Gabonese origin who are registered artisans under the direct control of the Government-owned mining company. Little interest has been shown in diamond mining owing to the small size of the deposits and exploitation difficulties.[19]

Ghana.—The Ghana Diamond Marketing Board was established January 1, 1963, for the purpose of purchasing, grading, and appraising diamonds produced within the country. Subject to the prior approval of the Minister of Finance and Trade, the Board has the power to control and fix prices paid to producers, to license agents to purchase diamonds from the Board, and to control exports of diamonds.

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[15] Mining Journal (London). V. 260, No. 6651, Feb. 8, 1963, p. 134.
[16] Jewelers' Circular-Keystone. V. 134, No. 2, November 1963, p. 121.
[17] Mining Journal (London). V. 260, No. 6669, June 14, 1963, p. 600.
[18] Bureau of Mines. Mineral Trade Notes. V. 58, No. 5, May 1964, pp. 17–18.
[19] Bureau of Mines. Mineral Trade Notes. V. 58, No. 3, March 1964, p. 49.

Previously licensed agents were to be relicensed to buy from the Board.[20] Diamond production of 2.7 million carats was reported for 1963. Twenty percent was gem quality.

Kenya.—About 48,000 pounds of semiprecious gem stone material, valued at about $4,000 was produced during 1963. The bulk of this material was rose quartz; smaller quantities of such materials as augite and corundum were also produced.

Rhodesia and Nyasaland, Federation of.—Amethysts have been discovered in the Gwaai section of Southern Rhodesia and development of the claim has begun. The stones are considered of excellent quality.[21] Gem stone production for 1963 was reported as follows: Southern Rhodesia, 4,000 pounds of jade valued at about $1,120, and 36 pounds of chrysoberyl valued at about $58; Northern Rhodesia, 34,000 pounds of amethyst valued at about $286,000. No gem stone production was reported in Nyasaland.

South Africa, Republic of.—The old De Beers mine, which was closed in 1908, has been prepared for reopening. A new shaft has been sunk to the 412-foot level and connected to the old shaft. Mining is to be done by dropping ore from upper levels through existing ore passes to the crushing plant on the 1,720-foot level, for crushing to minus 5 inches. From here the ore would be hoisted to the 412-foot level, carried to a new surface crusher by a 1,700-foot inclined conveyor, and crushed to 1.5 inches. Then the crushed material would travel by another conveyor to the central treatment plant.[22]

During 1962, the Premier diamond mine completed its $7 million plant expansion program to increase production to 2.5 million carats per year. New facilities were installed to treat 400,000 tons per month of tailings remaining from previous mining operations. These tailings contained small industrial diamonds for which there was small demand in the past.[23]

Rich diamond deposits have been found in Namaqualand, and it has been claimed that they may be larger than the Kimberly fields. The statement has been made that these deposits are the source of the diamonds found off the Namaqualand coast.[24] Production of emerald crystals was reported as 527 pounds. A like amount valued at $412,000 was exported. Production of tiger's-eye was reported as 129 tons. Exports were listed as 150 tons valued at $49,000.

South-West Africa.—The Marine Diamond Corp., Ltd., has sunk three boreholes in the offshore diamond-bearing gravel deposits located north of Plum Pudding Island. High-quality diamonds averaging in excess of one-half carat in size were found. This yield rivals that of the Chamels Reef deposit, where more than 150 carats per day, mostly of gem quality, is recovered.[25] During 11 months prior to June 1963, the Marine Diamond Corp. recovered 116,369 diamonds weighing 51,917 carats valued at $1.7 million.[26] The Diamond Mining & Utility

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[20] Bureau of Mines. Mineral Trade Notes. V. 56, No. 4, April 1963, pp. 14–15.
[21] Mining Journal (London). Amethyst in Southern Rhodesia. V. 261, No. 668, Oct. 11, 1963, p. 341.
[22] Mining Engineering. Famous Diamond Mine Comes to Life Again. V. 15, No. 9, September 1963, pp. 44–45.
[23] Skillings' Mining Review. Premier Diamond Mine Expands Plant. V. 52, No. 14, Apr. 6, 1963, p. 8.
[24] Engineering and Mining Journal. V. 164, No. 3, March 1963, pp. 155, 157.
[25] Bureau of Mines. Mineral Trade Notes. V. 56, No. 3, March 1963, p. 11.
[26] Bureau of Mines. Mineral Trade Notes. V. 58, No. 4, April 1964, pp. 11–12.

Co. agreed to lease its concessions and rights, granted by the South-West African Government, to the Tidewater Oil Co. The latter company thereby acquired diamond mining rights on land and from the highwater mark to the 6-mile limit. The lease will run for 25 years and includes an option to buy the grant after 5 years.[27]

In April the South-West Africa Administration granted a marine diamond mining concession to Terra Marina, a newly formed company composed of various financial interests in the Republic of South Africa. Their concession is off the South-West Africa coast and extends from Diaz Point at Lüderitz northward to Hottentot Bay.[28] Gem diamond production decreased about 15 percent from that of 1962. Semiprecious gem stone production decreased from about 419,000 pounds in 1962 to 155,000 pounds. Production for 1963 appears in table 4.

TABLE 4.—South-West Africa: Production and exports of gem stones in 1963

Gem	Production (quantity)	Exports	
		Quantity	Value
Diamond .... carats	1,076,000	1,329,644	$57,800,000
Amazonite .... pounds	18,000	------	------
Amethyst .... do	134,000	56,000	8,200
Chalcedony .... do	1,940	------	------
Rose quartz .... do	500	------	------
Tiger's-eye .... do	------	5,860	1,550
Tourmaline .... do	140	33	4,300

Tanganyika.—A total of 588,870 carats of diamonds valued at about $13.9 million were exported. This compared with 647,177 carats valued at $15.1 million in 1962.[29] About 46 pounds of rough ruby and sapphire, valued at about $46,800, were exported in 1962.[30]

OCEANIA

Australia.—The value of opal and sapphire produced in 1961 was reported as $1.9 million and $18,000, respectively.[31]

The Capricornia Mineral Development Co. Pty., Ltd., has been formed to mine crysoprase, which is available in the Marlboro ranges, near Rockhampton. This material has a marked similarity to Chinese jade. Crysoprase has been shipped to the United States, West Germany, Japan, and Hong Kong.[32] An access road has been constructed, and crysoprase veins have been exposed.[33]

French Pacific Islands.—Mother-of-pearl prices have been dependent on the economic conditions of both the United States and Europe, which are the chief markets. Prices have varied from a low of $0.25 per pound in 1951 to a high of $1 per pound in 1963. Previously, uncontrolled collection and export of shell depleted many collecting

[27] Bureau of Mines. Mineral Trade Notes. V. 57, No. 1, July 1963, p. 11.
[28] Bureau of Mines. Mineral Trade Notes. V. 57, No. 2, August 1963, p. 20.
[29] Mining Journal (London). V. 262, No. 6705, Feb. 21, 1964, p. 139.
[30] South African Mining and Engineering Journal (Johannesburg, Republic of South Africa). V. 74, pt. 1, No. 3656, Mar. 1, 1963, p. 497.
[31] Bureau of Mines. Mineral Trade Notes. V. 56, No. 6, June 1963, p. 17.
[32] World Mining. V. 17, No. 3, March 1964, p. 67.
[33] Queensland Government Mining Journal (Australia). V. 64, No. 746, December 1963, p. 797.

areas. However, rigid government controls have been applied. The Government is presently financing a program to repopulate the pearl shell beds and develop the culture of pearls. Seeding of pearls is being carried out experimentally. During 1961, 565 short tons of mother-of-pearl was exported.[34]

TECHNOLOGY

Each monthly issue of Mine and Quarry (London) beginning with October 1952 has described a mineral, giving the synonyms, nomenclature, varieties, composition, crystallography, physical and optical properties, tests, diagnosis, occurrences, and uses. In the February and May 1963 issues brazilinite and turquoise were described.

Spectrolite, the new gem form of labradorite coming from Finland, is described. The Finnish material occurs in isolated large to medium individual crystals, in contrast to the material from Labrador, which occurs in coarse-grained chunks with each crystal unit several inches across. Blue is the commonest sheen of the spectrolite, but other hues of equal intensity are common.[35] The tumbling method for evolving the irregularly shaped semiprecious stones (baroques) is reviewed.[36]

An article was written on gem mineral occurrences in Colorado that have been found and lost. Topaz, turquoise, sapphire, and jade are mentioned.[37]

Methods of developing "synthetic emeralds" were discussed, and products made by the Lechleitner method and the Chatham process were compared. The principle of the Lechleitner system, like Chatham's, is one of making an approximation of natural conditions in which a crystal is able to enlarge itself. The additional growth is crystallographically continuous.[38]

An article on turquoise reviewed the traditions of the celebrated historical mines of Persia (now Iran).[39]

The origin of Colorado gold stone was described. The product does not contain gold nor is it a stone. The process involved in producing this material is discussed.[40]

The techniques of the lapidary industry of Japan are discussed. Japanese stone carving is relatively new and expanded after German sources were cut off in 1939. The popular materials are rose quartz, rock crystal, aventurine, sodalite, lapis, tiger's-eye, gold stone, amethyst, and agate.[41]

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[34] Bureau of Mines. Mineral Trade Notes. V. 56, No. 5, May 1963, p. 15.

[35] Jewelers' Circular-Keystone. Spectrolite a New and Exciting Gem Stone. V. 133, No. 12, August 1963, pp. 138, 140, 159, 162.

[36] Rhodesian Mining and Engineering (Salisbury, Southern Rhodesia). How "Baroque" Gem Stones Are Polished. V. 27, No. 13, December 1962, p. 27.

[37] Pearl, Richard M. Colorado Minerals Lost and Found. Rocks and Minerals, v. 38, Nos. 3–4, March–April 1963, pp. 129–130.

[38] Pough, Frederick H. A Unique "Synthetic," the Linde-Lechleitner Stone. Jewelers' Circular-Keystone, v. 133, No. 11, July 1963, pp. 52, 54, 62, 64, 66.

[39] King, Frank A. Turquoise-Mining and Traditions of the Past. Canadian Min. J. (Quebec, Canada), v. 84, No. 1, January 1963, pp. 48–49.

[40] Pough, Frederick H. The True Story of Colorado Gold Stone. Jewelers' Circular-Keystone, v. 133, No. 5, February 1963, pp. 92, 98, 100, 101.

[41] Pough, Frederick H. The Lapidaries of Kofu. Jewelers' Circular-Keystone, v. 133, No. 4, January 1963, pp. 60, 62, 72–74.

Methods of irradiating diamonds with charged particles are described. A brief history of irradiation is given, problems are discussed, and results are evaluated.[42]

The practice of raising the color grade of certain diamonds to near colorless by disguising the true light-yellow or brown body color by applying a foreign substance to the surface of the stone was discussed for the first time. Guides are listed for detecting coating when examining diamonds.[43]

An article on the production of cultured pearls described the basic anatomy of the oyster, growing pearl oysters, color and luster of the pearl, chemical analysis of the pearl, and synthetic pearl essence.[44]

An unusual use of antibiotics was reported from Japan, where a scientist on the staff of the Fisheries School of Mie Prefecture described tests over 4 years in which the antibiotic chlortetracycline raised production of top-quality cultured pearls by 30 percent.[45]

A method for improving the color and quality of natural or cultured pearls was patented. The pearls are subjected to high-energy, ionizing radiation.[46]

A patent was issued in Australia on an improved method for manufacturing synthetic diamonds, wherein graphite or a carbide is dissolved in molten nickel or nickel alloy solvent to form a saturated solution.[47]

A cigarette filter tip consisting of tourmaline particles dispersed in a nontoxic carrier was patented.[48]

A French patent was granted on a method for producing blue diamonds by chemically coloring white natural diamonds.[49]

A description was given of simple tests that can be made to distinguish genuine precious and semiprecious stones from paste stones. The use of the spectroscope and specific gravity tests with heavy liquids such as bromoform, methylene iodide, and clerici's solution were discussed.[50]

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[42] Pough, Frederick H. Recent Diamond Irradiation Techniques. Jewelers' Circular-Keystone, v. 134, No. 3, December 1963, pp. 54, 56, 58, 60.
[43] Miles, Eunice Robinson. Coated Diamonds. Jewelers' Circular-Keystone, v. 133, No. 8, May 1963, pp. 66–69, 82, 84, 86, 88, 90, 92.
[44] Critides, Leon. Producing Cultured Pearls. Chemistry, v. 36, No. 11, December 1963, pp. 6–12, 31.
[45] Chemical Trade Journal and Chemical Engineer (London). Antibiotics in Pearl Production. V. 153, No. 3977, Aug. 30, 1963, p. 305.
[46] Chow, K. T. Process for Irradiating Pearls and Product Resulting Therefrom. U.S. Pat. 3,075,906, Jan. 29, 1963.
[47] Custers, J. F. H., H. B. Dyer, B. W. Senior, and P. T. Wedepohl. Australian Pat. 239,176, June 26, 1962.
[48] Jacobson, G. Cigarette Filters. U.S. Pat. 3,087,500, Apr. 30, 1963.
[49] Duchaine, M. P. J. French Pat. 1,316,489, Dec. 26, 1963.
[50] Parkinson, Kenneth. Test That Stone. Rocks and Minerals, v. 38, Nos. 3–4, March–April 1963, pp. 131–135, 216.

Gold

By J. P. Ryan [1]

MINE production of recoverable gold in the United States was 1.5 million ounces valued at $50.9 million, a decrease of 6 percent from 1962 production and the lowest peacetime output in more than 100 years. World gold production increased for the 10th consecutive year, reaching an alltime record of 52 million ounces valued at $1.81 billion.

The decline in domestic gold production reflected the reduced scale of placer mining operations and lower recovery of byproduct gold. The gain in world output of gold was again attributed almost entirely to expanded production from South African mines, which contributed slightly more than half of the total world output.

Domestic industries and the arts consumed 2.9 million ounces of gold, about 0.7 million ounces less than in 1962, and twice domestic production.

Although the U.S. balance-of-payments continued to show a deficit, the outflow of gold was slightly more than one-half that in 1962, reflecting a lower rate of conversion-of-dollar credits by foreign central banks. The U.S. gold stock at yearend was $15,596 million. Free world gold reserves totaled $42.3 billion at yearend, a gain of $860 million for the year.

As in 1962, the price of gold in the London market remained close to the official price of $35 per ounce. In most other world markets average prices were somewhat higher than at London but did not vary much from the average prices in 1962.

LEGISLATION AND GOVERNMENT PROGRAMS

Hearings were held in July by the Subcommittee on Minerals, Materials, and Fuels of the Senate Committee on Interior and Insular Affairs on S. 100 and S. 1273, bills to aid the gold-mining industry. S. 100 provided for a survey of the domestic gold-mining industry to develop information to be used by Congress in adopting remedial action to relieve the distressed conditions in the industry. The bill also prohibited industrial sale of gold. S. 1273 authorized the Secretary of the Interior to buy and sell gold for nonmonetary purposes at prices up to $105 an ounce.

In October, the subcommittee held hearings on S. 2125, the Gold Mine Revitalization Act, a bill to compensate primary gold producers

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for the difference between production costs in 1940 and current costs. The bill was referred to the Committee on Interior and Insular Affairs, but no further action was taken.

Bills to increase the rate of depletion allowance for gold mines (S. 134 and S. 5758) and to prohibit Government sale of gold for commercial use (S. 158) were introduced in the 88th Congress, 1st Session, and referred to the Senate Committees on Finance and Banking and Currency, respectively. No further action was taken.

Nine contracts totaling $595,348 were executed for gold or gold-silver exploration under the Government program of financial assistance, administered by the Office of Minerals Exploration. The Government share of the exploration cost was 50 percent. A bill (S. 2384) was introduced in Congress in December to amend the act of August 21, 1958, relating to the exploration program for discovering new minerals, including gold. The bill provides for including related development with exploration, joint participation of Government and exploration companies on an equity basis, and increasing the limit of Government participation to $500,000.

DOMESTIC PRODUCTION

Mine production of recoverable gold in the United States dropped 6 percent to 1.5 million ounces, valued at $50.9 million, the lowest annual output since 1859, except during 1943–46 when wartime restrictions were applied. Curtailed bucketline dredging in Alaska and California and decreases in lode mining operations in Colorado, Montana, and Utah were the principal factors contributing to the decline in domestic output. Gold output increased sharply in Nevada and small increases were recorded in Arizona, South Dakota, and Washington, but these gains were not enough to offset declines in other gold-producing States. Gold-mining operations continued to be adversely affected by rising production costs in relation to the fixed price of gold. Some placer mines closed when reserves were depleted; reserves at others continued to decline.

A sharp decrease in Alaska's gold output reflected chiefly the lack of production from dredging operations of United States Smelting, Refining and Mining Co. in the Nome district where two dredges were closed down in 1962. The company operated four dredges during 1963 and recovered 70,760 ounces of gold valued at $2.5 million, about half that of 1962.[2] California's output of gold, like that of Alaska, dropped sharply as both placer and lode mining operations were reduced. The closing of the Camp Bird mine in March contributed to the 32-percent drop in Colorado's gold output. In Montana, gold output dropped 24 percent to the lowest level on record. The decline reflected principally a reduction in production of copper ore yielding byproduct gold. The 57-percent gain in Nevada's gold output was attributed entirely to the Getchell Mine, Inc., which produced gold bullion valued at $1.96 million in its first full year of operation following completion of its new gold recovery plant.

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[2] United States Smelting, Refining and Mining Co. Annual Report 1963. P. 10.

South Dakota and Utah, the two leading gold-producing States, furnished 60 percent of the total domestic output. The Homestake mine in South Dakota contributed nearly 40 percent of the Nation's gold output. Most of Utah's output was recovered as a byproduct of copper ore at the Utah Copper mine. Arizona's gold output also was recovered as a byproduct of the treatment of copper ores and, to a minor extent, of copper-lead-zinc ores. Virtually all of Alaska's gold came from placer deposits and was recovered by bucketline dredging. Fifty-one percent of the total domestic output was recovered from gold ores, 13 percent from placers, and 36 percent was a byproduct of base-metal ores.

TABLE 1.—Salient gold statistics

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Mine production thousand troy ounces	1,815	1,603	1,667	1,548	1,543	1,454
Value thousands	$63,542	$56,103	$58,337	$54,189	$53,990	$50,889
Ore (dry and siliceous) produced:						
Gold ore thousand short tons	2,302	2,289	2,267	2,060	2,159	2,459
Gold-silver ore do	127	137	347	248	353	223
Silver ore do	658	597	641	565	524	556
Percentage derived from—						
Dry and siliceous ores	43	50	47	48	47	51
Base-metal ores	36	28	37	39	36	36
Placers	21	22	16	13	17	13
Imports, general thousand troy ounces [1]	4,713	8,485	9,322	1,615	4,312	1,281
Exports [1] do	1,416	50	47	22,146	10,884	5,820
Stocks Dec. 31: Monetary [2] millions	$21,758	$19,507	$17,804	$16,947	$16,057	$15,596
Consumption in industry and the arts thousand troy ounces	1,451	2,522	3,000	2,775	3,576	2,920
Price: Average per troy ounce [3]	$35.00	$35.00	$35.00	$35.00	$35.00	$35.00
World: Production thousand troy ounces	[4] 37,800	[4] 42,600	[4] 45,100	[4] 47,200	[4] 49,800	51,700

[1] Excludes coinage.
[2] Includes gold in Exchange Stabilization Fund.
[3] Price under authority of Gold Reserve Act of Jan. 31, 1934.
[4] Revised.

TABLE 2.—Gold produced in the United States according to mine and mint returns

(Troy ounces of recoverable metal)

	1954–58 (average)	1959	1960	1961	1962	1963
Mine	1,815,491	1,602,931	1,666,772	1,548,270	1,542,511	1,454,010
Mint	1,832,006	1,635,000	1,679,800	1,566,800	1,556,000	1,468,750

TABLE 3.—Mine production of gold in the United States in 1963, by months

Month	Troy ounces	Month	Troy ounces
January	109,403	August	129,197
February	102,543	September	129,093
March	120,072	October	140,551
April	126,432	November	122,646
May	130,546	December	118,922
June	116,216		
July	108,389	Total	1,454,010

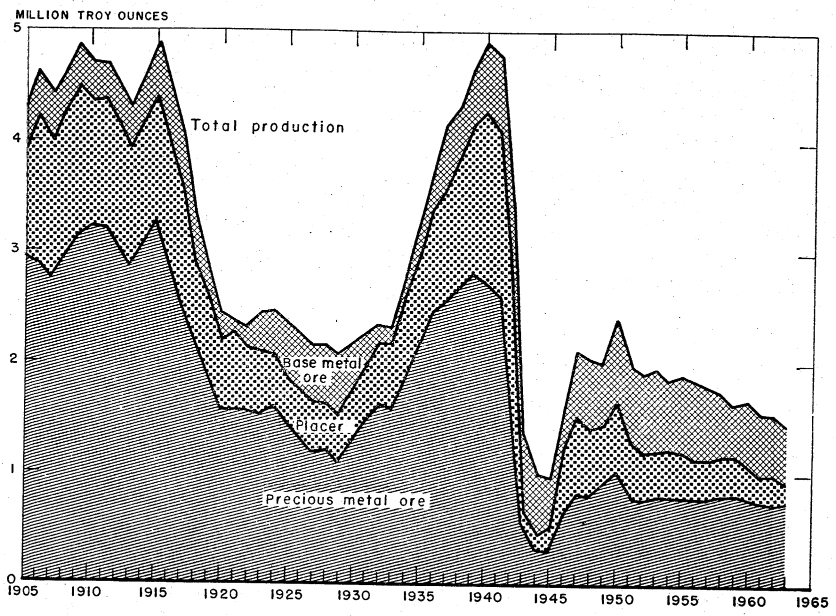

FIGURE 1.—Gold production in the United States, 1905–63.

The 25 leading U.S. gold producers, contributing 94 percent of the total domestic output, included 4 lode gold mines, 5 placer mines, 10 copper mines, 2 copper-lead-zinc mines, 3 lead-zinc mines, and 1 zinc mine.

The Homestake mine at Lead, S. Dak., the Nation's leading gold producer, recorded new highs in the quantity of ore mined and bullion produced. Value of recovered bullion was $20.3 million, a slight increase over that of 1962. Ore milled increased to 1.91 million tons with an average recovered grade of $10.62, compared with 1.87 million tons yielding $10.85 per ton in 1962. Metallurgical recovery was 96.9 percent. Measured ore reserves at yearend totaled 15.2 million tons averaging $11.32 per ton, compared with 15.4 million tons of the same grade at the end of 1962.[3]

Newmont Mining Corp. reported the discovery of a substantial ore deposit near Carlin, Nev. The corporation's annual report for 1963 stated:

> The ore bodies are not yet completely delineated but their presently proven ore reserves are sufficient for more than 10 year's production at a projected rate of 1,500 tons per day. The ore occurs at shallow depths, permitting open pit mining. Metallurgical tests show that the ore is amenable to direct cyanidation and that high gold recoveries can be expected at a relatively coarse grind. . . . The

[3] Homestake Mining Co. 86th Annual Report. Dec. 31, 1963, pp. 2-3.

TABLE 4.—Twenty-five leading gold-producing mines in the United States in 1963, in order of output

Rank	Mine	District or region	State	Operator	Source of gold
1	Homestake	Whitewood (Ida Gray).	South Dakota	Homestake Mining Co.	Gold ore.
2	Utah Copper	West Mountain (Bingham).	Utah	Kennecott Copper Corp.	Copper ore.
3	Yuba Unit	Yuba River	California	Yuba Consolidated Gold Fields.	Dredge.
4	Gold Dollar & Knob Hill.	Republic	Washington	Knob Hill Mines, Inc.	Gold ore.
5	Getchell Mine	Potosi	Nevada	The Goldfield Corp	Do.
6	Copper Queen-Lavender Pit.	Warren	Arizona	Phelps Dodge Corp	Copper ore.
7	Fairbanks Unit	Fairbanks	Alaska	United States Smelting, Refining and Mining Co.	Dredge.
8	Liberty Pit	Robinson	Nevada	Kennecott Copper Corp.	Copper ore.
9	New Cornelia	Ajo	Arizona	Phelps Dodge Corp	Gold-silver, copper ores.
10	Gold King	Wenatchee	Washington	L-D Mines	Gold ore.
11	Idarado	Red Mountain-Upper San Miguel.	Colorado	Idarado Mining Co	Copper-lead-zinc ores.
12	Mayflower Unit	Blue Ledge	Utah	Hecla Mining Co	Lead-zinc ore.
13	San Manuel	Old Hat	Arizona	Magma Copper Co	Copper ore.
14	Iron King	Big Bug	do	Shattuck Denn Mining Corp.	Lead-zinc ore.
15	Hogatza River	Hughes	Alaska	United States Smelting, Refining and Mining Co.	Dredge.
16	Chicken Creek	Fortymile	do	do	Do.
17	Morenci	Copper Mountain	Arizona	Phelps Dodge Corp	Gold-silver, copper ores.
18	United States and Lark.	West Mountain (Bingham).	Utah	United States Smelting, Refining and Mining Co.	Lead-zinc ore.
19	Berkley Pit	Summit Valley	Montana	The Anaconda Company.	Copper ore.
20	Magma	Pioneer	Arizona	Magma Copper Co	Copper, gold-silver ores.
21	Eagle	Red Cliff (Battle Mountain).	Colorado	The New Jersey Zinc Co.	Lead-zinc, copper ores.
22	Nyac	Aniak	Alaska	New York-Alaska Gold Dredging Corp.	Dredge.
23	Chino	Central	New Mexico	Kennecott Copper Corp.	Copper ore
24	Christmas	Banner	Arizona	Inspiration Consolidated Copper Co.	Do.
25	Zinc Mines Group	Summit Valley	Montana	The Anaconda Company.	Zinc ore.

overall capital costs of the Carlin project is estimated at approximately $5.8 million. . . . Production should commence in mid-1965. . . .

Approximately 5,200 persons were employed in the gold and gold-silver mining industry at 1,063 lode and placer mining operations, according to preliminary data compiled by the Bureau of Mines.

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TABLE 5.—Mine production of recoverable gold in the United States, by States

(Troy ounces)

	1954-58 (average)	1959	1960	1961	1962	1963
Alaska	221,801	178,918	168,197	114,216	165,259	99,573
Arizona	136,793	124,627	143,064	145,959	137,207	140,030
California	207,942	145,270	123,713	97,644	106,272	86,867
Colorado	89,972	61,097	61,269	67,515	48,882	33,605
Idaho	12,245	10,479	6,135	5,718	5,845	5,477
Montana	29,735	28,551	45,922	35,377	24,387	18,520
Nevada	80,372	113,443	58,187	54,165	62,863	98,879
New Mexico	3,064	3,155	5,423	6,201	7,529	7,805
North Carolina	707	965	1,826	2,094	460	33
Oregon	3,154	686	835	1,054	822	1,809
Pennsylvania	[1] 585	(2)	(2)	(2)	(2)	(2)
South Dakota	555,759	577,730	554,771	557,855	577,232	576,726
Tennessee	185	99	123	152	158	137
Utah	389,380	239,517	368,255	342,988	311,924	285,907
Vermont	451	----------	----------	----------	----------	----------
Washington	82,966	118,394	129,012	117,331	93,671	98,638
Wyoming	382	----------	40	1	----------	4
Total	1,815,493	1,602,931	1,666,772	1,548,270	1,542,511	1,454,010

[1] For 1957, Pennsylvania included in Vermont.
[2] Included with Washington.

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 1963

State	Gold ore		Gold-silver ore		Silver ore		Copper ore	
	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
Alaska	903	1.332	----------	----------	11	0.727	----------	----------
Arizona	150	.793	146,596	0.007	490	.010	78,347,588	0.002
California	11,761	.252	----------	----------	2,500	.287	----------	----------
Colorado	352	.804	254	.445	5,345	.003	20,908	.199
Idaho	1,200	.804	10	2.500	348,394	.003	38,916	.017
Montana	3,598	.346	17,089	.112	39,008	.018	8,139,432	.001
Nevada	356,202	.162	3	.333	1,595	.309	9,073,247	.004
New Mexico	58	1.414	47,679	.026	6	.167	6,858,514	.001
South Dakota	1,909,261	.302	----------	----------	----------	----------	----------	----------
Utah	----------	----------	7,035	.003	158,835	.009	26,282,400	.010
Undistributed [5]	175,351	.554	4,220	.282	----------	----------	48	.729
Total	2,458,836	.300	222,886	.025	556,184	.008	128,761,053	.003

See footnotes at end of table.

TABLE 6.—Ore, old tailing, etc., yielding gold produced in the United States, and average recoverable content, in troy ounces of gold per ton in 1963—Con.

State	Lead ore		Zinc ore		Zinc-lead, zinc-copper, and zinc-lead-copper ores		Total ore	
	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
Alaska	----------	----------	----------	----------	----------	----------	914	1.324
Arizona	1,594	0.021	----------	----------	409,272	0.043	78,905,690	.002
California	992	.022	----------	----------	3,043	.011	[1] 18,296	.211
Colorado	1,785	.124	1,077	0.023	945,010	.029	974,731	.033
Idaho	182,734	.010	42,929	(2)	831,151	.001	[3] 1,445,614	.004
Montana	2,421	.094	[4] 1,206,614	.002	147	.020	9,408,309	.002
Nevada	3,782	.057	----------	----------	34	.412	9,434,863	.010
New Mexico	51	.078	26,148	(2)	154,373	(2)	7,086,829	.001
South Dakota	33	.030	----------	----------	----------	----------	1,909,294	.302
Utah	6,526	.016	39,144	(2)	540,336	.055	27,034,276	.011
Undistributed [5]	----------	----------	----------	----------	1,431,270	(2)	[6] 2,203,245	.045
Total	199,918	.013	1,315,912	.002	4,314,636	.016	138,422,061	.009

[1] Includes an unspecified quantity of tungsten ore.
[2] Less than .001.
[3] Includes antimony ore.
[4] Includes manganese ore.
[5] Includes North Carolina, Oregon, Pennsylvania, Tennessee, Washington, and Wyoming.
[6] Includes tungsten ore in North Carolina, and magnetite-pyrite ore in Pennsylvania.

TABLE 7.—Mine and refinery production of gold in the United States in 1963, by States and sources

(Troy ounces of recoverable metal)

State	Mine Production							Refinery production [1]
	Placers	Dry ore	Copper ore	Lead ore	Zinc ore	Zinc-lead, zinc-copper, lead-copper, and zinc-lead-copper ores	Total	
Alaska	98,362	1,211	----------	----------	----------	----------	99,573	100,100
Arizona	53	1,077	121,226	34	----------	17,640	140,030	143,700
California	82,998	3,679	----------	22	----------	34	[2] 86,867	87,200
Colorado	1,539	410	4,170	222	25	27,239	33,605	34,700
Idaho	144	1,934	654	1,776	17	928	[3] 5,477	5,200
Montana	56	3,864	11,742	228	2,627	3	18,520	20,000
Nevada	868	58,182	39,598	217	----------	14	98,879	100,900
New Mexico	----------	1,341	6,418	4	2	40	7,805	7,810
North Carolina	----------	25	----------	----------	----------	----------	[2] 33	50
Oregon	528	1,246	35	----------	----------	----------	1,809	2,000
Pennsylvania	(4)	(4)	(4)	(4)	(4)	(4)	(4)	(4)
South Dakota	2	576,723	----------	1	----------	----------	576,726	576,700
Tennessee	----------	----------	----------	----------	----------	137	137	170
Utah	----------	1,454	254,610	105	14	29,724	285,907	291,200
Washington	9	97,054	----------	----------	----------	1,575	[5] 98,638	99,020
Wyoming	4	----------	----------	----------	----------	----------	4	----------
Total	184,563	748,200	438,453	2,609	2,685	77,334	1,454,010	1,468,750
Percent	12.7	51.4	30.2	0.2	0.2	5.3	100.0	----------

[1] U.S. Bureau of the Mint.
[2] Includes gold from tungsten ore.
[3] Includes gold from gold-antimony ore.
[4] Pennsylvania included with Washington.
[5] Includes gold from magnetite-pyrite ore in Pennsylvania.

TABLE 8.—Gold produced in the United States from ore and old tailings in 1963 by States and methods of recovery, in terms of recoverable metal

State	Total ore, old tailings, etc., treated (short tons)[1]	Ore and old tailings to mills: Short tons[1]	Recoverable in bullion: Amalgamation (troy ounces)	Recoverable in bullion: Cyanidation (troy ounces)	Concentrates smelted and recoverable metal[3]: Concentrates (short tons)	Concentrates smelted and recoverable metal[3]: Troy ounces	Crude ore to smelters: Short tons	Crude ore to smelters: Troy ounces
Alaska	914	903	1,203	----------	----------	----------	11	8
Arizona	81,282,358	80,566,143	29	----------	2,519,846	122,252	716,215	17,696
California	20,608	16,229	2,226	----------	3,651	1,535	4,379	108
Colorado	975,038	950,827	7,043	----------	141,897	20,098	24,211	4,925
Idaho	1,534,971	1,461,341	495	----------	224,730	4,062	73,630	776
Montana	9,506,227	9,351,796	55	----------	343,375	14,602	154,431	3,807
Nevada	[2] 9,436,692	[2] 9,353,430	593	56,524	312,844	38,971	83,262	1,923
New Mexico	7,443,289	7,308,245	----------	----------	262,469	6,458	135,044	1,347
South Dakota	1,909,296	1,909,261	425,567	151,156	----------	----------	35	1
Utah	27,059,271	26,820,668	----------	----------	796,369	284,259	238,603	1,648
Undistributed [3]	2,995,012	2,985,812	53	10,532	94,986	87,705	9,200	1,790
Total	142,163,676	140,724,655	437,264	218,212	4,700,167	579,942	1,439,021	34,029

[1] Includes some non-gold-bearing ores, not separable.
[2] Excludes leached copper ore.
[3] Includes North Carolina, Oregon, Pennsylvania, Tennessee, and Washington.

TABLE 9.—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): Amalgamation	Bullion and precipitates recoverable (troy ounces): Cyanidation	Gold from all sources (percent): Amalgamation	Gold from all sources (percent): Cyanidation	Gold from all sources (percent): Smelting[1]	Gold from all sources (percent): Placers
1954–58 (average)	439,229	265,756	24.2	14.6	40.4	20.8
1959	459,857	236,046	28.7	14.7	34.3	22.3
1960	438,207	210,354	26.3	12.6	45.2	15.9
1961	434,134	186,086	28.0	12.0	46.9	13.1
1962	455,412	173,386	29.5	11.2	42.1	17.2
1963	437,264	218,212	30.1	15.0	42.2	12.7

[1] Both crude ores and concentrates.

TABLE 10.—Gold production at placer mines in the United States, by methods of recovery

Method and year	Mines producing	Washing plants (dredges)	Material treated (thousand cubic yards)	Gold recoverable: Thousand troy ounces	Gold recoverable: Value (thousands)	Gold recoverable: Average value per cubic yard
Bucketline dredging:						
1954–58 (average)	20	32	50,714	316	$11,080	$0.218
1959	16	30	36,998	251	8,767	.237
1960	17	24	33,464	228	7,986	.239
1961	19	24	33,806	177	6,192	.183
1962	20	22	25,590	242	8,456	.330
1963	17	22	18,431	161	5,651	.307
Dragline dredging:						
1954–58 (average)	15	10	464	3	86	0.185
1959	12	12	157	2	73	.464
1960	20	20	144	1	47	.329
1961	16	16	[1] 608	1	43	.071
1962	13	13	532	1	47	.088
1963	11	11	266	2	70	.265
Hydraulicking:						
1954–58 (average)	43	2	192	2	74	0.385
1959	35	35	102	3	87	.855
1960	33	33	282	3	93	.330
1961	19	19	104	3	107	1.029
1962	21	21	124	2	83	.669
1963	12	12	43	1	45	1.056
Nonfloating washing plants:						
1954–58 (average)	111	113	2,276	54	1,891	0.831
1959	89	97	2,569	100	3,511	1.367
1960	80	80	938	30	1,045	1.114
1961	81	81	957	19	668	.698
1962	45	45	839	16	551	.657
1963	50	67	638	[1] 14	499	.782
Underground placer, small scale hand methods, and suction dredge:						
1954–58 (average)	100	1	139	3	104	0.748
1959	79	4	47	2	82	1.732
1960	89	89	60	2	73	1.207
1961	103	103	141	2	73	.518
1962	74	74	314	4	128	.408
1963	133	82	139	6	194	1.403
Grand total placers:						
1954–58 (average)	289	158	53,785	378	13,235	0.246
1959	231	178	39,873	[2] 358	12,520	.314
1960	239	246	34,888	264	9,244	.265
1961	238	243	35,616	202	7,083	.199
1962	173	175	27,399	265	9,265	.338
1963	223	194	19,517	185	6,452	.331

[1] Does not include commercial sand and gravel operations recovering byproduct gold.
[2] Includes 103 ounces of gold valued at $3,605 recovered from electrostatic separation.

CONSUMPTION AND USES

Industry and Arts.—The net consumption of gold in domestic industries was 2.9 million ounces, about 0.7 million ounces less than in 1962. The 1963 consumption exceeded domestic mine production by 2.2 million ounces. According to data compiled by the Office of Gold and Silver Operations, U.S. Treasury Department, nearly 80 percent of the total gold sold or transferred was for jewelry, artistic, and dental uses; the remainder was used chiefly for electrical and electronic components in defense and aerospace equipment and for other industrial products.

A significant expansion was noted in the use of gold plating to provide protective and decorative coatings on other materials. Gold electrodeposits are easily solderable, are ductile, and provide superior oxidation resistance, particularly at elevated temperature. Gold plate was specified for printed circuits, transistors, switches, bellows, connectors, pumps, and components for satellites and jet aircraft.

The development of a gold-spraying technique by Lockheed Missiles and Space Co., said to overcome some drawbacks of existing plating methods, may lead to new markets in aerospace and electronic applications, such as coatings on aerospace vehicles, miniaturized circuitry, and radiofrequency shielding. Other potential applications of gold-sprayed coatings are in architecture and dentistry, and for decorative finishes, mirrors, picture frames, dinnerware, signs, and coated fabrics. In the Gemini space capsule, gold is used to coat the interior of the large adapter ring which links the capsule to the booster rocket. The gold plating, by retaining heat generated within the adapter, maintains a suitable operating temperature.

Thin films of gold between glass sheets reduce glare and by reflection filter out the hot, red, and infrared rays. This glass has potential use in office windows, car windshields, and welder's goggles. Bearings with gold-plated balls and races to provide metallic lubrication were tested for use in aerospace vehicles.

Other established uses in the fields of optics, atomic energy, heat control and measurement, medical therapy, chemical manufacturing, and brazing continued to consume an appreciable quantity of gold.

Clyde Williams and Co., reporting on activities of the Committee for Research on the Properties and Uses of Gold, Inc., described the research projects being sponsored by the Committee that may lead to increased industrial use of gold. Investigations on the resistance of gold to molten salts indicates that gold may be the best container material for high-temperature fuel cells using molten-salt electrolytes. Studies on gold as a diffusion barrier indicate that gold protective coatings may protect stainless steel from a decrease in tensile strength when subjected to an environment of nascent hydrogen. Studies of transparent gold films on nonmetallic surfaces may determine the nature of the chemical bond between the gold atoms and the atoms of the ceramic material and lead to expanded applications of these films.

Monetary.—Foreign central bank buying of gold for official stocks increased substantially, but demand for gold from private sources was slightly less than in 1962. Operations of the gold pool and heavy

TABLE 11.—Gold consumption in industry and the arts, in the United States

(Troy ounces)

Year	Issued for industrial use	Returned from industrial use	Net industrial consumption
1954–58 (average)	2,246,307	795,696	1,450,610
1959	3,175,386	653,586	2,521,800
1960	3,700,000	700,000	3,000,000
1961	3,912,554	1,137,554	2,775,000
1962	4,485,670	909,670	3,576,000
1963	4,252,478	1,332,478	2,920,000

Source: U.S. Bureau of the Mint.

sales from the U.S.S.R. were major factors in providing sufficient gold to meet all demands.

Demand from Middle East countries fluctuated considerably, and sales aggregated 5.5 million ounces, an increase of 0.5 million ounces over that of 1962. The Far East absorbed 1.4 million ounces, about the same as in 1962. The demand for gold coins continued to be strong; however, Uruguay announced that it was converting its holdings of coin, valued at $60 to 80 million, into bar gold.[4]

MONETARY STOCKS

The total U.S. gold stock declined $461 million to $15,596 million at yearend, the lowest level since 1939. The gold outflow for the year was slightly more than half that in 1962 and was the smallest since 1957. As in 1962, most of the gold sold went to France, and a moderate quantity was sold to Spain. Purchases of gold from the United Kingdom partly offset these sales and helped to reduce the total outflow. The gold pool which became operative in 1962 functioned effectively as a buffer between the London market and the U.S. gold reserve.

Although the overall deficit in the U.S. balance of payments, including allowance for the sale of nonmarketable convertible securities, increased from $2.2 billion to nearly $2.6 billion, the rate of dollar-to-gold conversion was substantially reduced, largely because of measures taken to support the position of the dollar in world markets. The ratio of gold reserve to Federal Reserve note and deposit liabilities was 29.7 percent at yearend, compared with 31.8 percent at the end of 1962; 25 percent is required for legal cover.

Estimated gold reserves of central banks and governments and international banking institutions aggregated $42.3 billion at yearend, about $860 million more than at the end of 1962. The U.S. reserve of $15.6 billion thus constituted about 37 percent of the total free world gold reserve. Gold reserves of other principal free world countries in billions of dollars were as follows: West Germany, 3.8; France, 3.2; Switzerland, 2.8; United Kingdom, 2.5; Italy, 2.3; Netherlands, 1.6; Belgium, 1.4; and Canada, 0.8. The International Monetary Fund reported gold reserves of $2.3 billion.

U.S. net short-term liabilities to foreign interests (liabilities less claims) decreased $0.2 billion to $17.5 billion at yearend. These liabilities, payable in dollars, constituted a potential claim on the U.S. gold reserve. About three-fourths of the net liabilities was payable to Western European countries, Canada, and Latin America.[5]

PRICES

Owing principally to reduction in the gold outflow and a relatively stable gold price in the London market, speculation concerning revaluation of gold was much less in 1963 than in the preceding few

[4] S. Montague & Co. Ltd. Annual Bullion Review 1963, pp. 7-10.
[5] Federal Reserve Bulletin. V. 50, No. 4, April 1964. Pp. 528-533.

years. In this connection, President Kennedy in a message to Congress on July 18; and in an address to the annual meeting of the International Monetary Fund on September 30 affirmed that the U.S. would maintain the firm relationship of gold and the dollar at the price of $35 an ounce.

As in preceding years, mint institutions of the Treasury Department and licensed refiners and dealers bought virtually all newly mined gold from domestic mines and gold offered by foreign agencies at the official price of $35 per fine troy ounce (less one-fourth of 1 percent) plus mint charges for melting and refining. Similarly, gold was sold to licensed buyers by the Treasury at $35 (plus one-fourth of 1 percent) per fine troy ounce plus the regular mint charges.

There was little change in the price of gold on the London market during the year. Quotations remained near the official U.S. price owing to the stabilizing influence of the Bank of England's operations on behalf of the international gold pool and the bank's handling of the sale of South African gold. The equivalent dollar price ranged from $35.051 to $35.120. Soviet gold sales to cover large grain purchases from Canada and the United States were an important factor, tending to depress the London market price, especially in the last 4 months of the year when 6 million ounces were received. Total gold sales of the U.S.S.R. were estimated at more than $500 million. Prices in the last quarter were below the U.S. Treasury selling price and central bank buying increased substantially.

Gold bars were traded in most of the principal gold markets outside London at $0.25 to $3.60 higher than the London price, except in the Bombay market where trading was in local currencies, not readily convertible, which reflected local political conditions and monetary habits. Average prices per ounce in terms of U.S. dollars were as follows:

Market:	*Price*	Market—Continued	*Price*
Manila	$35.65	Beirut	$35.81
Hong Kong	38.69	Paris	35.32
Bombay	53.35	Buenos Aires	36.03

Strong demand for gold coins continued and several countries resumed the minting of gold coins—though not for circulation as money. Prices of coins continued to bring substantial premiums over bar gold. The 20-franc Napoleons reached a premium of 32 percent over the value of bar gold at the end of the year. The premium on the U.S. $20 double eagle was 23 to 26 percent over its gold content. On new £1 sovereigns the premium was 15 to 18 percent, and on Swiss 20-franc coins it was 35 to 42 percent.

FOREIGN TRADE

The quantity of gold exported from the United States dropped to 5.8 million ounces valued at $203.7 million, slightly more than one-half that in 1962. Nearly all of the gold exported went to France and the United Kingdom. As in 1962, part of the gold sent to the United Kingdom was used in connection with price stabilizing operations of the Gold Pool. Imports dropped to 1.3 million ounces, valued at $44.4 million, about 30 percent of the gold imported in 1962. Canada, Colombia, and the Philippines supplied about 93 percent of the total imports; nearly all of the remainder came from 15 other countries. About three-fourths of the total imports was refined bullion; the remainder was contained in ore and base bullion, mostly from Western Hemisphere countries. Nearly all exports were refined bullion.

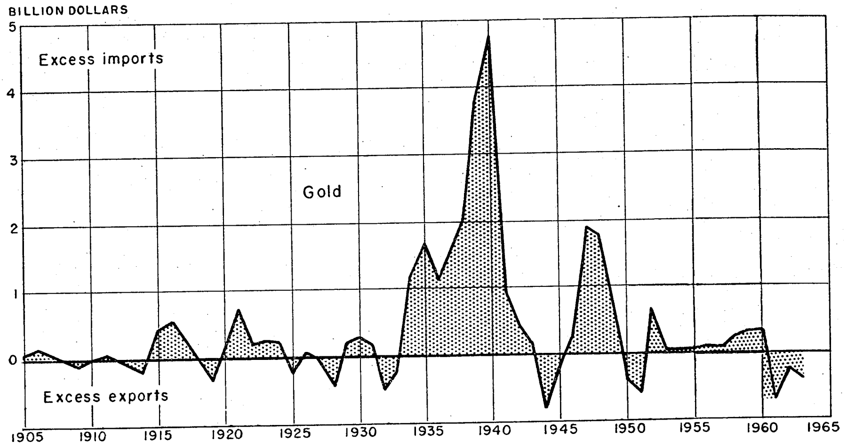

FIGURE 2.—Net imports or exports of gold, 1905–63.

TABLE 12.—U.S. imports of gold in 1963, by countries

Country	Ore and base bullion		Refined bullion	
	Troy ounces	Value	Troy ounces	Value
North America:				
Canada	37,797	$1,305,294	447,139	$15,646,226
Cuba			61	2,152
El Salvador	230	7,794		
Honduras	2,474	78,616		
Mexico	29,273	1,018,260		
Nicaragua	90,407	3,075,386		
Total	160,181	5,485,350	447,200	15,648,378
South America:				
Bolivia	129	4,477		
Chile	25,055	876,691	5,026	175,914
Colombia	293	9,241	160,345	5,588,541
Ecuador	17,797	619,066		
Peru	26,817	834,845		
Total	70,091	2,344,320	165,371	5,764,455
Europe:				
Austria	30	806		
Germany, West			1,560	54,828
Italy	2,174	76,083		
Norway	133	4,651		
United Kingdom	384	12,474	14,980	525,510
Total	2,721	94,014	16,540	580,338
Asia:				
Hong Kong	178	7,980		
Japan			46,924	1,642,292
Korea, Republic of	18	630		
Philippines	56,138	1,917,072	291,045	10,186,867
Total	56,334	1,925,682	337,969	11,829,159
Africa:				
Rhodesia and Nyasaland, Federation of	321	11,205		
South Africa, Republic of	370	12,959		
Total	691	24,164		
Oceania: Australia	23,262	709,364	259	8,847
Grand total	313,280	10,582,894	967,339	33,831,177

Source: Bureau of the Census.

TABLE 13.—U.S. exports of gold in 1963, by countries

Destination	Ore and base bullion		Refined bullion	
	Troy ounces	Value	Troy ounces	Value
North America:				
Canada	7	$248	245	$8,617
Mexico	100	2,249	169,999	5,950,004
Total	107	2,497	170,244	5,958,621
Europe:				
Belgium-Luxembourg	11,537	403,895		
France			4,018,830	140,658,979
Germany, West	1,500	64,000		
Italy			699	24,461
United Kingdom	16,963	670,077	1,600,053	56,001,825
Total	30,000	1,137,972	5,619,582	196,685,265
Grand total	30,107	1,140,469	5,789,826	202,643,886

Source: Bureau of the Census.

WORLD REVIEW

World gold output rose 1.9 million ounces to 51.7 million ounces valued at $1.81 billion. The production gain in 1963 was the 10th consecutive annual increase and was attributed almost entirely to continued expansion of mining operations in the Republic of South Africa, which more than doubled production since 1954.

The gain in South Africa's output of gold more than offset declines in most of the other principal gold-producing countries. Of the major gold-producing countries other than South Africa, only Ghana recorded a significant increase in gold output.

TABLE 14.—World production of gold by countries [1] [2]

(Troy ounces)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	4,459,501	4,483,416	4,628,911	4,473,699	4,178,396	4,011,003
Central America and West Indies:						
Costa Rica	[3] [4] 520	[5] 3,000	[5] 3,000	[5] 3,000	[5] 3,000	[5] 3,000
Cuba [3]	1,086	615	348	-----	-----	61
Dominican Republic	452	513	[3] 308	-----	-----	
El Salvador	3,401	2,394	1,121	-----	-----	-----
Guatemala	[5] 340	-----	-----	-----	[3] 8	-----
Honduras	5,319	[3] 2,798	[3] 2,172	[3] 1,685	[3] 2,132	[3] 2,474
Nicaragua	221,049	218,302	210,200	226,250	221,984	204,769
Mexico	359,715	313,663	300,256	268,684	236,758	237,948
United States [6]	1,832,006	1,635,000	1,679,800	1,566,800	1,556,000	1,468,750
Total	6,883,000	6,660,000	6,826,000	6,540,000	6,198,000	5,928,000
South America:						
Argentina	7,340	1,231	3,504	2,270	766	[5] 500
Bolivia (exports)	28,494	35,246	45,457	80,184	35,052	153,033
Brazil	159,200	[5] 180,000	[5] 180,000	[5] 180,000	[5] 180,000	[5] 180,000
British Guiana	20,100	3,448	2,364	1,702	1,903	2,847
Chile	102,870	58,547	54,367	56,489	65,009	79,572
Colombia	378,695	397,929	433,947	401,060	396,827	324,514
Ecuador	17,166	18,568	15,209	15,210	20,591	21,041
French Guiana	9,005	16,100	18,940	7,944	5,273	6,993
Peru [7]	159,641	150,299	141,001	137,418	122,985	94,369
Surinam	6,297	5,826	4,932	4,011	2,604	3,537
Venezuela	70,541	53,766	46,868	30,071	28,774	26,947
Total [5]	959,000	921,000	947,000	916,000	860,000	893,000
Europe:						
Finland	19,715	23,374	20,351	20,609	15,239	20,416
France	29,515	42,150	46,040	48,676	51,088	48,226
Germany, West	3,808	1,929	1,283	2,186	1,704	[5] 2,000
Greece	6,289	4,340	4,823	-----	-----	-----
Italy	5,664	3,260	3,034	600	-----	-----
Portugal	22,107	20,769	21,927	22,377	21,927	22,400
Spain	11,550	15,239	13,986	8,231	6,687	[5] 7,600
Sweden	105,885	102,979	94,073	83,270	128,667	120,600
U.S.S.R. [5] [8]	9,600,000	10,000,000	11,000,000	11,800,000	12,200,000	12,500,000
Yugoslavia	48,316	59,640	63,980	67,195	70,507	74,043
Total [1] [5]	10,000,000	10,500,000	11,600,000	12,500,000	12,900,000	13,200,000
Asia:						
Burma	150	212	304	194	[5] 200	[5] 200
Cambodia	[4] 800	4,823	4,180	4,180	965	6,687
China [5]	30,000	40,000	50,000	60,000	60,000	60,000
India	201,718	165,383	160,593	156,510	163,326	138,280
Japan	247,700	261,547	261,496	294,534	286,593	261,868
Korea:						
North [9]	130,000	160,000	160,000	160,000	160,000	160,000
Republic of	57,713	65,690	65,814	84,105	107,880	90,095
Malaya	19,537	26,739	20,745	12,486	6,923	9,116
Philippines	408,828	402,615	410,618	423,983	423,394	376,036
Sarawak	668	2,450	3,326	4,132	2,885	2,773
Saudi Arabia	6,860	-----	-----	-----	-----	-----
Taiwan	25,627	13,497	15,699	17,490	24,029	31,710
Total [1] [5] [8]	1,190,000	1,150,000	1,160,000	1,225,000	1,245,000	1,145,000

See footnotes at end of table.

TABLE 14.—World production of gold by countries [1] [2]—Continued

(Troy ounces)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
Africa:						
Angola	31	42	42	48	77	37
Bechuanaland	554	198	203	261	288	142
Cameroon, Republic of	2,922	971	416	537	775	1,874
Central Africa, Republic of	542	495	289	80	100	76
Congo, Republic of the (formerly Belgian)	364,064	347,967	314,145	233,672	203,707	213,995
Congo, Republic of	8,379	3,665	2,628	3,376	3,718	2,951
Eritrea	3,160	16,718	5144	5,529	2,315	[5] 2,300
Ethiopia	28,604	41,439	40,915	[5] 41,500	25,700	[5] 25,000
Gabon, Republic of	28,450	16,172	17,683	15,304	16,300	35,719
Ghana	769,239	913,141	893,113	852,619	888,038	921,255
Kenya	9,024	9,145	8,645	12,299	9,327	9,070
Liberia	618	1,401	1,036	2,088	2,184	[5] 2,100
Malagasy Republic	997	193	273	347	325	900
Morocco	1,620	----------	104	136	----------	----------
Mozambique	1,259	295	225	105	91	29
Nigeria	577	950	994	676	384	316
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia	3,050	4,685	6,300	4,192	3,625	4,960
Southern Rhodesia	537,726	566,883	562,703	570,095	554,647	566,277
Ruanda-Urundi	3,865	3,119	1,566	900	[5] 900	[5] 500
South Africa, Republic of	15,686,453	20,065,515	21,383,019	22,941,561	25,491,993	27,431,573
Sudan	1,782	1,419	2,116	1,226	[5] 1,500	[5] 900
Swaziland	52	----------	806	1,325	2,214	2,092
Tanganyika [10]	70,172	95,794	107,009	102,502	101,972	102,519
Uganda (exports)	375	405	744	453	412	16
United Arab Republic (Egypt)	7,289	2,486	1,000	[5] 1,000	[5] 1,000	[5] 1,000
Upper Volta	1,323	4,019	1,161	15,497	39,770	[5] 45,000
Total	17,530,000	22,100,000	23,350,000	24,810,000	27,350,000	29,370,000
Oceania:						
Australia	1,076,105	1,085,104	1,086,709	1,076,292	1,072,022	1,023,400
Fiji	74,344	72,565	72,203	83,417	87,354	107,262
New Guinea	70,216	46,663	45,019	41,789	39,007	[11] 43,599
New Zealand	29,879	36,758	33,326	28,294	21,742	14,206
Papua	521	156	132	31	45	([11])
Total	1,251,065	1,241,246	1,237,389	1,229,823	1,220,170	1,188,467
World total (estimate) [1]	37,800,000	42,600,000	45,100,000	47,200,000	49,800,000	51,700,000

[1] Gold is also produced in Bulgaria, Czechoslovakia, East Germany, Hungary, Indonesia, Rumania, and Thailand, but production data are not available; estimates for these countries are included in the total. For some countries accurate figures are not possible to obtain owing to clandestine trade in gold (as, for example, in former French West Africa).

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Imports into the United States.

[4] Average annual production 1956–58.

[5] Estimate.

[6] Refinery production.

[7] Official Government data include an estimate of 3,000 ounces of placer annually. Actual placer production is believed to be nearer 22,000 ounces.

[8] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[9] Estimate according to Minerais et Metaux (France), except 1963.

[10] Including gold in lead concentrates exported amounting to: 8,441 ounces, 1954–58 (average); 10,391 ounces in 1959; 8,963 ounces in 1960; 521 ounces in 1961; and none in 1962.

[11] Papua included with New Guinea.

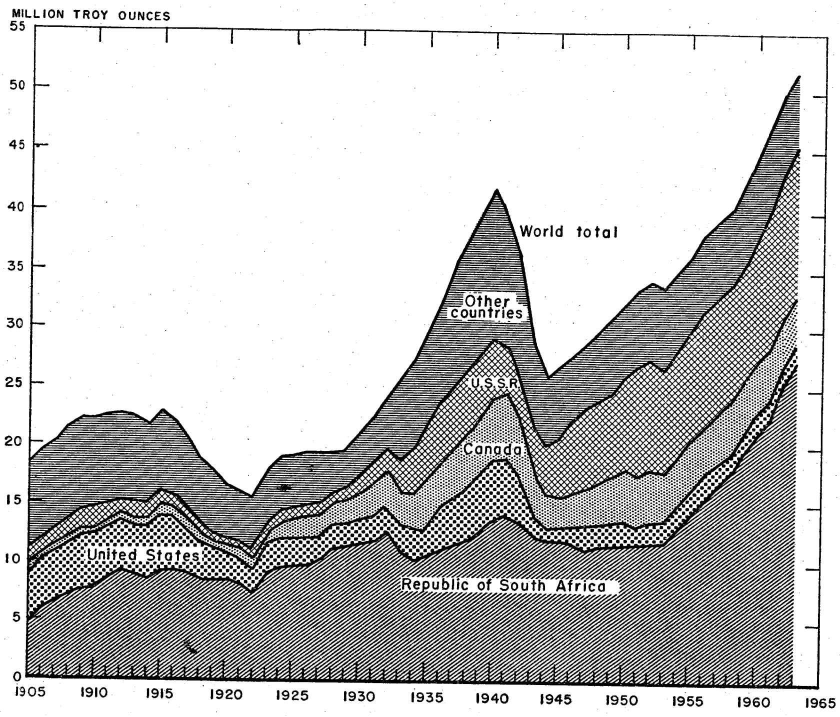

FIGURE 3.—World production of gold, 1905–63.

Australia.—Mine output of gold declined 4 percent to 1.02 million ounces, the lowest production since 1953. Production in Western Australia, the principal gold-producing state, dropped nearly 7 percent. Output in Victoria also declined, but output in Northern Territory and Tasmania increased. Only small changes in output were recorded in other states.

Western Australia contributed 78 percent of the total output; Northern Territory, 8 percent; Queensland, 7 percent; Tasmania, 3 percent; and other states, 4 percent. Most of the gold exported (472,100 ounces) went to Hong Kong. Imports aggregating 162,100 ounces came chiefly from Fiji and New Guinea. Nearly 90 percent of the total gold was produced from straight gold mines; the remainder was recovered as a byproduct of base-metal ores. About half of the total gold produced was sold on world markets at prices averaging slightly higher than the official price. Subsidies totaling A£759,196, equivalent to about $1.7 million, were paid to producers under the terms of the Gold Mining Assistance Act as amended in May 1962. Premiums received by producers on sales were offset against subsidy payments.

Under terms of the Gold Mines Development Assistance Act of December 1962, gold producers not receiving production subsidies received A£91,000 ($203,840) for development expenditures. About 5,300 persons were employed in the gold-mining industry at 286 mines.

Income derived from gold-mining operations and those gold-copper operations in which the value of the gold is 40 percent or more of the total output is tax exempt. Likewise, dividends paid out of tax exempt income are exempt from tax.

Canada.—Output of gold declined 4 percent to 4.0 million ounces valued at Can$151.4 million, notwithstanding an increase in the average mint price from $37.41 to $37.74 in 1962. The Canadian price was based on the fixed value of the Canadian dollar at US$0.925.

Gold production continued to decline at the Kerr-Addison mine, the largest producer. Two small mines in Quebec and one in Ontario closed; this loss in production was partly offset by production from new small mines in the Northwest Territories, British Columbia, and Ontario.

Except for Manitoba and Saskatchewan, all the principal gold-producing Provinces recorded lower gold output. Ontario furnished 58 percent of the total output; Quebec, 23 percent; Northwest Territories, 9 percent; and British Columbia, 4 percent.

Lode and placer mines continued to produce about 85 percent of the total gold output; the remainder was recovered as a byproduct of base-metal ores. Lode mines employed approximately 14,800 persons.

Kerr-Addison Mines, Ltd., reported a drop of 22 percent in gold output to about 325,000 ounces valued at $12.3 million. The daily milling rate was reduced 23 percent to 2,620 tons per day, but average recovered value increased to $12.86 per ton, the realized value per ounce was $0.20 higher than in 1962. Total production cost was $8.23 per ton compared with $7.54 in 1962, indicating an operating profit of $4.63 per ton. The proven ore reserve at yearend was 6.0 million tons averaging 0.42 ounce per ton, compared with 6.8 million tons averaging 0.41 ounce per ton at the end of 1962.[6]

Hollinger Consolidated Gold Mines, Ltd., treated 0.9 million tons of ore and recovered 247,300 ounces valued at $9.4 million, compared with 1.0 million tons yielding 269,500 ounces valued at $10.2 million in 1962. Average grade of ore increased slightly to $10.04 per ton, and total cost per ton increased 34 cents to $10.12. The cost of producing an ounce of gold rose from $37.94 to $39.34.[7]

The Yukon Consolidated Gold Corp. Ltd. operated six dredges and two hydraulic-mechanical placer mines in the Dawson area of the Yukon Territory. The company handled 4.5 million cubic yards and recovered gold valued at $1.5 million, about the same as in 1962. Average recovery per cubic yard was 28.5 cents at a cost of 31.5 cents, compared with recovery of 29.1 cents at a cost of 27.9 cents in 1962. The proved gravel reserve at yearend was 10.5 million cubic yards, averaging 43.5 cents per yard.[8]

Most gold mines continued to receive cost assistance under the terms of the Emergency Gold Mine Assistance Act. The act, originally passed in 1948, was extended in December to the end of 1967. An amendment restricted the eligibility of lode mines commencing production after June 30, 1965, to those providing direct support to existing gold-mining communities.

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6 Kerr-Addison Mines, Ltd. Annual Report 1963.
7 Hollinger Consolidated Gold Mines, Ltd. Annual Report covering operations for the year 1963. P. 15.
8 The Yukon Consolidated Gold Corporation, Ltd. President's Statement 1963.

TABLE 15.—Canada: Geographical distribution of gold production

(Troy ounces)

Province or Territory	1962	1963 [1]
Alberta	186	111
British Columbia	159,492	156,000
Manitoba	68,259	82,550
New Brunswick	553	850
Newfoundland	13,966	12,724
Northwest Territories	400,292	378,520
Ontario	2,421,249	2,326,433
Quebec	993,560	931,621
Saskatchewan	66,034	69,074
Yukon Territory	54,805	53,120
Total	4,178,396	4,011,003

[1] Preliminary.

Source: Dominion Bureau of Statistics.

Colombia.—Output of gold decreased 18 percent to 324,500 ounces. International Mining Corporation, which merged with South American Gold & Platinum Co., produced 122,590 ounces of gold from dredging operations and underground mining, 17 percent less than in 1962. Although the quantity of gravel dredged and gold recovered by the company increased about 7 percent, ore production and gold recovered from underground operations was sharply reduced by a 90-day labor strike at Frontino mines.

Four dredges were operated in the Choco district and one in Narino. Dredging reserves in Choco and Narino increased to 88.8 million cubic yards, averaging 16.2 cents per yard at yearend, compared with 87.9 million cubic yards of the same grade at the end of 1962. Underground reserves at yearend declined to 301,000 tons averaging 0.72 ounce of gold per ton, from 444,000 tons averaging 0.69 ounce per ton at the end of 1962. All gold was sold either to the Bank of the Republic or through the Colombian Mining Association. Gold sales converted at the free rate of exchange realized an average of $35.14 per ounce.[9]

Pato Consolidated Gold Dredging, Ltd., operated six dredges in Antioquia but production was sharply reduced by a 101-day strike which disrupted mining operations. About 15.5 cubic yards of gravel was dredged from which 51,100 ounces of gold was recovered, compared with 24.7 million yards and 93,200 ounces recovered in 1962. Average value per cubic yard dropped from 14.12 cents to 12.52 cents. The minable reserve at yearend was 393.3 million cubic yards, averaging 15.2 cents per yard. The average realized value for gold was Can$38.55, compared with Can$37.41 in 1962.[10]

Ghana.—Gold production increased 4 percent to 921,300 ounces. Ashanti Goldfields Corp., Ltd., the leading producer, reported output of 444,251 ounces, an alltime high and 6 percent more than in 1962. The corporation reported that the production cost per ounce was lowered about 55 cents and that the ore reserve increased to about 3.2 million tons averaging 1.09 ounces per ton, an alltime record, compared with 2.9 million tons averaging 1.04 ounces per ton in 1962.

[9] International Mining Corporation. Annual Report 1963. Pp. 2–4.
[10] Pato Consolidated Gold Dredging, Ltd. 30th Annual Report 1963.

The Government-owned Ghana State Mining Corp., established in 1961 as a holding company, reported slightly lower output at four of its five mines. The company's fifth mine, Bremang Gold Dredging Co., Ltd., reported increased production and profits. Konongo Gold Mines, Ltd., a privately owned mine, which had nearly depleted its reserves in 1962, discovered several rich pockets of ore by drilling exploration.

Philippines.—Gold production decreased about 12 percent to 376,000 ounces as a result of a 2-month strike at Benquet Consolidated, Inc., the country's largest producer.

The Gold Mining Assistance Act of 1961 was extended to mid-1967. Under this law the Central Bank buys the output from producers at the peso equivalent of US$35 per ounce and, in addition, pays a subsidy which varies with the production cost but cannot exceed ₱200, equivalent to approximately US$51.

Rhodesia and Nyasaland, Federation of.—Gold production in Southern Rhodesia increased by 11,600 ounces to 566,300 ounces, only slightly less than in the peak year 1961. The increase in 1963 was due to expansion at the Dalny mine, the country's second largest producer. The Rio Tinto group, including the Cam & Motor, Pickstone, and Patchway mines, produced 150,000 ounces. Falcon Mines Ltd., operating the Dalny, reported an ore reserve of 820,400 tons, averaging 6.82 pennyweights (0.341 ounce).

The Government increased available loan funds to supply working capital to approved mines and provided subsidy payments to cover working losses. In addition, tax concessions were granted comprising an increase in depletion allowance from 10 to 15 percent and permission to deduct capital expenditures from income in the year in which they occur, instead of over a period up to 20 years.

South Africa, Republic of.—Output of gold in South Africa increased for the 12th consecutive year, again establishing a record high of 27.4 million ounces, valued at $960 million, about 8 percent more than in 1962, and 68 percent of the total value of all minerals produced in South Africa in 1963. The country produced about 70 percent of the total gold output of the free world. The gain in production again reflected continued expansion of output at new mines in the Orange Free State, the Transvaal, and Evander area. Estimated ore reserves increased 4.8 million ounces to a total of 174.0 million tons averaging 0.44 ounce per ton. The average number of employees in the gold-mining industry declined to 47,350 Europeans and 381,440 Africans. Gold mining, the leading primary industry, accounted for about 44 percent of the country's exports.

Anglo-American Corporation of South Africa reported that the mines of its group produced 9.4 million ounces of gold valued at $330 million, compared with 8.5 million ounces valued at $298 million in 1962. This was approximately 34 percent of the gold produced in South Africa and 24 percent of the gold produced in the free world. Mining operations at Western Deep Levels, Ltd., continued to expand, and the milling rate reached 200,000 tons per month. The ore reserve at yearend was 4.5 million ounces averaging 511 inch-

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pennyweight, compared with 3.3 million ounces, averaging 583 inch-pennyweight at the end of 1962.[11]

Union Corp., Ltd., reported a continued gain in ore milled and gold output from its group of mines, chiefly due to the first full years' operations at the two new mines, Braken and Leslie, in the Evander area. The Union Corp. group milled 12.9 million tons of ore, yielding $10.36 per ton at a working cost of $4.58 per ton. Ore reserves increased 2.3 million tons to 37.0 million tons, averaging 0.33 ounce per ton ($11.55). The Braken mine milled 1.1 million tons, yielding $14.65 per ton at a working cost of $6.89 per ton. The ore reserves at yearend was 2.9 million tons, averaging 0.48 ounce per ton over a 40-inch stoping width. The Leslie gold mine milled 1.4 million tons, yielding $10.92 per ton at a working cost of $6.72. The ore reserve at yearend was 3.0 million tons, averaging 0.37 ounce ($12.95) per ton over a stoping width of 44 inches. At the East Geduld mine, tons milled and average yield declined to 1.4 million and $9.38, respectively. Ore reserves in the Main and Kimberley Reefs totaled 3.7 million tons, averaging about 0.27 ounce per ton ($9.45). The St. Helena gold mine in the Orange Free State milled 2.4 million tons, yielding $14.82 per ton at a working cost of $5.57 per ton. The yearend ore reserve was 7.8 million tons, averaging 0.50 ounce per ton ($17.50) across a stoping width of 56 inches.[12]

Consolidated Gold Fields of South Africa, Ltd., reported that its group of 13 gold and gold-uranium mines established a new record gold output of 4.7 million ounces, notwithstanding declines in production by some of the older mines and the interruption of operations at the West Driefontein mine due to a major surface subsidence in December 1962. Gold Fields group mines treated 12.9 million tons yielding 0.36 ounce per ton ($12.60) compared with 13.3 million tons yielding 0.34 ounce per ton ($11.90) in fiscal year 1962. Working costs per ounce increased 78 cents to $22.15; working profits were slightly lower. West Driefontein Gold Mining Co., Ltd., treated 2.3 million tons at an average working cost of $13.53 per ounce. Working profit dropped $3.9 million to $38.6 million. Both gold production and working profit for the year were the highest so far achieved by Venterspost Gold Mining Company, Ltd. Although operations were curtailed during April by an accident in a subvertical shaft, working profit rose substantially as average yield per ton increased. The company milled 1.5 million tons, averaging 0.35 ounce per ton, at a working cost of $25.91 per ounce.[13]

The South African Government appropriated $1.05 million to aid marginal producers for pumping costs in mines affected by inflow of water from inactive adjacent mines. Four mines near Johannesburg received such financial aid during the year.

[11] Anglo-American Corporation of South Africa, Ltd. 47th Annual Report. 1963, p. 8.
[12] Union Corporation, Ltd. Reports and Accounts for the Year Ended 31st December, 1963. Pp. 24–29.
[13] The Consolidated Gold Fields of South Africa, Ltd. 76th Annual Report. 1963, pp. 28, 29, 42–46.

TABLE 16.—Union of South Africa: Salient statistics of the gold mining industry

	1954–58 (average)	1959	1960	1961 [1]	1962 [1]	1963 [1]
Ore milled.............thousand tons..	65,533	70,479	71,259	67,365	70,805	73,649
Gold recovered..thousand troy ounces..	15,269	20,067	21,386	22,395	24,991	27,432
Gold recovered.........ounces per ton..	[2,3] .231	.278	.293	.325	.344	.358
Working revenue (gold)....thousands..	[2,3] $535,430	[3] $700,426	[3] $750,550	[3] $773,892	[3] $857,989	[3] $128,192
Working revenue per ton milled........	8.14	9.79	10.38	11.49	11.56	12.10
Working cost..............thousands..	393,153	448,130	464,386	460,068	514,348	550,166
Working cost per ton..................	6.00	6.35	6.51	7.06	7.25	7.47
Working cost per ounce of gold..........	25.97	22.74	22.12	21.63	21.05	20.87
Total working profit from gold thousands..	140,050	241,019	274,341	297,685	343,641	378,026
Estimated working profit per ton from gold..............................	2.14	3.44	3.87	4.43	4.85	5.15
Uranium profits............thousands..	79,171	76,268	77,033	67,136	55,147	55,452
Dividends paid.................do....	83,405	127,040	131,528	134,221	148,676	161,780

[1] Excludes primary uranium producers.
[2] Excludes gold produced by nonmembers of Chamber of Mines for years 1954–55.
[3] Includes non-Chamber of Mines Properties for 1956–63.

Source: The Mining Journal (London).

TECHNOLOGY

Hydrometallurgical investigations at several gold mills by the Canadian Mines Branch in cooperation with the gold-mining industry disclosed substantial variation in operating conditions of the cyanide process within each plant, and between different plants treating similar ores. The studies indicated that some variations are probably due to the chemical reactions of the various sulfide minerals in the ores with the cyanide-lime solutions. These reactions are not well understood. However, tests showed that significant improvement in cyanidation conditions may be obtained by closer control through automation and by utilization of modern techniques of cyanide-solution analysis, such as the oxygen meter for measuring oxygen content, the goldleaf test for assessing gold-leaching efficiency, and the use of organic amine for determining the total cyanide of solutions.[14]

Grinding tests at the Daggafontein gold mine in the Republic of South Africa disclosed that increasing mill speed 5 percent to 90 percent of critical resulted in a gain of nearly 9 percent in output, an increase of 6.4 percent in power consumption, and no loss in gold recovery.[15]

A process for recovering gold and collecting arsenic from roaster exit gases, developed by Giant Yellowknife Mines, Ltd., increased gold recovery 3.4 percent and prevented air and water pollution by arsenic. The treatment process consists of collecting the dust from the roaster by electrostatic precipitation at temperatures above 600° C, cooling the gases, and collecting the condensed arsenic in the baghouse. Dust from the precipitators is cyanided separately in the presence of activated carbon. Gold-bearing carbon is washed, dried, and shipped to a smelter.[16]

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[14] Department of Mines and Technical Surveys (Ottawa, Canada). Mines Memo 1962, 1963, pp. 29–31, 42, 43, 55.
[15] Engineering and Mining Journal. V. 164, No. 10, 1963. P. 102.
[16] Foster, E. O. The Collection and Recovery of Gold From Roaster Exit Gases at Giant Yellowknife Mines Limited. Canadian Min. and Met. Bull., v. 56, No. 614, 1963, pp. 469–475.

A simplified gold-plating technique was developed by researchers at Lockheed Missiles and Space Co. whereby a gold-salt solution can be sprayed from an ordinary spray gun or from an aerosol bomb. Gold has been applied in this way to surfaces of metals, glass, plastics, and ceramics. The technique involves the simultaneous spraying of two water-base solutions, one containing gold and the other containing strong chemical reducing agents. Plating thin films of gold by the new process is reported to be more economical than either the vacuum deposition or the goldleaf method.[17]

Research scientists have discovered that an alloy containing one part barium to five parts gold becomes superconducting at 0.7° K.[18]

Bell Telephone Laboratories developed an economical gold diffusion process which increased the speed of response and improved the switching characteristics of silicon transistors.[19] Gold diffusion at 970° C for 48 minutes provided optimum transistor characteristics and was compatible with high-capacity production goals. The capability to produce fast switches with high sustained voltages has permitted simplified circuity and reduced production costs.

A patent was issued for a method of selectively gold plating the alloy contacts of silicon semiconductor devices.[20] The method comprises immersing the device in a hot solution of an alkali metal hydroxide, diluting with water, and admixing a gold-plating agent to produce a bath containing potassium gold cyanide, ammonium citrate, and ethylene diamine tetraacetic acid, at pH 7 to 8.

Difficult problems of transporting equipment and supplies were resolved and increased metallurgical efficiency was achieved with an unusual countercurrent decantation system at the silver-gold operations of Minas de San Luis, S.A. at Tayoltita in western Mexico.[21]

Homestake Mining Co. has revised its milling flowsheet and increased its daily milling rate in recent years to counteract increased operating costs. Changes in metallurgical practice and comparative reduction in milling costs achieved through automation of milling operations and increasing tonnage milled were described.[22]

Gold-mining operations at La Luz Mines Ltd. in north-central Nicaragua were described, and a breakdown of costs was given.[23] Other significant articles on treatment of gold ores were published in trade journals.[24]

Mining and milling operations at the Getchell mine, the second largest straight gold producer in the United States, were described.[25]

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[17] Mining Journal (London). Simplified Gold Plating. V. 260, No. 6671, June 28, 1963, p. 651.

[18] Chemical and Engineering News. Gold May Be a Superconductor. V. 41, No. 40, Oct. 7, 1963, p. 37.

[19] Uhl, C. J. A Gold Diffusion Process for Reducing Switching Times in Diffused Silicon Transistors. West. Elec. Eng., v. 7, No. 1, 1963, pp. 18–24.

[20] Mocanu, T. (assigned to Clevite Corp., Quincy, Mass.). Selective Gold Plating of Semi-Conductor Contacts. U.S. Pat. 3,099,576, July 30, 1962.

[21] Bogert, J. R. Tayoltita: Mexico's Most Important Silver-Gold Mining Operation. Min. World, v 25, No. 7, June 1963, pp. 20–24; v. 25, No. 8, July 1963, pp. 22–25.

[22] Schmidt, C. E., and F. M. Howell, Jr. Cost-Price Squeeze Successfully Met by Homestake Mining Company. Min. Eng., v. 15, No. 4, April 1963, pp. 46–48.

[23] Plecash, J., and R. V. Hopper. Operations at La Luz Mines and Rosita Mines, Nicaragua, Central America. Canadian Min. and Met. Bull., v. 56, No. 616, August 1963, pp. 624–635.

[24] Engineering and Mining Journal. How Silver-Gold Ores Respond to Salt Roasting Cyanidation. V. 164, No. 4, April 1963, pp. 76–77, 83.

Mining Journal (London). Cyanidation of Gold Ore. V. 260, No. 6648, Jan. 18, 1963, pp. 57, 59.

[25] Chamberlain, Clair C. Mining Methods With Emphasis on Cost Records at Getchell Mine. Min. Cong. J., v. 49, No. 10, October 1963, pp. 93–96.

Huttl, John B. Getchell Mine Resumes Gold Production. Eng. and Min. J., v. 164, No. 1, January 1963, pp. 70–73.

Graphite

By Harold J. Drake[1]

WORLD production of natural graphite in 1963 was 24 percent greater than in 1962. This rise was principally due to a reported large increase in output in the Republic of South Korea; however, this country has occasionally included some coal in graphite production data.

The Republic of Korea, Austria, and Mexico produced 46, 15, and 5 percent, respectively, of total world output. Mexico supplied 77 percent of the natural graphite imported by the United States.

TABLE 1.—Salient graphite statistics

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Consumption short tons	37,700	40,200	37,300	35,700	44,400	47,000
Value thousands	$5,227	$5,395	$4,773	$4,651	$5,648	$6,111
Imports for consumption short tons	41,225	37,000	48,300	29,700	39,500	52,200
Value thousands	$2,114	$1,527	$1,755	$1,332	$1,783	$2,000
Exports short tons	1,154	1,400	1,900	1,600	1,200	900
Value thousands	$177	$222	$289	$257	$223	$190
World: Production short tons	305,000	410,000	[1] 475,000	[1] 450,000	[1] 590,000	730,000

[1] Revised figure.

DOMESTIC PRODUCTION

Crystalline flake graphite was produced by Southwestern Graphite Co. at Burnet, Tex.

Manufactured (artificial) graphite products were produced by Carbon Products Div. of Union Carbide Corp., Niagara Falls, N.Y., Clarksburg, W. Va., and Columbia, Tenn.; by Great Lakes Carbon Corp., Niagara Falls, N.Y., Morganton, N.C., and Antelope Valley, Calif.; by International Graphite & Electrode Division, Speer Carbon Co., St. Marys, Pa., and Niagara Falls, N.Y.; and by Stackpole Carbon Co., St. Marys, Pa. The Dow Chemical Co. produced graphite anodes for its own use at Midland, Mich.

CONSUMPTION AND USES

Demand for natural graphite in 1963 was 6 percent greater than in 1962 because flake consumption rose 20 percent and amorphous use rose 3 percent.

[1] Commodity specialist, Division of Minerals.

Amorphous graphite was used primarily in foundry facings (41 percent), steelmaking (19 percent), lubricants (13 percent), and refractories (13 percent). Crucible, foundry facing, and lubricant manufacturers consumed nearly seven-tenths of the flake graphite.

TABLE 2.—Consumption of natural graphite in the United States

Year	Short tons	Value	Year	Short tons	Value
1954–58 (average)	37,707	$5,227,200	1961	35,652	$4,651,200
1959	40,239	5,394,800	1962	44,383	5,648,000
1960	37,289	4,773,400	1963	47,006	6,110,900

TABLE 3.—Consumption of natural graphite in the United States in 1963, by uses

Use	Crystalline flake		Ceylon amorphous		Other amorphous [1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Batteries	67	$30,389			881	$116,100	948	$146,489
Bearings	117	48,559	57	$30,536	27	5,671	201	84,766
Brake linings	465	127,222	260	68,546	808	121,233	1,533	317,001
Carbon brushes	152	66,619	362	196,634	146	25,874	660	289,127
Crucibles, retorts, stoppers, sleeves, and nozzles	[2] 3,487	[2] 553,816					3,487	553,816
Foundry facings	1,321	218,615	635	121,822	14,896	1,137,833	16,852	1,478,270
Lubricants	1,426	318,529	2,392	437,827	2,628	290,145	6,446	1,046,501
Packings	267	120,802	27	16,450	283	41,917	577	179,169
Paints and polishes					453	36,059	453	36,059
Pencils	583	179,971	670	210,380	519	68,590	1,772	458,941
Refractories	213	27,877			4,834	472,155	5,047	500,032
Rubber	46	28,478	103	13,578	30	6,038	179	48,094
Steelmaking	474	73,539	400	20,524	6,716	607,422	7,590	701,485
Other [3]	367	123,474	78	32,098	816	115,533	1,261	271,105
Total	8,985	1,917,890	4,984	1,148,395	33,037	3,044,570	47,006	6,110,855

[1] Includes small quantities of crystalline flake and Ceylon amorphous, and mixtures of natural and manufactured graphite.
[2] Includes some amorphous.
[3] Includes adhesives, carbon resistors, catalyst manufacture, chemical equipment and processes, electronic products, powdered-metal parts, small packages, specialties, and other uses not specified.

PRICES

Published prices for graphite merely indicate the range of prices; actual prices are negotiated between buyer and seller on the basis of a wide range of specifications.

Prices quoted per pound of crystalline graphite by Oil, Paint and Drug Reporter follow: 88 to 90 percent carbon, 19 to 21.5 cents; 90 to 92 percent carbon, 21 to 24.5 cents; 95 to 97 percent carbon, 29 to 31.5 cents; and No. 1 and 2 flakes, 90 to 95 percent carbon, 29 to 31 cents. Amorphous graphite prices per pound shown by this publication ranged from 6 to 9.5 cents.

Prices shown by E&MJ Metal and Mineral Markets for flake and crystalline graphite, f.o.b. source, bags, per short ton, were Malagasy Republic, $82 to $181; Norway, $73 to $127; and West Germany, $103 to $610. Ceylon graphite was listed at $85 to $223 per short ton. Amorphous graphite was quoted as follows: Mexico (bulk) per short ton, $15 to $18; Republic of Korea (bulk) per short ton, $14; and Hong Kong (bags) per short ton, $19.

FOREIGN TRADE

Imports of natural graphite totaled 51,815 short tons, nearly 17,000 tons more than in 1962. This additional tonnage came from Mexico, although consumption of Mexican graphite was about the same as in 1962.

Exports of graphite were about 900 short tons with an average value per ton of $211.

TABLE 4.—U.S. imports for consumption of natural and artificial graphite, by countries

Year and country	Crystalline				Amorphous				Total	
	Flake		Lump, chip, or dust		Natural		Artificial			
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1954-58 (average)	6,359	$842,115	233	$40,072	34,520	[1] $1,225,412	113	[1] $6,701	41,225	[1] $2,114,300
1959	5,208	457,313	94	23,968	31,741	1,043,977	5	1,620	37,048	1,526,878
1960	3,753	340,753	121	36,630	44,265	1,321,137	185	56,952	48,324	1,755,472
1961	4,377	428,793	55	17,138	25,246	863,457	70	22,787	29,748	1,332,175
1962:										
North America:										
Canada					58	1,142			58	1,142
Mexico					22,519	431,806	4,439	86,462	26,958	518,268
Europe:										
Austria					15	585	36	1,433	51	2,018
France	25	10,326							25	10,326
Germany, West	215	40,138	181	55,769	1,556	164,245	5	875	1,957	261,027
Norway					2,106	170,763			2,106	170,763
United Kingdom					(2)	134	28	2,478	28	2,612
Asia:										
Ceylon					2,811	327,849	17	1,512	2,828	329,361
Hong Kong					129	2,498	114	2,514	243	5,012
Korea, Republic of					56	1,050			56	1,050
Turkey	110	10,710							110	10,710
Africa: Malagasy Republic	5,108	471,096							5,108	471,096
Total	5,458	532,270	181	55,769	29,250	1,100,072	4,639	95,274	39,528	1,783,385
1963:										
North America:										
Mexico					39,724	766,229	302	5,912	40,026	772,141
Europe:										
Austria					10	868			10	868
France	16	7,340							16	7,340
Germany, West	331	61,127	165	51,450	898	102,686			1,394	215,263
Norway					2,652	220,515	33	2,183	2,685	222,698
Switzerland							6	2,448	6	2,448
United Kingdom					71	8,077	28	1,983	99	10,060
Asia:										
Ceylon					2,467	278,566			2,467	278,566
Hong Kong					112	2,400			112	2,400
Korea, Republic of					194	4,099			194	4,099
Turkey	55	5,592							55	5,592
Africa: Malagasy Republic	5,087	468,315	33	10,290					5,120	478,605
Total	5,489	542,374	198	61,740	46,128	1,383,440	369	12,526	52,184	2,000,080

[1] Owing to changes in tabulating procedures by the Bureau of the Census, some data known to be not comparable with other years.
[2] Less than 1 ton.

Source: Bureau of the Census.

TABLE 5.—U.S. exports of natural graphite, by countries

Year and destination	Amorphous		Crystalline flake, lump, or chip		Natural, n.e.c.[1]		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1962:								
North America:								
Canada	325	$44,302	57	$17,167	6	$2,280	388	$63,749
Dominican Republic			2	432			2	432
Honduras			(2)	100			(2)	100
Mexico			19	11,081	10	3,940	29	15,021
South America:								
Argentina					5	2,117	5	2,117
Brazil	90	14,188			2	928	92	15,116
Chile	2	476			2	294	4	770
Colombia			26	6,058	5	900	31	6,958
Ecuador			2	410			2	410
Peru					(2)	202	(2)	202
Venezuela	7	969	12	1,930	19	3,872	38	6,771
Europe:								
Denmark					11	2,061	11	2,061
France	38	7,378	(2)	608	136	20,241	174	28,227
Germany, West					1	464	1	464
Italy					3	1,300	3	1,300
Netherlands					1	618	1	618
Sweden					6	1,295	6	1,295
Switzerland					1	770	1	770
United Kingdom	264	38,620			26	4,925	290	43,545
Asia:								
India	8	1,465	1	657			9	2,122
Pakistan					9	1,720	9	1,720
Philippines	12	2,253	3	2,502	13	3,998	28	8,753
Viet-Nam					4	994	4	994
Africa: South Africa, Republic of					3	622	3	622
Oceania: Australia			5	1,319	23	17,422	28	18,741
Total	746	109,651	127	42,264	286	70,963	1,159	222,878
1963:								
North America:								
Canada	123	22,520	63	21,570			186	44,090
Canal Zone					1	500	1	500
Costa Rica			(2)	208	1	580	1	788
Dominican Republic			(2)	230			(2)	230
Honduras	(2)	202					(2)	202
Mexico	6	2,521	10	5,680	37	14,522	53	22,723
Trinidad and Tobago			2	788			2	788
South America:								
Argentina	2	684			10	3,063	12	3,747
Chile			4	960			4	960
Colombia			18	3,346	2	1,164	20	4,510
Ecuador			2	410			2	410
Peru			6	2,398	1	236	7	2,634
Venezuela			14	3,327	33	9,306	47	12,633
Europe:								
Denmark			1	605			1	605
France	34	7,447	2	1,201	32	6,142	68	14,790
Italy			1	934	1	616	2	1,550
Netherlands					1	620	1	620
Sweden	4	778					4	778
United Kingdom	336	49,016			13	1,604	349	50,620
Asia:								
India	8	1,664					8	1,664
Israel					1	530	1	530
Japan	3	1,372					3	1,372
Pakistan	10	1,924					10	1,924
Philippines	5	766	6	4,375	3	900	14	6,041
Oceania: Australia	2	468	15	3,420	86	11,536	103	15,424
Total	533	89,362	144	49,452	222	51,319	899	190,133

[1] Not elsewhere classified.
[2] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW [2]

Canada.—The graphite deposit near Portland, Ontario, was being developed, and a concentrating plant was being erected at a cost of about $160,000.[3] The initial capacity of the mill was 100 tons per day. The graphite deposit was reported to be 2,050 feet long and 80 to 200 feet wide covering 160 acres.[4]

Italy.—In 1961, Italy imported about 70 percent of the graphite available for consumption.[5] Imports amounted to nearly 10,000 tons and exports to about 1,650 tons. Apparent consumption was 12,830 tons.

TABLE 6.—World production of natural graphite by countries [1] [2]

(Short tons)

Country [1]	1954-58 (average)	1959	1960	1961	1962	1963
North America: [1]						
Canada	493	-----	-----	1	-----	2
Mexico	27,302	30,684	37,827	19,846	31,992	[3] 33,000
South America:						
Argentina	349	554	538	858	468	[3] 470
Brazil	930	1,334	1,433	1,599	1,664	[3] 1,650
Europe: [1]						
Austria	20,718	68,444	97,043	89,255	98,416	109,778
Germany, West	11,892	12,377	12,760	13,349	13,134	[3] 13,000
Italy	3,488	3,457	4,098	4,484	3,703	1,884
Norway	5,344	5,396	6,437	6,283	7,055	[3] 7,000
Spain	333	457	288	303	-----	-----
Sweden	433	-----	-----	-----	-----	-----
U.S.S.R.[3]	45,000	50,000	50,000	55,000	60,000	60,000
Asia:						
Ceylon (exports)	9,109	8,816	10,107	10,016	9,665	9,280
China [3]	25,000	45,000	45,000	45,000	45,000	45,000
Hong Kong	2,780	3,676	4,255	1,865	902	891
India	692	([4])	([4])	([4])	([4])	([4])
Japan	4,160	4,453	4,979	3,836	3,812	3,243
Korea:						
North	23,003	[3] 57,000	[3] 68,000	[3] 72,000	[3] 72,000	[3] 77,000
Republic of	89,674	91,045	101,777	98,892	204,032	334,777
Taiwan	1,192	621	551	882	[3] 880	[3] 880
Africa:						
Kenya	601	635	1,113	-----	-----	-----
Malagasy Republic	15,719	12,614	15,923	16,473	19,274	[5] 17,319
Morocco	53	132	-----	-----	-----	-----
South Africa, Republic of	1,542	617	894	963	1,308	671
South-West Africa	225	-----	-----	-----	-----	-----
Tanganyika	6	28	26	-----	-----	-----
Oceania: Australia	23	-----	-----	-----	-----	-----
World total (estimate) [1] [2]	305,000	410,000	475,000	450,000	590,000	730,000

[1] Graphite has been produced in Czechoslovakia, but production data are not available; estimates by author of chapter included in total. U.S. figure withheld to avoid disclosing individual company confidential data, included in world total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Data not available; estimate by author of chapter included in total.
[5] Exports.

[2] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[3] E&MJ Newsletter. V. 34, No. 1, January 1963, p. 8.
[4] Pit and Quarry. V. 56, No 2, August 1963, p. 68.
[5] Bureau of Mines. Mineral Trade Notes. V. 56, No. 3, March 1963, pp. 13–14.

TABLE 7.—Ceylon: Exports of graphite by countries [1]

(Short tons)

Destination	1962	1963	Destination	1962	1963
North America:			Asia:		
Canada	31	84	India	555	702
United States	2,615	2,670	Japan	2,056	2,004
Europe:			Pakistan	239	218
Belgium	37	59	Singapore	29	5
Czechoslovakia	137		Syria		49
France	399	215	Thailand	28	37
Germany, West	74	53	Oceania: Australia	647	538
Netherlands	45	22	Other countries	17	18
Poland	27	51			
United Kingdom	2,729	2,555	Total	9,665	9,280

[1] This table incorporates some revisions.

TABLE 8.—Ceylon: Exports of graphite to the United States, by grades, in 1963 [1]

Grade	Short tons	Percent of total	Value per ton
97 percent carbon or higher	999	44	$137.27
90 to 96 percent carbon	987	43	100.34
Less than 90 percent carbon	308	13	84.55
Total	2,294	100	114.30

[1] U.S Embassy, Colombo, Ceylon. State Department Airgram A-17, July 9, 1963, pp. 1-2; State Department Airgram A-487, Jan. 14, 1964, pp. 1-2.

Artificial graphite electrodes were to be manufactured in southern Italy using Japanese technology, according to unconfirmed reports.[6] Initial production was expected to be about 12,000 tons a year with sales in the European Economic Community.

Peru.—A graphite deposit near Trujillo, Peru, would be used for the production of graphite-refractory brick if capital and technical assistance could be arranged.[7] The property was reported to contain millions of tons of high-grade graphite suitable for other applications in addition to refractory brick.

Rhodesia and Nyasaland, Federation of.—Investigation of large reserves of graphite in the Dowa District was continuing.[8] The work carried on by the Nyasaland Geological Department consisted of regional mapping and mineral investigations.

[6] Oil, Paint and Drug Reporter. Graphite Technology Takes Journey From Japan to Italy. V. 183, No. 3, Jan. 21, 1963, p. 29.
[7] International Commerce. Graphite Brick Output Planned by Peruvian. V. 69, No. 6, Feb. 11, 1963, p. 28.
[8] Engineering and Mining Journal. This Month in Mining. V. 164, No. 12, December 1963, p. 168.

TABLE 9.—Malagasy Republic: Exports of graphite, by countries[1]

(Short tons)

Destination	1961	1962	Destination	1961	1962
			Europe—Continued		
North America:			Italy	1,076	1,290
Canada	66		Netherlands	55	
United States	3,887	5,494	Spain	121	209
Europe:			United Kingdom	3,874	4,135
Belgium-Luxembourg	29	55	Asia: Japan	709	871
France	3,375	3,033	Oceania: Australia	55	179
Germany:			Other countries	31	17
East		123			
West	3,135	2,741	Total	16,413	18,147

[1] This table incorporates some revisions.

TECHNOLOGY

The American Society for Testing Materials organized a committee, C–5, on carbon and graphite products to promote knowledge, stimulate research, and develop test methods, specifications, and nomenclature for manufactured carbon and graphite products.[9]

The American Carbon Committee sponsored a new journal, "Carbon," devoted to the physics and chemistry of aromatic or tetrahedrally bonded carbonaceous solids.[10]

A Soviet manual on theory and practice in the manufacture of carbon and graphite products was published.[11] The book is a detailed study of the technology of the production of manufactured graphite and carbon and covers a wide range of products.

Vitreous carbon, a new development, was reported to have high purity, low permeability and porosity, nonwettability, and high resistance to chemical corrosion.[12] The material has potential applications in the electrical, chemical, and metallurgical industries.

Large blocks of pyrolytic graphite were being produced by a plasma spray technique that allows the crystal lattice to be preset to permit control of heat flow within the structure.[13]

Pyrolytic graphite was used in rocket nozzles[14] and was tested for modulus of rupture and bending modulus of elasticity.[15]

A patent was issued for a method of depositing pyrolytic graphite from a carbon vapor containing nitric oxide.[16]

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[9] Materials Research and Standards. Society Affairs. V. 3, No. 9, September 1963, pp. 743–744.

[10] Chemical Trade Journal and Chemical Engineer (London). "Carbon": A New Scientific Quarterly. V. 153, No. 3992, Dec. 13, 1963, p. 899.

[11] Chalykh, Y. F. (Technology of Carbon and Graphite Materials.) Metallurgizdat, Moscow, U.S.S.R., 1963, 304 pp. (available from Library of Congress).

[12] Metallurgia (Manchester, England). Plessey Develops Vitreous Carbon. V. 67, No. 402, April 1963, p. 208.

Yamada, Keihiko, and Hiroshi Sato. (Characteristics of "Vitreous Carbon".) J. Chem. Soc. Japan, v. 65, No. 7, 1962, pp. 1139–1140; U.S. Atomic Energy Commission, Div. of Tech. Inf., AEC–TR–5838, May 1962, 3 pp.

[13] Missiles and Rockets. Advanced Materials. V. 12, No. 4, Jan. 28, 1963, p. 31.

[14] Batchelor, J. D., E. F. Ford, and E. L. Olcott. Improvement of the Usefulness of Pyrolytic Graphite in Rocket Motor Applications. Atlantic Res. Corp., Contract DA 36 034, ORD 3279, Proj. TB 4–004, Final Tech. Summary Rept., February 1963, 96 pp.

Judge, J. F. C–W Bids for Broader Space Role. Missiles and Rockets, v. 12, No. 2, Jan. 14, 1963, p. 36.

Materials in Design Engineering. Rocket Nozzle Uses Pyrolytic Graphite. V. 57, No. 2, February 1963, pp. 139–140.

[15] Marcus L. Modulus of Rupture Tests on Pyrolytic Graphite. Bell Aerosystems Co., Contract AF 33(657)8555, Rept. BLR 62–13(M), Rev. A, Oct. 31, 1962, 39 pp.

[16] Diefendorf, R. J. (assigned to General Electric Company, New York). Process for Deposition of Pyrolytic Graphite. U.S. Pat. 3,107,180, Oct. 15, 1963.

The mechanical and thermal properties of several types of recrystallized graphite were described in detail.[17]

Colloidal graphite was tested as a protective finish on glass-fiber fabrics.[18] The study was sponsored by the Department of Health, Education, and Welfare because of a need to improve filter media in the filtration of industrial gases.

A graphite cloth tape was developed for use as heating elements in electric furnaces.[19] The material can be used up to 5,000° F in vacuum or a protective atmosphere.

Papers on fuel and moderator materials for reactors presented at a symposium by the American Nuclear Society were reviewed.[20] Among the materials covered were uranium carbides and graphite.

Production of graphite bricks [21] for reactor cores and fuel elements [22] utilizing high-temperature graphite was reported.

Patents were issued for reactor components [23] using graphite and for the production of high-purity graphite [24] for use in nuclear reactors.

The oxidation of graphite was studied [25] as was the reaction of graphite with metal chlorides.[26]

An article covering the manufacture of carbon-bonded silicon carbide crucibles was published.[27]

A new crystalline form of carbon was revealed by high-pressure resistance techniques.[28] The studies were made on a single crystal of natural graphite and the new phase was found to have an estimated density of 2.80 grams per cubic centimeter.

Patents were issued for the manufacture of carbon and graphite structures utilizing thermosetting resins [29] and for the production of a furnace-lining brick resistant to alkali slag.[30]

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[17] Neel, E. A., A. A. Kellar, and J. J. Zeitsch. Research and Development on Advanced Graphite Materials. High Density Recrystallized Graphite by Hot Forming. National Carbon Co., Contract AF 33(616)6915, Proj. Nos. 7350, 7381, and 7-817, WADD TR 61-72, v. 7, June 1962, 63 pp.

[18] Spaite, P. W., J. E. Hagan, and W. F. Todd. A Protective Finish for Glass-Fiber Fabrics. Chem. Eng. Prog., v. 59, No. 4, April 1963, pp. 54-57.

[19] Metal Progress. Graphite Tape for Elements. V. 84, No. 2, August 1963, pp. 44-45.

[20] Schumar, J. F., and M. T. Simnand. Metals Engineering Digest. Metal Prog., v. 83, No. 2, February 1963, pp. 136, 138-140, 144, 148, 150-151.

[21] New Scientist (London). Making the Cores for Trawsfynydd. V. 18, No. 336, Apr. 25, 1963, p. 197.

[22] Chemical & Engineering News. V. 41, No. 18, May 6, 1963, p. 27.

[23] Knights, H. C., and P. N. Munn (assigned to U.K. Atomic Energy Authority, London). Graphite Moderator Structures for Nuclear Reactors. U.S. Pat. 3,085,958, Apr. 16, 1963.

Pyle, R. J., and G. L. Allen (assigned to U.S. Atomic Energy Commission). Coated Carbon Element for Use in Nuclear Reactors and the Process of Making the Element. U.S. Pat. 3,073,717, Jan. 15, 1963.

[24] Nedopil, E. (assigned to Siemens-Planiawerke Aktiengesellschaft für Kohlefubrikate, Meitingen, Germany). Method for Producing High-Purity Graphite. U.S. Pat. 3,089,754, May 14, 1963.

[25] Gulbransen, E. A., K. F. Andrew, and F. A. Brassart. The Oxidation of Graphite at Temperatures of 600° to 1,500° C and at Pressures of 2 to 76 Torr of Oxygen. J. Electrochem. Soc., v. 110, No. 6, June 1963, pp. 476-483.

[26] Rüdorff, W., E. Stumpp, W. Spriessler, and F. W. Siecke. Reactions of Graphite With Metal Chlorides. Angew. Chem. (Internat. Ed.), v. 2, No. 2, February 1963, pp. 67-73.

[27] Ceramic Age. Manufacture of Carbon Bonded Silicon Carbide Crucibles at Electro Refractories. V. 79, No. 6, June 1963, pp. 50-52.

[28] Aust, R. B., and H. G. Drickamer. Carbon: A New Crystalline Phase. Sci., v. 140, No. 3568, May 17, 1963, pp. 817-819.

[29] Boquist, C. W. (assigned to Armour Research Foundation, Chicago, Ill.). Method of Fabricating Carbon and Graphite Structures. U.S. Pat. 3,107,153, Oct. 15, 1963.

Johnson, P. C. (assigned to Union Carbide Corp., New York). Manufacture of Carbon Articles. U.S. Pat. 3,112,208, Nov. 26, 1963.

[30] Nickerson, J. D. (assigned to Union Carbide Corp., New York). Furnace Lining Brick. U.S. Pat. 3,083,111, Mar. 26, 1963.

A process was developed for fabricating substantially impermeable carbon articles.[31] Finely divided carbon powder in a mold is subjected to a moving stream of gaseous hydrocarbon within a range of 500° to 1,500° C at about atmospheric pressure, two or more times to produce the impermeable article.

Graphite was joined to graphite by a brazing technique employing iron-based alloys[32] and to certain metals by a process using nickel carbonyl.[33]

Studies of erosion- and oxidation-resistant coatings for graphite were made,[34] and a patent was issued for a method of protecting graphite surfaces.[35]

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[31] Bickerdike, R. L., Garyth Hughes, and William Watt (assigned to the Minister of Aviation, Great Britain). Process for Forming Impermeable Carbon Articles. U.S. Pat. 3,107,973, Oct. 22, 1963.

[32] Steel. Graphite Joins Graphite. V. 152, No. 2, Jan. 14, 1963, p. 20.

[33] Davidson, H. W., and J. W. Ryde (assigned to General Electric Company, Ltd., London). Method of Joining Graphitic Surfaces. U.S. Pat. 3,097,931, July 16, 1963.

[34] Goodman, E., and R. Thompson. Electrodeposition of Erosion and Oxidation Resistant Coatings for Graphite. Value Eng. Co., Contract N600(19)58317, Final Summary Rept., Mar. 15, 1963, 17 pp.

[35] Davidson, H. W., and J. W. Ryde (assigned to General Electric Company, Ltd., London). Methods of Protecting Graphite Surfaces. U.S. Pat. 3,070,525, Dec. 25, 1962.

Gypsum

By William R. Barton [1]

MINE production of crude gypsum and production of calcined gypsum both increased 4 percent over that of the previous year. There was a general upward trend in the consumption of most gypsum products because of increased building construction. Value of calcined gypsum and of products sold reached an alltime high as did total world production.

TABLE 1.—Salient gypsum statistics

(Thousand short tons and thousand dollars)

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Active establishments [1]	85	93	96	98	102	103
Crude: [2]						
Mined	9,758	10,900	9,825	9,500	9,969	10,388
Value	$31,557	$39,231	$35,690	$34,996	$36,343	$38,138
Imports for consumption	4,014	6,132	5,301	4,967	5,421	5,490
Calcined:						
Produced	8,199	9,268	8,591	8,246	8,819	9,181
Value	$86,188	$111,740	$120,984	$118,145	$127,436	$131,668
Products sold (value)	$308,659	$388,335	$361,190	$358,811	$392,300	$414,090
Gypsum and gypsum products:						
Imports for consumption (value)	$7,516	$13,196	$10,426	$10,306	$11,912	$12,357
Exports (value)	$1,198	$1,296	$1,293	$1,299	$1,302	$1,431
World: Production	36,920	[3] 47,500	[3] 46,660	[3] 47,750	[3] 51,690	[4] 54,000

[1] Each mine, calcining plant, or combination mine and plant is counted as 1 establishment.
[2] Excludes byproduct gypsum.
[3] Revised figure.
[4] Estimate.

DOMESTIC PRODUCTION

Crude.—Domestic mine production was approximately 10.4 million short tons compared with almost 10.0 million tons in 1962. The production rate was greater during each of the first three quarters of 1963 than in the corresponding quarters of 1962. In the fourth quarter, however, less production was recorded. By State, the leading crude gypsum producers were: California, 17 percent; Michigan, 13 percent; Iowa, 12 percent; and Texas, 11 percent. Seventy-one mines were operated, 55 open pit and 16 underground. Eighty-two percent of the total output came from 39 mines operated by companies having

[1] Commodity specialist, Division of Minerals.

calcining equipment. Seventy-five percent of the crude gypsum mined in Texas, about 70 percent of that mined in Iowa, and 28 percent of that mined in Michigan was calcined in those States. More than 40 percent of the California output was sold uncalcined for agricultural purposes.

Calcined.—Domestic or imported gypsum was calcined at 68 plants that had 224 kettles and 62 other pieces of calcining equipment. A total 9.2 million short tons of calcined gypsum worth $131.7 million, was produced in 1963 compared with 8.8 million tons worth $127.4 million the previous year. Oil, natural gas, and coal were used as fuel at various plants.

TABLE 2.—Crude gypsum mined in the United States, by States

(Thousand short tons and thousand dollars)

State	1962			1963		
	Active mines	Quantity	Value	Active mines	Quantity	Value
Arkansas	1	83	$261	(1)	(1)	(1)
California	11	1,747	4,113	11	1,756	$4,222
Colorado	5	108	383	4	99	346
Iowa	5	1,256	5,318	5	1,282	5,667
Michigan	5	1,278	4,791	5	1,315	4,938
Nevada	3	817	2,952	3	890	3,216
New Mexico	3	151	564	3	179	656
New York	5	601	3,122	5	647	3,339
Oklahoma	7	509	1,668	7	531	1,462
South Dakota	1	23	93	1	24	97
Texas	7	1,120	3,956	7	1,099	3,999
Other States [2]	17	2,276	9,122	20	2,566	10,196
Total	70	9,969	36,343	71	10,388	38,138

[1] Included with "Other States."
[2] Includes the following States to avoid disclosing individual company confidential data: Louisiana and Virginia, 1 mine each; Arkansas (1963), Indiana, Kansas, Montana, Ohio, Utah, and Wyoming, 2 mines each; and Arizona (1962), 3 mines, (1963), 4 mines.

TABLE 3.—Calcined gypsum produced in the United States, by States

(Thousand short tons and thousand dollars)

State	1962					1963				
	Active plants	Quantity	Value	Calcining equipment		Active plants	Quantity	Value	Calcining equipment	
				Kettles	Other [1]				Kettles	Other [1]
California	6	843	$8,002	18	12	6	1,017	$9,936	18	13
Iowa	5	845	12,704	23	4	5	896	13,423	23	4
Louisiana	3	229	4,084	6	1	3	227	4,035	6	1
Michigan	4	359	5,151	14	1	4	372	5,360	14	1
New York	7	1,153	17,389	24	6	7	1,192	18,269	24	6
Ohio	3	296	4,573	9	1	3	324	4,913	9	1
Texas	6	821	13,135	29	--------	6	822	12,075	29	--------
Other States [2]	34	4,273	62,398	99	37	34	4,331	63,657	101	36
Total	68	8,819	127,436	222	62	68	9,181	131,668	224	62

[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; Colorado, 2; Connecticut, 1; Delaware, 1; Florida, 2; Georgia, 2; Illinois, 1; Indiana, 3; Kansas, 2; Maryland, 2; Massachusetts, 1; Montana, 1; Nevada, 2; New Hampshire, 1; New Jersey, 2; New Mexico, 2; Oklahoma, 1; Pennsylvania 1, Utah, 2; Virginia, 2; Washington, 1; and Wyoming, 1.

Mine and Products-Plant Development.—American Gypsum Co. increased the production capacity at its Albuquerque, N. Mex., plant from 100 million square feet of wallboard to 150 million square feet. Two calcining kettles and an electrostatic precipitator (to reduce dust) were included in new equipment to be installed. A new automated gypsum wallboard plant was under construction near Nashville, Ark. The plant owned by Dierks-Forest, Inc., will have a rated capacity of 400,000 square feet per day. To supply the operation, 600 tons per day of raw gypsum will be mined nearby. The Flintkote Co., announced it will build an $8.5 million gypsum products plant near Savannah, Ga. It will be on tidewater and use rock gypsum from Flintkote's Newfoundland quarries. Gypsum Products of America announced it will build a wallboard plant at Lovell, Mont., to process gypsum mined about 8 miles south. The company reported receipt of a $2,049,000 Area Redevelopment Administration loan to assist construction. Kaiser Gypsum Co. began construction, on a 34-acre site, of a new $6 million gypsum products plant at Jacksonville, Fla. It will process gypsum mined in the Maritime Provinces and have a rated annual capacity of 180 million square feet of gypsum board and 40,000 tons of plaster. The firm also announced plans to build an identically sized facility in Burlington County, N.J., to serve northeastern U.S. markets. These are the first expansions of Kaiser Gypsum Co. into the eastern United States. National Gypsum Co. announced plans to construct a new $5 million gypsum products plant at Richmond, Calif. It will be the firm's first such plant on the west coast and will be supplied with gypsum from Mexico. The company's new, automated gypsum products plant at Tampa, Fla., was described.[2] A new firm, Republic Gypsum Co., began constructing a $4.5 million automated wallboard plant at Duke, Okla. An Area Redevelopment Administration loan of $2.6 million will assist financing. Locally mined gypsum will be used to produce 12 carloads of wallboard per day. United States Gypsum Co. began operations at its new Baltimore, Md., plant. It will make a full line of gypsum products from raw gypsum mined in Nova Scotia, Canada. The firm also added ceiling tile production facilities to its plant at Greenville, Miss., and modernized its installation at Wabash, Ind.

CONSUMPTION AND USES

New construction, a guide to demand for gypsum products, set many records in 1963.[3] Value of new construction put in place in the United States was a record $62.8 billion compared with $59 billion in 1962. A new record was also set for physical volume of new construction (dollar value adjusted for price changes), inasmuch as construction costs during the year rose only about 3 percent. Gains were sizable in both private and public construction sectors, private up from $41.5 billion to $43.8 billion and public up from $17.6 billion to $19 billion. Residential building, the dominant factor in the private

[2] Bergstrom, John H. Gypsum Products Plant Paces Prosperous Florida. Rock Products, v. 66, No. 6, June 1963, pp. 60–63.
[3] U.S. Dept. of Commerce. Construction Review. Periodical issued monthly. For sale by Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

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sector, was marked by a further shift to multiunit dwellings which accounted for almost 40 percent of the record of 1.6 million private, nonfarm housing unit starts.

Overall outlays for new construction moved upward during the year. The seasonally adjusted annual rate ranged from $59.2 billion to $60.5 billion during the first 5 months, climbed to $62.3 billion in June, rose to a peak of $66.1 billion in November, and remained high at $65.5 billion in December, bringing the annual total to $62.8 billion. New construction put in place during 1963 accounted for 11 percent of the gross national product, about the same as in 1962.

Private home construction had a record year in 1963. About 1,559,000 private, nonfarm housing units were started, about 120,000 more than in 1962 and 65,000 more than in 1959, the previous peak year. The 27,400 private, farm housing starts were 3,700 more than those in 1962; and the 30,800 public housing starts were 1,200 more than those in 1962. Both totals were still below record 1961 figures of 28,200 and 52,000, respectively. The overall rate of starts by the yearend set a new record of 1,617,200 compared with 1,492,400 in 1962 and 1,553,500 in the previous record year, 1959.

Expenditures for private, nonfarm housing units topped $20 billion, an increase of $2 billion from 1962.

Apartment-house construction continued to flourish. The percentage of multiunit dwellings, compared with total housing units, rose from 20 percent in 1959 to 33 percent in 1962 and almost 40 percent in 1963. The number of apartment units (residential structures with two or more units are classified as apartments) was about 610,000 compared with approximately 500,000 in 1962. This contrasted with single-family unit starts which increased from 996,000 in 1962 to 1,007,000 in 1963.

The Gypsum Association released a new series of use specifications for gypsum plastering,[4] as a replacement for American Standards Association Specification A42.1. The principal changes are concerned with the addition of fine sand or perlite to trowel finishes and the proportioning of perlite or vermiculite in lightweight aggregate plasters.

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[4] Gypsum Association. Recommended Specifications, Gypsum Plastering, AIA File No. 21-A-2, 1963, 11 pp.

TABLE 4.—Gypsum products (made from domestic, imported, and byproduct crude gypsum) sold or used in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1962		1963	
	Quantity	Value	Quantity	Value
Uncalcined:				
Portland-cement retarder	2,765	$12,365	2,898	$12,931
Agricultural gypsum	1,241	4,222	1,262	4,372
Other uses [1]	43	510	49	562
Total	4,049	17,097	4,209	17,865
Calcined:				
Industrial:				
Plate-glass and terra-cotta plasters	43	714	46	776
Pottery plasters	48	1,073	50	1,115
Dental and orthopedic plasters	13	487	13	484
Industrial molding, art, and casting plasters	85	1,806	90	1,945
Other industrial uses [2]	80	2,665	80	2,774
Total	269	6,745	279	7,094
Building:				
Plasters:				
Base-coat	1,026	18,294	1,036	19,158
Sanded and premixed perlite	504	12,247	477	11,837
To mixing plants	1	16	1	21
Gaging and molding	119	2,521	123	2,649
Prepared finishes	10	869	9	821
Roof-deck	344	5,186	325	4,622
Other [3]	16	997	19	1,033
Keene's cement	35	924	36	963
Total	2,055	41,054	2,026	41,104
Prefabricated products [4]	[5] 7,711	327,404	[5] 8,214	348,027
Total	----------	368,458	----------	389,131
Grand total, value	----------	392,300	----------	414,090

[1] Includes uncalcined gypsum for use as filler and rock dust, in brewer's fixe, in color manufacture, and for unspecified uses.
[2] Includes dead-burned filler, granite polishing, and miscellaneous uses.
[3] Includes joint filler, patching, painter's, insulating, and unclassified building plasters.
[4] Excludes tile.
[5] Includes weight of paper, metal, or other materials.

TABLE 5.—Prefabricated products sold or used in the United States, by products

Product	1962			1963		
	Thousand square feet	Thousand short tons [1]	Value (thousands)	Thousand square feet	Thousand short tons [1]	Value (thousands)
Lath:						
⅜-inch	1,529,652	1,142	$41,863	1,486,624	1,113	$40,490
½-inch	51,154	52	1,766	58,533	59	2,087
Other [2]	3,964	6	275	3,903	7	182
Total	1,584,770	1,200	43,904	1,549,060	1,179	42,759
Wallboard:						
¼-inch	145,968	81	4,578	134,585	76	4,296
⅜-inch	1,962,121	1,498	71,093	1,881,293	1,432	67,796
½-inch	4,112,080	4,145	175,040	4,547,745	4,566	192,386
⅝-inch	402,745	523	23,201	534,178	678	30,687
1-inch [3]	8,841	17	795	11,326	24	1,024
Total	6,631,755	6,264	274,707	7,109,127	6,776	296,189
Sheathing	186,265	195	6,706	196,935	206	6,970
Laminated board	7,141	8	380	[4] 6,568	6	333
Formboard	42,013	44	1,707	44,582	47	1,776
Grand total [5]	8,451,944	7,711	327,404	8,906,272	8,214	348,027

[1] Includes weight of paper, metal, or other materials.
[2] Includes a small amount of ¼-inch, ⅝-inch, and 1-inch lath.
[3] Includes a small amount of 5/16-inch, ¾-inch, 1⅝-inch, and 3¾-inch wallboard.
[4] Area of component board and not of finished product.
[5] Excludes tile, for which figures are withheld to avoid disclosing individual company confidential data.

STOCKS

Producers reported that stocks of crude gypsum on hand December 31 totaled 3.94 million short tons, a 9 percent increase over the 3.61 million short tons reported at the end of 1962.

PRICES

Producers reported that the average value of crude gypsum mined in the United States was $3.67 per short ton compared with $3.65 in 1962. The reported values were not actual sales prices (since much was internally consumed by reporting firms), but rather values assigned by producers as a calculated or book cost of the crude gypsum mine production. Actual mining costs varied considerably among producers.

The average value of cement retarder was $4.46 per short ton compared with $4.47 in 1962. Average value of agricultural gypsum was $3.46 per ton compared with $3.40 in 1962. The average value of industrial plasters was $25.40 per ton, building plasters, $20.28 per ton, and prefabricated gypsum products, $42.37 per ton; compared, respectively, with $25.06, $20.00, and $42.41 in 1962.

Based on 1957–59 averages equaling 100, prices of gypsum products, as reported by the U.S. Department of Commerce in 1963, averaged 105.4 compared with 105.0 in 1962. The actual 1963 yearend index was 106.1, indicating a rising trend.

FOREIGN TRADE

Imports of crude gypsum increased slightly compared with that of 1962. Canada provided 80 percent of the total crude imports; Mexico, 16 percent; and Jamaica, 3 percent. Exports of gypsum and gypsum products totaled $1.4 million and were composed of 17,000 tons of crude, crushed, or calcined material valued at $669,000 and manufactured gypsum products valued at $762,000.

TABLE 6.—U.S. imports for consumption of gypsum and gypsum products [1]

Year	Crude (including anhydrite)		Ground or calcined		Alabaster manufactures,[2] value (thousands)	Other manufactures n.e.s., value (thousands)	Total value (thousands)
	Short tons	Value (thousands)	Short tons	Value (thousands)			
1954–58 (average)	4,014,568	$6,685	885	$33	$433	$365	$7,516
1959	6,131,625	11,862	1,025	46	946	342	13,196
1960	5,301,224	8,990	1,159	48	963	425	10,426
1961	4,967,061	9,043	1,127	51	836	376	10,306
1962	5,420,876	10,490	1,780	55	1,025	342	11,912
1963	5,490,298	10,887	226	62	1,031	377	12,357

[1] In addition, Keene's cement was imported as follows: 1954–58 (average), 2 short tons ($253); 1959–61, none; 1962, 2,760 short tons ($2,073), 1963, none.
[2] Includes imports of jet manufactures, which are believed to be negligible.

Source: Bureau of the Census.

TABLE 7.—U.S. imports for consumption of crude gypsum (including anhydrite), by countries

(Thousand short tons and thousand dollars)

Country	1962		1963	
	Quantity	Value	Quantity	Value
North America:				
Canada	4,086	$7,473	4,400	$8,714
Dominican Republic	453	1,240	26	77
Jamaica	283	1,052	169	508
Mexico	599	725	891	1,577
Total	5,421	10,490	5,486	10,876
Europe:				
France			4	10
Italy	(1)	(2)	(1)	1
Total	(1)	(2)	4	11
Grand total	5,421	10,490	5,490	10,887

[1] Less than 1,000 tons.
[2] Less than $1,000.

Source: Bureau of the Census.

TABLE 8.—U.S. exports of gypsum and gypsum products

Year	Crude, crushed, or calcined		Other manufactures, n.e.c., value (thousands)	Total value (thousands)
	Short tons (thousands)	Value (thousands)		
1954–58 [1] (average)	24	$779	$419	$1,198
1959	14	641	655	1,296
1960	17	687	606	1,293
1961	20	731	568	1,299
1962	20	736	566	1,302
1963	17	669	762	1,431

[1] Effective Jan. 1, 1958, plasterboard, wallboard, and tile not separately classified included with "gypsum manufactures, n.e.c." 1954: 20,968,956 square feet, $688,820; 1955: 8,686,854 square feet, $412,397; 1956: 7,026,932 square feet, $363,648; 1957: 8,866,572 square feet, $519,668.

Source: Bureau of the Census.

WORLD REVIEW

NORTH AMERICA

Canada.—Gypsum shipments increased more than 10 percent to 5.9 million short tons in 1963, as a result of increased shipments to the United States. Alba Gypsum Co., a subsidiary of Kaiser Gypsum acquired from Allied Chemical Canada, Ltd., a 3,500-acre gypsum deposit at Bras d'Or Lake, Cape Breton Island, Nova Scotia. The ore body will be operated in conjunction with a Kaiser gypsum product plant at Jacksonville, Fla. Production began from the Flat Bay, Newfoundland, mine of Flintkote Company of Canada, Ltd. A new underground gypsum mine was being developed by Western Gypsum Products, Ltd., at Silver Plains, 30 miles south of Winnipeg, Manitoba. The firms new Can$3.5 million gypsum products plant at Clarkson, Ontario, was completed in May.

TABLE 9.—World production of gypsum by countries [1 2]

(Thousand short tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada [3]	4,461	5,983	5,093	5,060	5,333	5,932
Cuba [4]	36	45	29	21	21	24
Dominican Republic	69	175	358	451	[4] 485	[4] 485
Guatemala	[5] 15	20	16	13	[4] 11	[4] 11
Jamaica	260	524	275	250	252	256
Mexico	678	913	871	857	876	1,210
Nicaragua	----	----	----	----	4	3
Trinidad	[6] 2	5	7	4	4	[4] 4
United States	9,758	10,900	9,825	9,500	9,969	10,388
Total [4]	15,279	18,565	16,474	16,156	16,955	18,313
South America:						
Argentina	171	127	160	198	237	276
Brazil	140	202	114	172	119	[4] 121
Chile	81	87	45	88	[4] 127	116
Colombia	59	77	77	83	91	[4] 91
Peru	69	61	69	70	67	[4] 72
Venezuela	[4] 56	[4] 73	[4] 64	[4] 66	[4] 69	71
Total [4]	576	627	529	677	710	747

See footnotes at end of table.

TABLE 9.—World production of gypsum by countries [1] [2]—Continued

(Thousand short tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
Europe:						
Austria [3]	507	621	730	750	754	644
Bulgaria	(7)	121	132	149	129	[4] 132
Czechoslovakia	222	319	364	390	411	411
France [3]	3,908	4,126	4,163	4,227	4,519	[4] 4,519
Germany:						
East [8]	240	279	276	284	302	303
West (marketable)	[9] 985	1,115	1,153	1,315	1,227	[8] 1,218
Greece	13	89	94	99	[4] 99	[4] 99
Ireland	129	152	200	184	130	[4] 132
Italy	1,010	2,186	2,098	[4] 2,315	3,496	[4] 3,527
Luxembourg	5	7	9	8	9	7
Poland	373	[4] 518	[4] 573	516	605	[4] 606
Portugal	59	60	68	79	80	[4] 80
Spain	1,404	2,357	2,296	2,822	3,287	[4] 3,307
Switzerland	202	[4] 110	[4] 110	[4] 110	[4] 110	[4] 110
U.S.S.R.	[10] 4,041	[4] 7,275	[4] 7,715	[4] 8,000	[4] 8,275	[4] 8,815
United Kingdom [3]	3,497	3,794	4,026	4,179	4,479	4,614
Yugoslavia	97	102	137	107	[4] 110	156
Total [4]	16,800	23,310	24,230	25,620	28,130	28,790
Asia:						
Burma	1	2	1	1	2	[4] 2
China [4]	330	550	650	450	450	550
Cyprus	105	94	106	56	[4] 44	[4] 44
India	865	948	1,099	953	1,239	1,309
Iran [4] [11]	495	440	440	600	600	550
Iraq [4]	635	440	440	(7)	(7)	(7)
Israel [4]	49	66	66	[12] 88	[12] 84	[12] 85
Japan	444	596	810	799	882	863
Jordan	----	----	----	8	10	[4] 10
Mongolia [4]	(13)	10	10	10	10	15
Pakistan	51	109	100	112	167	[4] 165
Philippines	(14)	2	10	9	16	35
Saudi Arabia	----	----	----	----	[4] 12	[4] 12
Syrian Arab Republic [15]	[4] 2	[4] 7	15	9	17	[4] 17
Taiwan	9	11	12	13	18	29
Thailand	3	9	16	13	23	26
Turkey	35	[4] 57	67	[4] 66	154	198
Total [4]	3,024	3,341	3,842	3,627	4,168	4,350
Africa:						
Algeria	97	189	195	[4] 195	[4] 195	[4] 195
Angola	9	15	[4] 14	[4] 14	18	[4] 18
Congo, Republic of the	11	----	----	----	----	----
Kenya	4	15	19	22	29	22
Morocco	24	[4] 28	[4] 28	[4] 28	[4] 28	[4] 28
South Africa, Republic of	199	224	216	191	212	207
Sudan	2	[4] 2	----	6	2	5
Tanganyika	9	8	5	1	2	2
Tunisia	25	13	15	18	18	20
United Arab Republic (Egypt)	335	577	441	510	515	[4] 515
Total [4]	715	1,071	933	985	1,019	1,012
Oceania:						
Australia	529	579	651	683	707	[4] 740
New Caledonia	1	----	----	----	----	----
Total	530	579	651	683	707	[4] 740
World total (estimate) [1] [2]	36,920	47,500	46,660	47,750	51,690	54,000

[1] Gypsum is also produced in Rumania, but production data are not available; an estimate is included in the total. Production in Ecuador and Korea is negligible.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Includes anhydrite.
[4] Estimate.
[5] Average annual production 1957–58.
[6] Average annual production 1956–58.
[7] Data not available; estimate included in total.
[8] Crude production estimates based on calcined figures.
[9] Includes Saar, beginning in 1957.
[10] Gypsum used for construction only, through 1957.
[11] Year ended March 20 of year following that stated.
[12] Year ended March 31 of year following that stated.
[13] Data not available; no estimate included in total.
[14] Less than 500 tons.
[15] Some pure, some 80 percent gypsum and 20 percent limestone.

EUROPE

Poland.—The Dolina Nidy plant at Gacki started production of masonry and high-strength gypsum cements in furnaces purchased from East Germany.

United Kingdom.—The development procedures and production methods at the British Plaster Board (Holdings) Limited Group mine at Brightling, Sussex, were described.[5]

Yugoslavia.—A new plant opened in Belgrade to produce prefabricated gypsum products and dry mortar.

ASIA

India.—Reserves of gypsum in India were estimated to total nearly 1 billion tons.[6] With the expansion of existing fertilizer and cement plants and the setting up of new units, including possible use in sulfuric acid manufacture, gypsum utilization is expected to increase.

Indonesia.—It was reported that gypsum deposits in South Sulawei could produce approximately 300 tons annually if developed.[7]

Pakistan.—Large deposits of high quality gypsum, mainly in the salt ranges of the Sargoha, Rawalpindi, and Peshawar Divisions of West Pakistan were under utilized.[8]

Present demand is between 100,000 and 150,000 tons per year, mined chiefly to supply the chemical fertilizer industry.

Thailand.—Thai Gypsum Company completed a plant which will use 16 tons of gypsum per day to manufacture gypsum board, plaster, calcium sulfate, and chalk.

AFRICA

Tanganyika.—Complicated geological structures were delimited which will make the Kilwa gypsum deposits more difficult to develop than had been anticipated.[9]

OCEANIA

Australia.—Gypsum was blended with iron ore at the Iron Monarch mine to act as a flocculant in the thickener at the dense medium concentrating plant.

TECHNOLOGY

Gypsum and anhydrite deposits of the United States were compiled and indexed on a resource map.[10] Several articles were written on

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[5] Mine and Quarry Engineering. The Brightling Development. V. 29, No. 9, September 1963, pp. 378–389.
[6] Bureau of Mines. Mineral Trade Notes. V. 57, No. 6, December 1963, p. 21.
[7] Mining Journal (London). Survey of Indonesian Gypsum. V. 261, No. 6679, Aug. 23, 1963, p. 173.
[8] Master, J. M. Gypsum Deposits of West Pakistan. In Cento Symposium on Industrial Rocks and Minerals, Lahore, West Pakistan, 1962. Mineral Research and Exploration Institute of Turkey, 1963, pp. 363–370.
[9] Bureau of Mines. Mineral Trade Notes. V. 57, No. 4, October 1963, p. 25.
[10] Withington, C. F. Gypsum and Anhydrite in the United States. Geol. Survey, Min. Invest. Map MR–33, 1962.

equipment usage in mines.[11] Preliminary drying of gypsum was eliminated by crushing wet crude gypsum in a clog-resistant reversible impact crusher.[12]

The Bureau of Mines produced sulfur dioxide by reducing gypsum in a fluidized-bed reactor.[13] The effluent sulfur dioxide gas was rich enough to be converted to sulfuric acid by the contact process. Residues, after further calcination at a higher temperature, were suitable for lime or cement manufacture. A process to achieve similar results was patented.[14]

Raw gypsum or anhydrite was ground and treated with hydrofluosilicic acid, then molded into shapes.[15] Two patents were issued for improved methods of making gypsum board.[16] Calcination time was shortened, in production of low-consistency gypsum plaster, by precoating the gypsum particles in a crystal-habit modifying solution and treating them under rising stream pressure.[17] Gypsum board was surfaced with wood veneer [18] and with aluminum.[19]

Gypsum and potassium chloride were ingredients in an ion exchange process for the manufacture of sulfuric acid and potassium sulfate.[20]

A byproduct of the paper pulp industry containing alkali-treated sulfonated lignin was used to reduce water requirements in gypsum plaster.[21] Lightweight gypsum block was made by mixing plaster of paris, manganese dioxide, a foaming agent, and hydrogen peroxide.[22]

Mechanisms involved in setting of gypsum plasters were reviewed.[23] Setting time of gypsum plaster was retarded by addition of certain hydroxyethylammonium salts.[24]

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[11] Appleyard, F. C. Experience With Diesel Haulage Units Underground. Min. Cong. J., v. 49, No. 12, December 1963, pp. 52–54.
Mining Journal (London). Increased Output at Sandwich Mine: Two Machines Load 10,000 Tons Per Week. V. 260, No. 6651, Feb. 8, 1963, p. 133.
Steel and Coal (London). Loading Equipment at an Anhydrite Mine. V. 186, No. 4939, Mar. 15, 1963, p. 535.
Mine and Quarry Engineering (London). Ore Handling Underground at Long Meg. V. 29, No. 7, July 1963, pp. 282–293.

[12] Mine and Quarry Engineering (London). Reversible Impactor for Gypsum Reduction. V. 30, No. 6, June 1963, p. 246.

[13] Martin, D. A., F. E. Brantley, and D. M. Yergensen. Decomposition of Gypsum in a Fluidized-Bed Reactor. BuMines Rept. of Inv. 6286, 1963, 15 pp.

[14] Boylan, D. R. (assigned to Iowa State College Research Foundation, Ames, Iowa). Reduction Decomposition of Calcium Sulfate. U.S. Pat. 3,087,790, Apr. 30, 1963.

[15] DelMar, R. Building Material and Manufacture Thereof. U.S. Pat. 3,094,426, June 18, 1963.

[16] Loechl, C. J. (assigned to the Celotex Corp., Chicago, Ill.). Drying Gypsum Wallboard. U.S. Pat. 3,088,218, Apr. 7, 1963.
Page, J., and R. E. McCleary (assigned to U.S. Gypsum Co., Chicago, Ill.). Board-Forming Machine. U.S. Pat. 3,083,756, Apr. 12, 1963.

[17] Johnson, E. S. (assigned to U.S. Gypsum Co., Chicago, Ill.). Process for Calcination of Gypsum. U.S. Pat. 3,081,152, Mar. 12, 1963.

[18] Turner, T. M. Wood Veneered Gypsum Board and Panel, Process for Making Same. U.S. Pat. 3,106,500, Oct. 8, 1963.

[19] Shanley, J. H. Process for Bonding Gypsum to Aluminum. U.S. Pat. 3,104,982, Sept. 24, 1963.

[20] Hadzeriga, P. (assigned to Standard Magnesium Corp., Inc., Tulsa, Okla.). Ion Exchange Process for Producing Potassium Sulfate and Sulfuric Acid. U.S. Pat. 3,096,153, July 2, 1963.

[21] King, E. G., and C. Adolphson (assigned to Puget Sound Pulp and Timber Co., Bellingham, Wash.). Gypsum Composition and Method. U.S. Pat. 3,108,002, Oct. 22, 1963.

[22] Beukers, W. Canadian Pat. 671,281, Oct. 1, 1963.

[23] Hansen, W. C. The Setting and Hardening of Gypsum Plasters. Mat. Res. and Standards, v. 3, No. 5, May 1963, pp. 359–363.

[24] Sherr, A. E., and J. Roshal (assigned to American Cyanamid Co., N.Y.). Calcium Sulfate Plasters Containing Stearamidopropyldimethyl-Beta-Hydroxyethylammonium Salts. U.S. Pat. 3,072,494, Jan. 8, 1963.

Studies on hydration of gypsum plaster showed that reaction of water with calcium sulfate hemihydrate was self-accelerating under both isothermal and adiabatic conditions. An order of effectiveness of various salts on acceleration of hydration was given.[25] Rate of hydration decreased with lengthened calcination time and increased with finer grinding when gypsum was calcined at 200° C.[26] Results were attributed to loss of nucleation sites from extended heating and to new sites formed by grinding. The effect of various inhibitors (such as borax, calcium acetate, or egg albumin) or accelerators (such as sodium chloride or sulfate) on hydration temperatures was discussed.[27] The effect of these additives on amounts of water required for proper setting [28] was also discussed.

The effect of the physical properties of component materials on the flexural behavior of fibrous plaster sheets was considered.[29] A simple mathematical equation was included to permit selecting optimum quantity and properties of fiber in the sheet.

The use of gypsum and a carbonaceous reductant to recover iron and copper from copper reverberatory slags was patented.[30]

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[25] Ridge, M. J. and H. Surkevicius. Hydration of Calcium Sulphate Hemihydrate. I. Kinetics. J. Appl. Chem., v. 12, No. 6, June 1962, pp. 246–252; Building Sci. Abs. (London), v. 35, No. 9, September 1962, p. 258.
Ridge, M. J., H. Surkevicius, and K. I. Lardner. Hydration of Calcium Sulphate Hemihydrate. II. Acceleration by Neutral Salts. J. Appl. Chem., v. 12, No. 6, June 1962, pp. 252–256; Building Sci. Abs. (London), v. 35, No. 9, September 1962, p. 258.

[26] Waters, E. H., S. J. Way, and K. W. Lewis. Reasons for the Change of Setting Time of Gypsum Plasters With Change of Thermal and Mechanical History. Australian J. Appl. Sci., v. 13, No. 2, February 1962, pp. 147–163; Building Sci. Abs. (London), v. 35, No. 10, October 1962, pp. 289–290.

[27] Ridge, M. J., and G. R. Boell. Effect of Temperature on the Inhibited and Accelerated Hydration of Calcined Gypsum. J. Appl. Chem., v. 12, No. 6, June 1962, pp. 241–246.

[28] Ridge, M. J., and G. R. Boell. Effects of Some Additives on the Water Requirement of Calcined Gypsum. J. Appl. Chem., v. 12, No. 12, December 1962, pp. 521–526.

[29] Brotchie, J. F., and Gerda Urbach. The Flexural Behavior of Fibrous Plaster Sheets. Australian J. of Appl. Sci., v. 14, No. 1, March 1963, pp. 69–93.

[30] Udy, M. C. (assigned to Strategic-Udy Metallurgical and Chemical Processes Ltd.) Canadian Pat. 653,054, Nov. 27, 1962.

Iodine

By William C. Miller [1]

DOMESTIC production of iodine in 1963 increased for the second consecutive year and crude iodine imports rose for the fourth consecutive year.

Gradual transfer of iodine production from a California to a Michigan plant began. The Atomic Energy Commission stopped routine production of iodine 125 and iodine 131.

Crude iodine prices were increased 8 cents per pound.

DOMESTIC PRODUCTION

Extraction of crude iodine from well brines increased 25 percent in quantity and 31 percent in value compared with that of 1962. Iodine was produced by the Dow Chemical Co., in plants at Seal Beach, Calif., and Midland, Mich.

The Dow Chemical Co. started a program of phasing out iodine production at the Seal Beach, Calif., plant and transferring the operation to the existing brine extraction plant at Midland, Mich. The reasons given by the company were increased extraction and production costs at the Seal Beach plant and a more economic extraction of iodine from the Midland brines resulting from engineering advances. The moving of the facilities will not involve iodine production.

Routine production of iodine 125 and iodine 131 was stopped at the Oak Ridge National Laboratories of the Atomic Energy Commission because these materials are reasonably available from commercial sources.

CONSUMPTION AND USES

A record high of U.S. consumption of iodine and iodine compounds was established. The 1963 consumption increased 8 percent compared with 1962 and 4 percent over the previous high set in 1961.

Most of the crude iodine, which usually contains more than 99 percent iodine, was resublimed to greater purity or converted to organic or inorganic compounds. Potassium iodide was the principal compound produced; however, the percentage of the total crude iodine used in 1963 for this compound was 6 percent less than that used in 1962. This was the second consecutive year that the production of potassium iodide declined. Other inorganic compounds, organic compounds, and resublimed iodine showed increases in production.

[1] Commodity specialist, Division of Minerals.

TABLE 1.—Crude iodine consumed in the United States

Product	1962			1963		
	Number of plants	Crude iodine consumed		Number of plants	Crude iodine consumed	
		Thousand pounds	Percent of total		Thousand pounds	Percent of total
Resublimed iodine	8	106	4	7	150	5
Potassium iodide	11	1,079	43	11	1,018	38
Sodium iodide	5	(1)	(1)	4	(1)	(1)
Other inorganic compounds	24	774	31	21	910	34
Organic compounds	27	538	22	24	617	23
Total	[2] 45	2,497	100	[2] 43	2,695	100

[1] Included with "Other inorganic compounds" to avoid disclosing individual company confidential data.
[2] Nonadditive total because some plants produce more than 1 product.

Iodine and iodine compounds were consumed in numerous and varied uses in medicine, sanitation, agriculture, and industry during 1963. Resublimed iodine was used in the preparation of organic and inorganic compounds. Potassium and sodium iodides were consumed chiefly in medicine, photography, and analytical chemistry. The use of potassium iodide as a swimming pool disinfectant increased during 1963. Iodine was consumed in the production of other inorganic compounds used in the preparation of high-purity metals, disinfectants, nonoxidizing products, stock feed supplements, pharmaceuticals, metallic iodides, and analytical reagents. Organic compounds containing iodine were used as rubber emulsifiers, chemical antioxidates, dyes, pigments, and in organic synthesis and microscopy.

STOCKS

Stocks held by firms that convert crude iodine into resublimed iodine and iodine compounds totaled 1,155,528 pounds on December 31, 1963.

PRICES

Major Japanese importers increased the price of crude iodine to $1.18 per pound. Mitsubishi International initiated the increase because of increased production costs.[2] According to the Oil, Paint and Drug Reporter changes in the prices of crude iodine and potassium iodine occurred in August.

	Per pound	
	Jan.-Aug.	Aug.-Dec.
Crude iodine kegs	$1.10	$1.18
Resublimed iodine, U.S.P., drums, f.o.b. works	2.20-2.22	2.20-2.22
Ammonium iodide, National Formulary (N.F.), 25-pound jars, f.o.b. works	4.51	4.51
Calcium iodide, 25-pound jars, f.o.b. works	4.27	4.27
Potassium iodide, U.S.P., crystals, granular, 500-pounds or more delivered east of Mississippi River	1.15-1.55	----------
Potassium iodide, U.S.P., crystals, drums, 500-pounds or more, delivered east of Mississippi River	----------	1.15
Drums, smaller lots, delivered east of Mississippi River	----------	1.20-1.55
Sodium iodide, U.S.P., 300-pound drums, f.o.b. works	2.13	2.13

[2] Chemical Week. V. 93, No. 4, July 27, 1963, p. 112.

FOREIGN TRADE

Imports.—Imports of crude iodine increased 10 percent in quantity and 4 percent in value compared with that in 1962. Shipments of resublimed iodine in 1963 from Japan totaled 3,000 pounds valued at $3,826, which was a 33 percent decrease in quantity and value compared with shipments in 1962.

TABLE 2.—U.S. imports for consumption of crude iodine, by countries

(Thousand pounds and thousand dollars)

Country	1954-58 (average)		1959		1960		1961		1962		1963	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Chile	1,207	$1,231	1,243	$892	1,420	$1,011	1,964	$1,822	2,229	$2,054	2,462	$2,093
France	(1)	(2)										
Japan	419	534	223	191	474	414	1,053	1,030	797	787	874	865
Total	1,626	1,765	1,466	1,083	1,894	1,425	3,017	2,852	3,026	2,841	3,336	2,958

[1] Less than 1,000 pounds.
[2] Less than $1,000.

Source: Bureau of the Census.

TABLE 3.—U.S. exports of iodine, iodide, and iodates

(Thousand pounds and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1954-58[1] (average)	304	$449	1961	176	$282
1959	175	249	1962	178	296
1960	251	353	1963	141	327

[1] Beginning in 1958 data not strictly comparable with earlier years.

Source: Bureau of the Census.

TABLE 4.—U.S. reexports of iodine, iodide, and iodates

(Thousand pounds and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1954-58[1] (average)	77	$97	1961	85	$94
1959	35	34	1962	64	71
1960	38	37	1963	47	52

[1] Beginning with 1958 data not strictly comparable with earlier years.

Source: Bureau of the Census.

Exports.—Shipments of iodine, iodides, and iodates were made to 35 countries with the major portion going to Canada, United Kingdom, Mexico, West Germany, Philippines, and Colombia. Iodine, iodides, and iodates re-exported to five countries declined 27 percent in quantity and value compared with that of 1962. This was the second consecutive year that the quantity and value declined.

Tariff.—According to the new Tariff Schedules of the United States annotated for classification of imports, the duties of iodine remained unchanged as follows:

TSUS Item:	*Type of iodine*	*Duty*
415.25	Iodine, crude	Free.
415.27	Iodine, resublimed	10¢ per pound.
420.20	Potassium iodide	25¢ per pound.

WORLD REVIEW

Chile.—Crude iodine exports decreased to 4,622,885 pounds in fiscal year 1963 that ended June 30, 1963, compared with 5,230,260 pounds (revised figure) in fiscal year 1962. Of the total exports 55 percent was shippped to the United States, 44 percent to European countries, and 1 percent to other South American countries.

Indonesia.—In 1963, iodine production increased about 39 percent to 9,642 pounds compared with 6,938 pounds (revised) in 1962.

Japan.—Production of iodine in 1963 increased to 3,117,870 pounds compared with 2,469,152 pounds in 1962.

TECHNOLOGY

Doses of 3 to 4 milligrams to adults and 1 to 2 milligrams to children of sodium iodide were discovered to counteract absorption into the human body of radioactive iodine.[3]

Results of treatment for thyroid cancer with radioactive iodine were published.[4] Thirteeen years after surgery and treatment with radioactive iodine, patients are still apparently free of thyroid cancer. Follow-up examinations showed that nearly 50 percent of the patients had no signs of the disease for an average of 5 years.

Smog abatement studies indicated that, in sunshine, the presence of traces of iodine either inhibited or reduced the concentration of ozone.[5] The usual index of smog severity is the quantity of ozone. Iodized atmospheres reduced eye and respiratory irritations. The effectiveness of iodine in suppressing ozone in photochemical smog atmosphere is greater than in purified air.

Studies made to determine the safety aspects of iodine in swimming pools indicated that it is superior to, safer, and more effective than chlorine.[6] One advantage of iodine is that swimmers have less eye discomfort and irritation. Changes in blood iodine and urine were insignificant, and accepted limits of bacteria count were reported.

A compact, portable oxidant recorder that is highly sensitive to iodine vapors, chlorine, and ozone was made available.[7] Oxidant concentrations in the atmosphere or in gas samples can be measured and continuously recorded. Oxidation-reduction of potassium iodide or similar chemicals contained in a sensing solution was used to detect the oxidant concentration.

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[3] Science News Letter. V. 83, No. 5, Feb. 2, 1963, p. 3.
[4] Science News Letter. V. 83, No. 7, Feb. 16, 1963, p. 112.
[5] Science. Atmospheric Iodine Abates Smog. V. 140, No. 3563, Apr. 12, 1963, pp. 190–191.
[6] Science News Letter. Swimming Pools Treated With Iodine Preferred. V. 83, No. 23, June 8, 1963, p. 363.
[7] Chemical Engineering. New Equipment. V. 70, No. 15, July 22, 1963, pp. 182, 184.

A model was used successfully to predict the operation of a continuous system in the oxidation of iodate.[8] Criteria were developed for judging cell performance.

An extraction technique has been developed for the removal of iodine from aqueous solutions of hydriodic acid.[9] During the reaction between the aqueous hydrogen iodide and solutions of long-chain aliphatic amines, any free iodine in the aqueous solution was almost completely extracted into the organic phase.

A study of the reactions of iodine with saturated hydrocarbons at high temperatures found three general reaction classes between 500° and 600° C.[10]

A combined experimental-analytical study of the iodine-iodide transformation was made to obtain information on the kinetics of fast interfacial reactions.[11] The apparatus developed and the procedures used were successful in obtaining the objectives of the study; however, the most important result is that the technique developed is apparently applicable to the study of other reactions.

A method was devised for rapidly dissolving iodine in water by using a magnetic field.[12] The magnetic field has greater strength than the earth's magnetic field and extends perpendicularly through the water.

A combination of iodine with an inert ester was used to make an antibacterial composition for tropical application.[13]

A process was patented for the preparation of iodine pentafluoride by the reaction of carbonyl fluoride with iodine pentoxide.[14]

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[8] Lancaster, E. B., and H. J. Conway. A Practical Model for An Anode Reaction: Oxidation of Iodate. Electrochem. Tech., v. 1, No. 7–8, July–August 1963, pp. 253–256.

[9] Davidson, C. M., and R. F. Jameson. A Convenient Method for the Removal of Iodine From Aqueous Solutions of Hydriodic Acid. Chemistry and Industry (London), No. 42, Oct. 19, 1963, pp. 1686–1687.

[10] Chemical & Engineering News. High-Temperature Reactions Detailed for Saturated Hydrocarbons With Iodine. V. 41, No. 43, Oct. 28, 1963, pp. 44, 46.

[11] Cowherd, Chatten, Jr., and H. E. Hoelscher. The Kinetics of Iodine Dissolution in Potassium Iodide. I&EC Fundamentals, v. 2, No. 4, November 1963, pp. 272–277.

[12] Myers, Thomas E. Method of Dissolving Iodine in Water. U.S. Pat. 3,080,217, Mar. 5, 1963.

[13] Powers, Donald H., and Martin M. Rieger (assigned to Warner-Lambert Pharmaceutical Co., Morris Plains, N.J.). Iodine Preparation and Method of Disinfecting the Skin. U.S. Pat. 3,081,232, Mar. 12, 1963.

[14] Tawcett, Frank S., and Allen L. McClelland (assigned to E. I. du Pont de Nemours Co., Inc., Wilmington, Del.). Preparation of Iodine Pentafluoride. U.S. Pat. 3,097,067, July 9, 1963.

Iron Ore

By Horace T. Reno [1]

THROUGHOUT the free world a buyers' market for iron ore prevailed. There was even a surplus of high-grade ore. Many producers who had been accustomed to a ready European market cut back production, and some held more than 6 months' output in stock. European consumers did not renew purchase contracts for low-grade or high-phosphorous ore, and they made few long-term commitments. Nevertheless, world productive capacity continued to be expanded.

Researchers on both sides of the Atlantic reported progress in their search for the key to beneficiating soft hematite ores economically by roasting and magnetic separation, but none was yet ready to claim success. In three separate studies of the economics of smelting iron ore, the blast furnace was found to be superior to so-called direct reduction except in unusual circumstances. Taconite-type deposits continued to command the interest of geologists, mining engineers, and metallurgists.

TABLE 1.—Salient iron ore statistics

(Thousand long tons and thousand dollars)

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Iron ore (usable; [1] less than 5 percent Mn):						
Production [2]	90,573	60,276	88,784	71,329	71,829	73,599
Shipment [3]	89,751	59,164	82,963	72,379	69,969	73,564
Value [3]	$691,931	$514,067	$724,131	$650,500	$618,242	$678,181
Average value at mines per ton	$7.71	$8.69	$8.73	$8.99	$8.84	$9.22
Imports for consumption	26,174	35,617	34,578	25,805	[4] 33,409	33,263
Value	$212,815	$312,447	$321,919	$250,226	[4] $324,573	$323,158
Exports	4,349	2,967	5,273	4,958	5,898	6,813
Value	$38,605	$33,831	$57,899	$54,230	[4] $62,847	$76,390
Consumption	113,141	93,662	108,050	99,254	99,562	112,535
Stocks Dec. 31:						
At mines [2]	6,127	7,358	12,337	10,335	[4] 11,614	11,268
At consuming plants	48,313	53,038	61,569	58,869	59,553	55,260
At U.S. docks	5,361	7,575	6,839	6,100	6,429	5,347
Manganiferous iron ore (5 to 35 percent Mn):						
Shipments	631	420	588	201	302	485
Value	$4,227	$3,153	$4,466	$1,480	([5])	([5])
World: Production	375,754	432,182	513,952	494,704	499,363	509,908

[1] Direct shipping ore, washed ore, concentrates, agglomerates, and byproduct pyrites cinder and agglomerates.
[2] Includes byproduct ore.
[3] Excludes byproduct ore.
[4] Revised figure.
[5] Figure withheld to avoid disclosing individual company confidential data.

[1] Commodity specialist, Division of Minerals.

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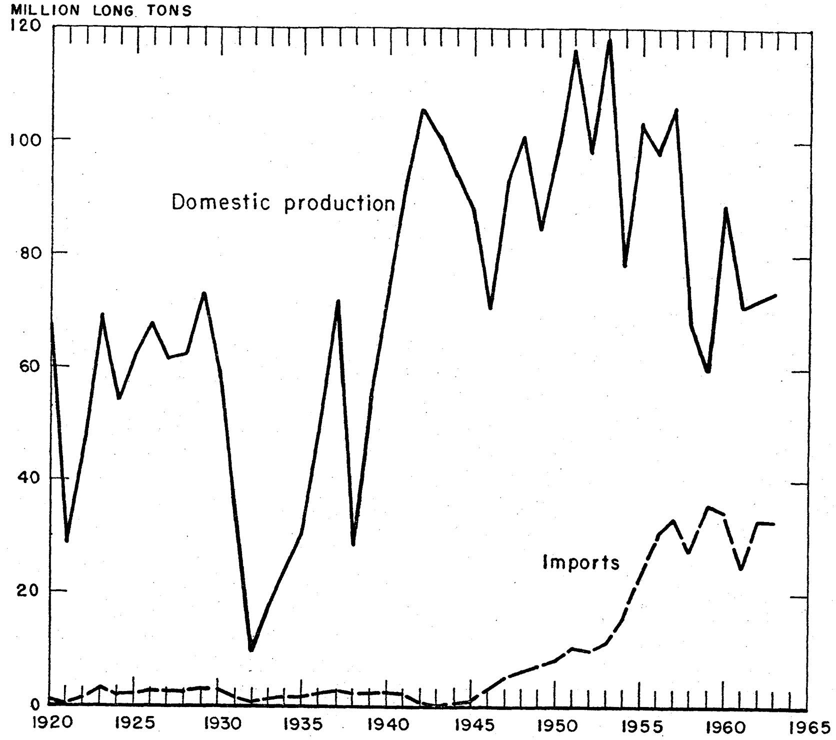

FIGURE 1.—Production of iron ore in the United States and iron ore imports for consumption, 1920–63.

EMPLOYMENT

The average number of men employed in iron ore mines and mills in 1962 and the total man-hours worked were little different from 1961. Indicated productivity measured in terms of contained iron followed the long-term trend and increased 4 percent.

Year to year measure of productivity in the past has not been significant because of the policy of mining companies of keeping men employed year-round, whether they were producing iron ore or not. This policy has not changed, but increasing production from the large low-grade taconite-type deposits has made the productivity measure more meaningful. The indicated productivity increased 13 percent in the Lake Superior district between 1961 and 1962. Undoubtedly this is not a precise figure, but it is valid enough to show that higher grade and better structure have not been the only reasons the taconite industry has competed on even terms with foreign producers since its beginning in 1954.

TABLE 2.—Employment at iron ore mines and beneficiating plants, quantity and tenor of ore produced, and average output per man in 1962, 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: Thousand long tons	Production [1]: Usable ore: Iron contained: Natural (percent)	Production [1]: Average per man: Crude ore: Per shift	Production [1]: Average per man: Crude ore: Per hour	Production [1]: Average per man: Usable ore: Per shift	Production [1]: Average per man: Usable ore: Per hour	Production [1]: Average per man: Usable ore: Iron contained: Per shift	Production [1]: Average per man: Usable ore: Iron contained: Per hour
Lake Superior:															
Michigan	3,795	234	886	8.0	7,098	13,561	9,259	5,160	55.73	15.30	1.91	10.45	1.30	5.82	0.73
Minnesota	9,621	270	2,596	8.0	20,790	97,806	45,356	25,301	55.78	37.68	4.70	17.47	2.18	9.75	1.22
Wisconsin	658	178	117	8.0	934	1,081	1,081	586	54.21	9.24	1.16	9.24	1.16	5.00	.63
Total	14,074	256	3,599	8.0	28,822	112,448	55,696	31,047	55.74	31.24	3.90	15.48	1.93	8.63	1.08
Southeastern States: Alabama and Georgia	1,806	192	347	8.5	2,937	7,357	3,186	948	29.76	21.20	2.50	9.18	1.08	2.73	.32
Northeastern States: New Jersey, New York, Pennsylvania	2,708	246	665	8.2	5,482	11,232	4,584	2,890	63.05	16.89	2.05	6.89	.84	4.35	.53
Western States:															
Arkansas and Missouri	505	242	122	8.1	989	974	407	212	52.10	7.98	.99	3.34	.41	1.74	.21
Idaho and Montana	14	7	1	10.0	10	14	14	7	50.00	14.00	1.40	14.00	1.40	7.00	.70
Nevada, Utah, New Mexico	515	207	107	8.1	865	3,841	3,243	1,737	53.57	3.59	4.44	30.31	3.75	1.62	2.01
South Dakota and Wyoming	551	198	109	8.0	876	1,521	775	387	49.94	13.95	1.74	7.11	.88	3.55	.44
Total [2]	1,585	214	339	8.1	2,740	6,350	4,438	2,343	52.79	18.73	2.32	13.09	1.62	6.91	.86
Undistributed [3]	837	239	200	8.1	1,615	6,535	3,485	1,877	53.86	32.68	4.05	17.43	2.16	9.39	1.16
Grand total [2]	21,010	245	5,150	8.1	41,596	143,921	71,391	39,102	54.77	27.95	3.46	13.86	1.72	7.59	.94

[1] Includes manganese-bearing ore from the Lake Superior district.
[2] In some instances data may not add to totals owing to rounding.
[3] "Undistributed" includes Tennessee, Arizona, California, Colorado, Oregon, and Texas.

DOMESTIC PRODUCTION

Domestic usable iron ore [2] production was slightly above the 1962 level, but the ore produced in 1963 contained 6 percent more iron. Crude ore production was 7 percent more than in 1962 and 18 percent more than the previous 5-year average.

This year marked the first decade of U.S. dependence on imports for part of its iron ore. During that 10 years (1954–63), the domestic industry shifted from high-grade to low-grade ore, shut down most of its underground mines, converted from simplex to complex beneficiation, and added agglomeration to its processing plants. The result has been evolution to a stronger industry that apparently can compete on even terms with essentially all foreign producers.

Domestic mines produced 690 million tons of crude iron ore in the last half of the last decade and only 668 million tons in the first half. In 1954, the average grade of usable ore was 51 percent iron, and the crude to usable ore ratio was 1.4:1. In 1963, the average grade was 56 percent iron, and the crude to usable ore ratio was 2.1:1. There was dislocation and consequent unemployment in the iron ore industry, but on the whole the domestic industry held its own, as operations geared to the new era were developed.

Following the pattern of the last 10 years, and despite the worldwide buyers' market for iron ore that existed in 1963, the U.S. iron ore industry planned and built new processing plants and expanded old plants. Eveleth Taconite Co. was organized by the Ford Motor Co. and Oglebay Norton Co. to start engineering studies for a taconite-processing plant on the Mesabi Range. Oliver Iron Mining Division of United States Steel Corp. announced that it was planning a 4-million-ton plant in Minnesota, to be built if residents approved a "taconite" amendment to the State constitution. Reserve Mining Co. essentially completed expansion of its E. W. Davis plant at Silver Bay, Minn. Cleveland-Cliffs Iron Co. completed its 1.2-million-ton-per-year plant at the Empire mine in the Upper Peninsula of Michigan. The Hanna Mining Co. completed expansion of its Groveland mill to a 1.5-million-ton-per-year capacity and construction of the adjacent 1.25-million-ton-per-year agglomerating plant. Cleveland-Cliffs Iron Co. and McLouth Steel Corp. announced plans to build a 1.2-million-ton-per-year agglomerating plant to pelletize iron ore from the Mather underground mine. Colorado Fuel and Iron Corp. announced that it would build a 600,000-ton-per-year concentrating plant at its Sunrise, Wyo., mine.

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[2] Definition of terms:

Usable ore is the product of mine or beneficiating plant and is measured in the form shipped to the consumer. Thus, it includes direct-shipping ore, concentrate, and agglomerate.

Direct-shipping ore is sufficiently high in quality for shipment directly to the consumer as mined. The grade may vary according to the consumer's specifications.

Crude ore includes direct-shipping and all other ore mined, prior to any treatment for removing waste constituents or otherwise improving the product.

Beneficiation is any treatment to improve the chemical composition or physical structure of iron ore. Concentration and agglomeration are included in the more general term "beneficiation."

Concentration is the treatment of ore to remove waste constituents. The treatment includes any of numerous procedures ranging from simple washing or gravity separations to complex operations involving crushing, grinding, flotation, magnetic separation, or other mineral-dressing techniques. Although concentrate (and direct-shipping ore) may subsequently be agglomerated, the term as used here refers only to concentrate shipped to consumers in the unagglomerated form.

Agglomeration is the binding or compaction of fine-sized ore particles into compact masses by any means including sintering, pelletizing, nodulizing, and briquetting.

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	1962					1963				
	Number of mines	Hematite	Brown ore	Magnetite	Total	Number of mines	Hematite	Brown ore	Magnetite	Total
Lake Superior:										
Michigan	24	13,513		48	13,561	20	16,518			16,518
Minnesota	69	51,454	681	45,052	97,187	71	49,283	970	50,131	100,384
Wisconsin	2	1,081			1,081	2	413			413
Total	95	66,049	681	45,100	111,829	93	66,213	970	50,131	117,314
Southeastern States:										
Alabama	[1] 24	(2)	6,525		6,525	[1] 24	1,285	4,248		5,533
Georgia	10		832		832	8		1,015		1,015
Total	34		7,357		7,357	32	1,285	5,262		6,547
Northeastern States:										
New Jersey, New York, Pennsylvania	8			11,232	11,232	8			11,344	11,344
Western States:										
Arkansas	1		51		51	(3)		(3)		(3)
Idaho	3	(2)		5	5	3	6		(2)	6
Missouri	11	(2)	923		923	8	956	(2)		956
Montana	2			9	9	2			13	13
Nevada	13	(2)		741	741	7	(2)		951	951
New Mexico	2			42	42	(3)			(3)	(3)
South Dakota	2	25			25					
Utah	6	3,058		(2)	3,058	6	1,782		(2)	1,782
Wyoming	4	(2)		1,496	1,496	4	(2)		4,096	4,096
Total	44	3,083	974	2,293	6,350	30	2,744		5,060	7,805
Undistributed [3]	19	3,933	2,401	201	6,535	16	6,131	3,569	66	9,766
Grand total [4]	200	73,064	11,413	58,825	143,303	179	76,373	9,801	66,601	152,776

[1] Excludes a number of small pits. Output of these pits included in total.
[2] Included with other varieties in the same State.
[3] Included in "Undistributed" to avoid disclosing individual company confidential data. Totals for 1962 include Tennessee, Arizona, California, Colorado, Oregon, and Texas; total for 1963 include Tennessee, Arizona, Arkansas, California, Colorado, New Mexico, and Texas.
[4] In some instances data do not add to totals because of rounding.

The Bennett and Longyear mines in Minnesota and the Lawrence mine in Michigan were closed in 1963.

Crude Ore.—Direct-shipping ore comprised only 10 percent of the crude ore shipped in 1963. Half of that produced was hematite ore, 43 percent was magnetite ore, and the remaining 7 percent was brown ore. Underground mines produced 13 percent of the total.

Usable Ore.—Usable ore produced contained an average of 56 percent iron; 21 percent was direct-shipping ore, 36 percent was agglomerate, and 43 percent was concentrate. The Lake Superior district produced 76 percent of the usable ore, 82 percent of the direct-shipping ore, 80 percent of the iron ore agglomerates, and 74 percent of the iron ore concentrate. Of the total iron ore agglomerates produced at mines, 23.1 million long tons was pellet, 2.7 million tons was sinter, and 459,000 tons was nodule.

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)

State	1962			1963		
	Open pit	Underground	Total [1]	Open pit	Underground	Total [1]
Lake Superior:						
Michigan	6,859	6,702	13,561	10,604	5,914	16,518
Minnesota	95,576	1,611	97,187	99,094	1,289	100,384
Wisconsin		1,081	1,081		413	413
Total	102,435	9,394	111,829	109,698	7,616	117,314
Southeastern States:						
Alabama	6,525	(2)	6,525	(3)	5,533	5,533
Georgia	832		832	1,015		1,015
Total	7,357		7,357	1,015	5,533	6,547
Northeastern States:						
New Jersey, New York, Pennsylvania		11,232	11,232	11,344	(2)	11,344
Western States:						
Arkansas	51		51	(4)		(4)
Idaho	5		5	6		6
Missouri	923	(2)	923	(3)	956	956
Montana	9		9	13		13
Nevada	741	(2)	741	(3)	951	951
New Mexico	42		42	(4)		(4)
South Dakota	25		25			
Utah	3,058		3,058	1,782		1,782
Wyoming	1,496	(2)	1,496	4,096	(2)	4,096
Total	6,350		6,350	5,897	1,907	7,805
Undistributed [4]	6,535		6,535	9,766		9,766
Grand total [1]	122,676	20,626	143,303	137,720	15,056	152,776

[1] In some instances data does not add to total because of rounding.
[2] Included with "open pit".
[3] Included with "underground".
[4] Included with "Undistributed" to avoid disclosing individual company confidential data. Totals for 1962 include Tennessee, Arizona, California, Colorado, Oregon, and Texas; totals for 1963 include Tennessee, Arizona, Arkansas, California, Colorado, New Mexico, and Texas.

TABLE 5.—Crude iron ore shipped from mines in the United States, by districts, States, and disposition

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1962			1963		
	Direct to consumers	To beneficiation plants	Total [1]	Direct to consumers	To beneficiation plants	Total [1]
Lake Superior:						
Michigan	5,557	7,956	13,513	4,852	11,842	16,694
Minnesota	11,466	85,729	97,195	7,468	93,082	100,550
Wisconsin	1,045	-----	1,045	938	-----	938
Total	18,067	93,685	111,753	13,258	104,925	118,183
Southeastern States:						
Alabama	(2)	6,528	6,528	(2)	5,533	5,533
Georgia	-----	832	832	-----	1,015	1,015
North Carolina	1	-----	1	1	-----	1
Total	1	7,360	7,361	1	6,548	6,549
Northeastern States:						
New Jersey, New York, Pennsylvania	-----	11,124	11,124	-----	11,543	11,543
Western States:						
Arkansas	43	-----	43	-----	(3)	(3)
Idaho	5	-----	5	6	-----	6
Missouri	-----	923	923	-----	934	934
Montana	9	-----	9	13	-----	13
Nevada	742	(4)	742	443	508	951
New Mexico	(2)	28	28	(3)	(3)	(3)
South Dakota	34	-----	34	-----	-----	-----
Utah	2,727	(4)	2,727	2,046	(4)	2,046
Wyoming	-----	1,450	1,450	(2)	4,096	4,096
Total	3,559	2,400	5,960	2,508	5,538	8,046
Undistributed [3]	485	6,002	6,487	67	9,745	9,811
Grand total	22,113	120,571	142,684	15,834	138,297	154,131

[1] In some instances data do not add to totals because of rounding.
[2] Included with ore shipped to beneficiation plants.
[3] Included with "Undistributed" to avoid disclosing individual company confidential data. Totals for 1962 include Tennessee, Arizona, California, Colorado, Oregon, Texas; 1963, Tennessee, California, Colorado.
[4] Included with ore shipped direct to consumers.

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	1962				1963			
	Hematite	Brown ore	Magnetite	Total [1]	Hematite	Brown ore	Magnetite	Total [1]
Lake Superior:								
Michigan	9,259	-------	-------	9,259	10,336	-------	-------	10,336
Minnesota	30,119	362	14,735	45,216	28,845	(2)	16,538	45,383
Wisconsin	1,081	-------	-------	1,081	413	-------	-------	413
Total	40,459	362	14,735	55,556	39,593	-------	16,538	56,132
Southeastern States:								
Alabama	(2)	2,978	-------	2,978	1,103	1,062	-------	2,165
Georgia	-------	208	-------	208	-------	254	-------	254
Total	-------	3,186	-------	3,186	1,103	1,316	-------	2,419
Northeastern States:								
New Jersey, New York, Pennsylvania	-------	-------	4,584	4,584	-------	-------	4,922	4,922
Western States:								
Arkansas	-------	51	-------	51	-------	(3)	-------	(3)
Idaho	(2)	-------	5	5	6	-------	(2)	6
Missouri	356	(2)	-------	356	369	(2)	-------	369
Montana	-------	-------	9	9	-------	-------	13	13
Nevada	(2)	-------	617	617	(2)	-------	722	722
New Mexico	-------	-------	11	11	-------	-------	(3)	(3)
South Dakota	25	-------	-------	25	-------	-------	-------	-------
Utah	2,614	-------	(2)	2,614	1,767	-------	(2)	1,767
Wyoming	(2)	-------	750	750	(2)	-------	1,604	1,604
Total	2,995	51	1,392	4,438	2,141	-------	2,390	4,531
Undistributed [3]	3,409	(2)	77	3,485	3,672	1,125	41	4,838
Total all States	46,863	3,599	20,788	71,250	46,509	2,443	23,891	72,841
Byproduct ore [4]	-------	-------	-------	579	-------	-------	-------	757
Grand total	46,863	3,599	20,788	71,829	46,509	2,443	23,891	73,599

[1] In some instances data do not add to totals because of rounding.
[2] Included with other varieties in the same State.
[3] Included with "Undistributed" to avoid disclosing individual company confidential data. Totals for 1962 include Arizona, California, Colorado, Oregon, and Texas; totals for 1963 include Tennessee, Arizona, Arkansas, California, Colorado, New Mexico, and Texas.
[4] Cinder and sinter obtained from treating pyrities. Ore was treated in Arizona, Colorado, Tennessee, Pennsylvania, 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	1962				1963			
	Direct shipping ore	Agglomerates [1]	Concentrates	Iron content (natural percent) [2]	Direct-shipping ore	Agglomerates [1]	Concentrates	Iron content (natural percent) [2]
Lake Superior:								
Michigan	5,064	2,427	1,768	55.73	4,574	4,414	1,348	57.21
Minnesota	11,385	14,840	18,991	55.83	7,336	16,619	21,428	56.36
Wisconsin	1,081	---	---	54.21	413	---	---	55.73
Total	17,531	17,267	20,759	55.78	12,323	21,032	22,777	56.51
Southeastern States:								
Alabama	(3)	(3)	2,978	28.52	327	1,838	---	36.54
Georgia	---	---	208	47.60	---	254	---	46.64
Total	---	---	3,186	29.76	327	2,092	---	36.79
Northeastern States: New Jersey, New York, Pennsylvania	---	3,392	1,192	63.05	---	3,798	1,125	63.13
Western States:								
Arkansas	51	---	---	48.53	---	---	(4)	(4)
Idaho	5	---	---	60.95	6	---	---	49.45
Missouri	---	---	356	52.62	---	---	369	52.63
Montana	9	---	---	45.00	13	---	---	42.38
Nevada	617	---	(3)	61.42	772	---	(3)	62.30
New Mexico	(3)	---	11	63.64	(4)	---	(4)	(4)
South Dakota	25	---	---	42.00	---	---	---	---
Utah	2,614	---	(3)	51.68	1,767	---	(3)	52.57
Wyoming	750	(3)	(3)	50.18	(3)	1,604	(3)	55.43
Total	4,072	---	367	52.79	2,558	1,604	369	55.21
Undistributed [4]	530	---	2,955	53.86	11	(3)	4,827	55.12
Total all States	22,132	20,659	28,459	54.80	15,218	26,434	31,189	56.13
Byproduct ore [5]	---	579	---	69.79	---	757	---	67.86
Grand total	22,132	21,238	28,459	54.93	15,218	27,192	31,189	56.25

[1] Exclusive of agglomerates produced at consuming plants.
[2] Average iron content of all types shipped. For breakdown by type see table 6.
[3] Included with other types in the same State.
[4] Included with "Undistributed" to avoid disclosing individual company confidential data. Totals for 1962 include Tennessee, Arizona, California, Colorado, Oregon, and Texas; totals for 1963 include Tennessee, Arizona, Arkansas, California, Colorado, New Mexico, and Texas.
[5] Cinder and sinter obtained from treating pyrites.

TABLE 8.—Shipments of usable iron ore from mines in the United States in 1963

(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[1]
	Direct-shipping ore	Agglomerates	Concentrates	Total quantity[1]	Direct-shipping ore	Agglomerates	Concentrates	Total quantity[1]	
Lake Superior:									
Michigan	4,852	4,364	1,574	10,789	2,716	13,087	12,316	31,955	$107,201
Minnesota	7,468	16,857	21,110	45,435	3,835				408,486
Wisconsin	938	----------	----------	938	510	----------	----------	510	(2)
Total	13,258	21,220	22,684	57,163	7,061	13,087	12,316	32,465	515,688
Southeastern States:									
Alabama	328	----------	1,798	2,126	(3)	----------	769	769	11,806
Georgia	----------	----------	260	260	----------	----------	120	120	1,304
North Carolina	1	----------	----------	1	----------	----------	----------	----------	10
Total	328	----------	2,058	2,386	----------	----------	889	889	13,119
Northeastern States: New Jersey, New York, Pennsylvania	----------	3,798	778	7,475	----------	2,432	478	2,909	67,293
Western States:									
Idaho	6	----------	----------	6	3	----------	----------	3	40
Missouri	----------	----------	345	345	----------	----------	177	177	3,085
Montana	13	----------	----------	13	6	----------	----------	6	89
Nevada	772	----------	(3)	772	478	----------	(3)	478	3,921
Utah	1,881	----------	(3)	1,881	960	----------	(3)	960	12,900
Wyoming	(3)	1,604	(3)	1,604	(3)	889	(3)	889	17,504
Total	2,672	1,604	345	4,622	1,446	889	177	2,512	37,539
Undistributed[2]	129	(3)	4,690	4,820	70	(3)	2,678	2,748	44,542
Total all States	16,388	26,622	30,555	73,564	8,577	16,408	16,539	41,524	678,181
Byproduct ore[4]	----------	823	----------	823	----------	559	----------	559	10,503
Grand total	16,388	27,445	30,555	74,387	8,577	16,967	16,539	42,083	688,684

[1] In some instances data do not add to totals because of rounding.
[2] "Undistribute " includes totals for Tennessee, Virginia, Arizona, Arkansas, California, Colorado, New Mexico, Oregon, and Texas and value for Wisconsin.
[3] Included with other types in the same State.
[4] " and sinter obtained from treating pyrites. Ore was treated in Deleware, Colorado, Pennsylvania, Virgina, Arizona, and Tennessee.

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	Vermillion	Mesabi	Cuyuna	Total [1]
1854–1958	299,966	260,991	305,739	[2] 93,566	2,202,245	62,602	3,225,110
1959	2,851	2,677	2,546	(4)	34,556	[3] 1,321	43,950
1960	6,619	4,079	3,653	[3] 1,834	54,442	1,166	71,792
1961	3,205	4,097	2,190	[3] 1,421	41,199	1,095	53,207
1962	4,563	3,460	2,318	[3] 1,521	43,041	655	55,556
1963	5,706	3,729	1,314	[3] 1,298	43,570	515	56,132
Total	322,910	279,033	317,760	99,640	2,419,053	67,354	3,505,747

[1] In some instances data do not add to totals due to rounding of figures.
[2] Production for 1957 included with Mesabi range.
[3] Includes production from Spring Valley district not in the true Lake Superior district.
[4] Included with Mesabi range to avoid disclosing individual company confidential data.

TABLE 10.—Average analyses of total tonnages (bill-of-lading weights) of all grades of iron ore from all ranges of Lake Superior district

Year	Thousand long tons	Content (natural), percent					
		Iron	Phosphorus	Silica	Manganese	Moisture	Alumina [1]
1954–58 (average)	71,381	51.63	0.092	9.69	0.66	10.10	----------
1959	44,403	53.81	.085	8.93	.61	8.29	----------
1960	67,439	53.84	.083	8.90	.63	8.26	----------
1961	55,403	55.20	.080	8.60	.56	7.19	1.21
1962	55,010	55.60	.077	8.45	.51	7.04	1.24
1963	57,591	56.34	.074	8.19	.52	6.30	1.10

[1] Alumina analyses not available prior to 1961.

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)
1954–58 (average)	35,239	89,751	39.3
1959	30,363	59,164	51.3
1960	46,012	82,963	55.5
1961	46,125	72,379	63.7
1962	46,942	69,969	67.1
1963	57,277	73,564	77.86

[1] Excludes byproduct ore.

CONSUMPTION AND USES

The format for reporting iron ore consumption was changed again this year, so that as in 1962 the tables in this chapter are not strictly comparable with those of preceding years. The change was made to present consumption data in the terms used at the mines—iron ore, iron ore concentrates, and iron ore agglomerates.

Inasmuch as iron ore concentrate used to make agglomerate at the mines is simply material in the process of being beneficiated from crude to usable ore, such use is not reported as iron ore consumption. On the other hand, iron ore fines and iron ore concentrate used to make agglomerate (principally sinter) at steel mills has been beneficiated from crude to usable ore. Accordingly material used for this purpose is reported as iron ore consumption. This method of reporting will lead to a valid balance between consumption and iron ore production plus imports less exports, considering processing losses and ore lost in transit.

Iron ore consumed in making agglomerate at steel mills included 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 from iron ore consumption.

Consumption data listed in the miscellaneous category included iron ore used in making cement and special high-density concrete and for paint pigments and heavy medium in coal processing plants.

TABLE 12.—Consumption of iron ore and agglomerates in the United States in 1963

(Long tons and exclusive of ore containing 5 percent or more manganese)

	Iron ore [1]		Agglomerates [2]		Miscellaneous [3]	Total
	Blast furnaces	Steel furnaces	Blast furnaces	Steel furnaces		
Alabama, Kentucky, Tennessee, Texas	5,179,355	305,142	4,003,575	(4)	96,026	9,584,098
California, Colorado, Utah	3,489,013	439,010	2,711,656		55,868	6,695,547
Maryland and West Virginia	3,784,526	599,744	6,011,538		(4)	10,395,808
Illinois and Indiana	12,345,820	1,685,638	9,713,025	(4)	[5] 57,042	23,801,525
Michigan and Minnesota	6,218,206	172,269	3,370,600			9,761,075
New York, Ohio, Pennsylvania, New Jersey	29,922,367	3,465,304	18,532,413	(4)	215,469	52,135,553
Undistributed [4]				63,495	97,723	161,218
Total	60,939,287	6,667,107	44,342,807	63,495	522,128	112,534,824

[1] Includes 18.3 million 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, and ore consumed in ferroalloy furnaces.
[4] Included in "undistributed" to avoid disclosing individual company confidential data.
[5] Included with Illinois and Indiana.

TABLE 13.—Iron ore [1] consumed in agglomerating plants and agglomerate produced in 1963, by States

(Long tons)

State	Iron ore [1] consumed	Agglomerate produced
Alabama, Kentucky, Tennessee, Texas	2,824,068	3,667,457
California, Colorado, Utah, Wyoming	2,339,423	2,770,340
Maryland and West Virginia	5,462,808	5,758,252
Illinois and Indiana	8,210,412	9,798,804
Michigan and Minnesota	2,825,094	3,348,137
New York, Ohio, Pennsylvania	14,188,611	15,343,792
Total	35,850,416	40,686,782

[1] Does not include material used in agglomerates produced at mine site.

TABLE 14.—Production of agglomerates[1] in the United States in 1963, by types

(Long tons)

Type	Agglomerate produced
Sinter [2]	43,336,082
Pellets	23,089,811
Nodules	516,880
Other	(3)
Total	66,942,773

[1] Production at mines and consuming plants.
[2] Includes 13,783,000 tons of self-fluxing sinter.
[3] Included with "Nodules."

STOCKS

Iron ore stocks at mines, U.S. docks, and consuming plants totaled 71.8 million long tons on December 31, 1963, 7 percent less than at the same time in 1962. Stocks at mines totaled 11.3 million long tons and at U.S. docks 5.3 million tons, according to the American Iron Ore Association. Stocks at consuming plants totaled 55.3 million long tons, 44.8 million tons of domestic and foreign ore, 10 million tons of domestic and foreign iron ore agglomerate, and 489,000 tons of manganiferous ore.

TABLE 15.—Stocks of usable iron ore at mines,[1] Dec. 31, by States

(Thousand long tons)

State	1962	1963
Michigan, Minnesota, Wisconsin	[2] 8,795	7,764
Alabama and North Carolina	58	97
New Jersey, New York, Pennsylvania	[2] 1,864	2,216
Arizona, California, New Mexico, Utah, Washington	[2] 808	599
Arkansas, Colorado, Idaho, Missouri, Texas, Wyoming	[2] 89	229
Total	[2] 11,614	[3] 10,904

[1] Excluding byproduct ore.
[2] Revised figures.
[3] Data do not add to totals shown because of rounding.

PRICES

Quoted base prices for Lake Superior iron ore containing 51.5 percent iron, natural, rail of vessel at lower lake ports per long ton were unchanged in 1963. Mesabi non-Bessemer was $10.65, Mesabi Bessemer $10.80, Old Range non-Bessemer $10.90, and Old Range Bessemer $11.05. Lake Superior pellets were quoted at $0.252 per long ton unit. E&MJ Metal and Mineral Markets quoted open-hearth lump iron ore at $12.70 per long ton, Brazilian ore (68.5 percent iron) at $11.25, spot sales at $11.50, and small sellers at $11 to $11.25.

The average value of domestic-usable ore per long ton f.o.b. mines, excluding byproduct ore, was $9.22, compared with $8.84 in 1962 and $8.99 in 1961. These values were compiled from producers' statements and approximate the commercial selling price less the cost of mine-to-market transportation.

TABLE 16.—Average value of iron ore shipped from mines in the United States in 1963

(Per long ton)

District	Direct-shipping ore			Iron ore concentrates			Iron ore agglomerates
	Hematite	Brown ore	Magnetite	Hematite	Brown ore	Magnetite	
Lake Superior	$7.26			$7.63	(1)		$11.97
Southeastern	6.02		$13.45		$5.41		
Northeastern						$14.24	14.80
Western	6.22	(2)	6.80	7.13	10.92	5.63	11.98
Total	7.11		6.80	7.57	6.84	11.27	12.37

[1] Included with hematite.
[2] Included with magnetite.

TRANSPORTATION

Economy, competition, and the threat of more competition marked iron ore transportation in 1963. Larger ships were planned and built, and Great Lake carriers reduced freight charges 10 cents per ton. The case for rail transportation of iron ore was presented at the University of Minnesota Mining Symposium held at Duluth in January.[3] Proposals for year-round lake transportation and for transporting iron ore in a slurry by pipeline were made at the same meeting.[4]

The Wilson Marine Transit Co. expected to cut labor costs about one-third by converting the Great Lakes ore freighter *Horace S. Wilkinson* to a barge. San Juan Carriers, Ltd., which transports iron ore from Peru to Japan and other countries, added the 70,000-ton ore-oil carriers *San Juan Prospector* and *San Juan Pathfinder* to its fleet. These ships and the *San Juan Pioneer* owned by the same company were the largest combination ore-oil carriers in service.

Japanese steel companies agreed to build three 58,000-ton bulk carriers to haul Kaiser Steel Co. iron ore pellets from southern California ports. These ships apparently were to be designed to specifications similar to those of the *Long Beach Maru,* which sailed December 22, 1963, on its maiden voyage from Long Beach, Calif., with 53,000 tons of Kaiser Steel iron ore destined for Wakayam, Japan. The *Long Beach Maru* was built by the Mitsubishi Shipbuilding Co. It has a loaded draft of 38 feet and a service speed of 16.6 knots, which will enable it to make 12 round trips per year between the United States and Japan.[5]

[3] Heineman, B. W. The Case for Rail Transportation of Iron Ore. Proc. 24th Ann. Min. Symp., Univ. of Minnesota, Minneapolis, Minn., Jan. 14–16, 1963, pp. 113–115.
[4] Costantini, R. A Case Study in Pipeline Transportation of Solids: The Challenge and the Promise With Beneficiated Iron Ore. Proc. 24th Ann. Min. Symp., Univ. of Minnesota, Minneapolis, Minn., Jan. 14–16, 1963, pp. 121–123.
Thiele, E. H. Year-Round Lakes Transportation. Proc. 24th Ann. Min. Symp., Univ. of Minnesota, Minneapolis, Minn., Jan 14–16, 1963, pp. 117–120.
[5] Skillings' Mining Review. M. V. Long Beach Maru. V. 53, No. 1, Jan. 4, 1964, p. 17.

On the east coast of the United States, the Delaware River was deepened to 40 feet as far as the Fairless Works. Baltimore, Md., maritime interests withdrew their opposition to parity freight rates on iron ore with the port of Philadelphia. A study of the relation of the Philadelphia iron and steel district to the St. Lawrence Seaways indicated that foreign ores could be delivered to Youngstown, Ohio, competitively through either the Philadelphia district or the St. Lawrence Seaway.[6]

The St. Lawrence Seaway maximum permissible draft was increased from 25 feet to 25 feet 6 inches. A record 12.8 million tons of iron ore was moved through the Seaway in 1963; 8.4 million tons was moved up and 4.4 million tons down through the Welland Canal section, and 8.2 million tons was moved through the Montreal-Lake Ontario section.

The Great Lakes shipping season opened April 19, when the *Edward L. Ryerson* loaded at the C. & N.W. dock at Escanaba, and closed December 16, when the *John J. Boland* loaded at the same dock.[7]

Freight Rates—Lake vessel freight rates from upper Lake Superior ports to the lower lake ports were reduced April 24, 1963, from $2.00 to $1.90 per long ton, excluding handling charges. Rates from the Minnesota Ranges to the Pittsburgh district totaled $6.60 per long ton. Component charges were $1.28 rail from the Ranges to Duluth-Superior, $0.19 handling charge, $1.90 Duluth-Superior to lower lake ports, $0.28 hold to rail of vessel, $0.22 rail of vessel to car, and $2.73 rail lower lake ports to the Pittsburgh district. All rail rates from the Minnesota Ranges to the Pittsburgh district were $10.23 per long ton. The freight rate from the Eastern seaboard to the Pittsburgh district was $3.76 per long ton plus $0.55 per ton unloading charges, vessel to car.

FOREIGN TRADE

U.S. iron ore trade with Canada and Liberia was substantially greater than in 1962. Its trade with South American countries decreased sufficiently to offset this; the total imported was about the same. Exports to Canada and Japan were about 1 million tons more than in 1962. The change in trade pattern was caused partly by newly producing concerns offering quality ore at competitive prices and capturing part of the U.S. market. The pattern also was influenced by a high level of activity in the steel industries of Japan, the United Kingdom, and the European Coal and Steel Community countries and by commercial ties between producing companies and U.S. consumers.

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[6] Sharer, C. J. The Philadelphia Iron and Steel District: Its Relation to the Seaways. Econ. Geog., v. 39, No. 4, October 1963, pp. 363–367.
[7] Skillings, D. N., Jr. Lake Superior Region Iron Ore Shipments in 1963. Skillings, Min. Rev., v. 53, No. 1, Jan. 4, 1964, pp. 4–5.

TABLE 17.—U.S. imports for consumption of iron ore,[1] by countries

(Thousand long tons and thousand dollars)

Country	1954–58 (average)		1959		1960		1961		1962		1963	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
North America:												
Canada	9,633	$82,891	13,458	$128,940	10,595	$104,709	9,683	$99,164	[2] 16,825	[2] $169,765	18,891	$199,416
Mexico	181	584	106	356	150	513	123	421	145	546	1	5
Other	148	1,734	54	592	3	30						
Total	9,962	85,209	13,618	129,888	10,748	105,252	9,806	99,585	[2] 16,970	[2] 170,311	18,892	199,421
South America:												
Brazil	1,018	13,186	1,200	13,613	1,461	15,518	889	9,613	[2] 1,299	[2] 14,080	781	7,731
Chile	2,052	14,115	3,590	27,815	3,942	30,684	2,604	21,913	3,400	[2] 28,907	2,679	25,332
Peru	1,876	16,667	2,236	21,358	2,758	26,828	1,209	11,752	[2] 573	[2] 6,196	290	2,406
Surinam			2	23								
Venezuela	9,219	63,845	13,542	104,347	14,555	133,138	10,478	99,118	[2] 10,328	[2] 96,981	9,231	76,937
Total	14,165	107,813	20,570	167,156	22,716	206,168	15,180	142,396	[2] 15,600	[2] 146,164	12,981	112,406
Europe:												
Sweden	911	9,941	136	1,737	94	1,543	78	1,156	32	566	37	742
United Kingdom	1	43	19	195	(3)	29	2	147				
Other	(3)	5	16	168	1	20	1	10	1	24	(3)	13
Total	912	9,989	171	2,100	95	1,592	81	1,313	33	590	37	755
Asia:												
Iran	2	127	3	187	2	133						
Philippines	15	302	71	1,491	1	22			49	1,018	22	367
Other					57	367	(3)	1	(3)	12	(3)	1
Total	17	429	74	1,678	60	522	(3)	1	49	1,030	22	368
Africa:												
British West Africa	154	972	62	481	46	315						
Liberia	952	8,269	1,105	10,981	907	8,034	715	6,728	757	6,478	1,310	9,944
Other	12	134	17	163	6	36	23	203			21	264
Total	1,118	9,375	1,184	11,625	959	8,385	738	6,931	757	6,478	1,331	10,208
Grand total	26,174	212,815	35,617	312,447	34,578	321,919	25,805	250,226	[2] 33,409	[2] 324,573	33,263	323,158

[1] In addition pyrites cinder (byproduct iron ore) was imported as follows: 1954–58 (average), 1,899 long tons ($7,353) all from Canada; 1959, Canada 6,741 tons ($22,988), Italy 3,416 tons ($24,812); 1960, 5,884 tons ($19,679); 1961, 3,504 tons ($17,822) all from Canada; 1962, 4,248 tons ($26,345) all from Canada; 1963, Canada 3,489 tons ($46,057), West Germany 22 tons ($2,294).

[2] Revised figure.

[3] Less than 1,000 tons.

Source: Bureau of the Census.

TABLE 18.—U.S. imports for consumption of iron ore, by customs districts

Customs district	1962 Long tons	1962 Value	1963 Long tons	1963 Value
Buffalo	1,349,464	$17,486,445	1,602,438	$19,376,294
Chicago	[1] 1,881,119	[1] 18,516,411	3,016,544	31,384,520
Connecticut	1,302	18,228		
Dakota			66	2,946
Duluth and Superior	201	1,983	200	1,258
Galveston	377,503	[1] 3,537,257	396,657	4,805,849
Laredo	144,770	545,828	1,021	4,831
Maryland	[1] 9,574,671	[1] 88,299,526	8,835,105	76,617,494
Michigan	[1] 1,711,279	[1] 17,824,420	1,419,761	17,174,788
Mobile	[1] 1,466,378	[1] 13,491,760	2,672,041	21,874,484
New Orleans	811,700	7,819,271	525,686	4,157,437
New York	68	275	241	1,635
Ohio	[1] 4,611,238	[1] 43,097,661	5,339,799	55,524,801
Philadelphia	[1] 11,127,495	[1] 110,626,307	9,059,750	88,512,535
St. Lawrence	390	38,385	9,649	162,353
San Francisco	1,555	14,617		
Vermont			84	7,894
Virginia	349,482	3,250,975	383,470	3,545,364
Washington			325	2,884
Wisconsin	270	3,625	55	262
Total	[1] 33,408,885	[1] 324,572,974	33,262,892	323,157,629

[1] Revised figure.

Source: Bureau of the Census.

TABLE 19.—U.S. exports of iron ore, by countries

(Thousand long tons and thousand dollars)

Destination	1954–58 Average Quantity	1954–58 Average Value	1959 Quantity	1959 Value	1960 Quantity	1960 Value	1961 Quantity	1961 Value	1962 Quantity	1962 Value	1963 Quantity	1963 Value
Canada	3,722	$32,318	2,453	$28,189	4,428	$48,989	3,889	$42,269	4,781	$51,377	4,987	$58,054
Germany, West	(1)	(2)			(1)	(2)	172	1,993	64	[3] 340	72	423
Japan	625	6,166	507	5,247	839	8,622	883	9,655	981	10,213	1,682	17,087
South Africa, Republic of	2	90	3	127	4	174	4	179	5	164	3	155
United Kingdom							6	70	64	714	65	605
Other	(4)	31	4	268	2	114	4	64	3	39	4	66
Total	4,349	38,605	2,967	33,831	5,273	57,899	4,958	54,230	5,898	[3] 62,847	6,813	76,390

[1] Less than 1,000 tons.
[2] Less than $1,000.
[3] Revised figure.
[4] Includes countries receiving less than 1,000 each.

Source: Bureau of the Census.

WORLD REVIEW [8]

A large surplus capacity to produce iron ore existed throughout the world, and buyers were interested in only the highest grade, best structure ore or iron ore agglomerate. The potential market for these high grades continued to exceed the supply. Consequently, there existed the seeming enigma of great expansion plans in an oversaturated environment in most iron-ore-producing areas.

[8] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

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TABLE 20.—World production of iron ore, iron ore concentrates, and iron ore agglomerates by countries [1]

(Thousand long tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	14,998	21,865	19,242	18,178	24,428	26,906
Cuba	97	[2] 3	[2] 3	[2] 2	[2] 1	[2] 1
Dominican Republic	115	12	121	15	---	138
Guatemala	3	[2] 4	[2] 4	[2] 5	[2] 5	[2] 6
Mexico (60% Fe equivalent)	781	878	855	1,127	1,790	2,291
United States [3]	90,573	60,276	88,784	71,329	71,829	73,599
Total	106,567	83,038	109,009	90,656	98,053	102,941
South America:						
Argentina	69	108	157	137	119	128
Brazil	4,073	8,766	9,197	10,059	10,608	[14] 8,137
Chile	2,530	4,576	5,946	6,879	7,964	8,373
Colombia	390	399	645	665	669	684
Peru	2,710	3,519	6,880	8,599	5,855	6,064
Venezuela	10,973	16,929	19,182	14,335	13,057	11,676
Total	20,745	34,297	42,007	40,674	38,272	35,062
Europe:						
Albania	[4] 64	173	251	352	[2] 420	[2] 295
Austria	3,095	3,329	3,486	3,635	3,692	3,675
Belgium	117	140	157	113	80	93
Bulgaria	203	367	405	411	618	645
Czechoslovakia	2,525	2,921	3,071	3,242	3,422	3,354
Finland [5]	187	224	269	276	292	360
France	51,986	59,976	65,907	65,554	65,254	56,971
Germany:						
East	1,550	1,574	1,616	1,617	1,616	1,624
West	16,132	17,778	18,571	18,568	16,380	12,694
Greece	257	154	292	287	[2] 295	[2] 195
Hungary	361	432	508	595	671	719
Italy	1,384	1,217	1,242	1,216	1,133	990
Luxembourg	6,922	6,406	6,867	7,340	6,404	6,880
Norway	1,404	1,558	1,665	1,647	1,919	1,935
Poland	1,706	1,982	2,148	2,348	2,398	2,568
Portugal	208	238	297	230	229	221
Rumania	653	1,047	1,437	1,710	1,711	2,250
Spain	4,219	4,536	5,549	5,967	5,670	5,200
Sweden	17,689	18,061	21,348	23,220	21,675	23,258
Switzerland	109	[2] 60	[2] 125	[2] 85	[2] 100	95
U.S.S.R. [6] [7]	76,256	92,531	104,186	115,776	126,079	134,640
United Kingdom	15,899	14,870	17,088	16,518	15,277	14,912
Yugoslavia	1,595	2,062	2,165	2,150	2,155	2,261
Total [6]	204,521	231,636	258,650	272,857	277,490	275,835
Asia:						
Burma	4	4	16	[2] 16	9	---
China [2] [8]	13,400	44,300	54,100	34,400	29,500	34,400
Goa	2,366	3,025	5,764	6,381	5,354	[2] 4,920
Hong Kong	105	120	115	117	111	112
India	5,001	7,856	10,514	12,076	13,151	14,690
Iran [9]	35	59	57	41	10	---
Japan [10]	1,847	2,508	2,809	2,826	2,546	2,360
Korea:						
North	945	2,660	3,059	3,494	3,287	3,799
Republic of	112	278	386	497	464	493
Lebanon	39	3	8	---	---	---
Malaya	2,178	3,761	5,641	6,734	6,508	7,264
Pakistan [11]	[12] 13	2	6	4	---	---
Philippines	1,328	1,211	1,121	1,153	1,365	1,339
Taiwan [13]	[12] 6	9	8	13	6	5
Thailand	8	6	11	55	44	16
Turkey	866	859	778	746	800	735
Total [2] [6]	28,300	66,700	84,400	68,600	63,200	70,100
Africa:						
Algeria	2,811	1,897	3,384	2,822	2,029	1,945
Angola	[12] 134	343	649	799	740	628
Guinea, Republic of	707	337	764	533	689	[14] 364
Liberia	1,883	2,647	3,003	3,200	3,550	[14] 6,453
Mauritania	---	---	---	295	984	1,279
Morocco	1,552	1,245	1,552	1,439	1,131	1,019

See footnotes at end of table.

TABLE 20.—World production of iron ore, iron ore concentrates and iron ore agglomerates by countries[1]—Continued
(Thousand long tons)

Country	1954-58 (average)	1959	1960	1961	1962	1963
Africa—Continued						
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	107	128	156	382	609	645
Sierra Leone	1,198	1,426	1,447	1,668	1,983	[14] 1,954
South Africa, Republic of	2,018	2,845	3,023	3,898	4,263	4,390
Sudan	------	------	3	5	20	------
Tunisia	1,093	966	1,017	836	749	832
United Arab Republic (Egypt)	[12] 185	242	237	415	454	481
Total	11,688	12,076	15,235	16,292	17,201	19,990
Oceania:						
Australia	3,748	4,141	4,355	5,342	4,843	5,685
Fiji	[4] 2	12	24	10	6	1
New Caledonia	[12] 183	282	272	273	298	294
Total	3,933	4,435	4,651	5,625	5,147	5,980
World total (estimate)[1]	375,754	432,182	513,952	494,704	499,363	509,908

[1] This table incorporates some revisions. Data do not add to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Includes byproduct ore.
[4] Average annual production 1957-58.
[5] Iron concentrates and pellets.
[6] U.S.S.R. in Asia included with U.S.S.R. in Europe.
[7] Data represents iron concentrates of approximately 60 percent iron.
[8] Roughly equivalent of 50 percent iron.
[9] Year ending March 20 of year following that stated.
[10] Includes iron sand production as follows: 1954-58 (average), 788,732; 1959, 1,335,655; 1960, 1,539,346; 1961, 1,685,137; 1962, 1,419,744; and 1963, 1,247,629.
[11] Obtained principally during exploration activities.
[12] Average annual production 1956-58.
[13] Principally magnetite sands with limonite.
[14] Exports.

NORTH AMERICA

Canada.—The Canadian iron ore industry continued to expand at the rapid rate of the last decade, in which more than one-half billion dollars has been invested for capital improvements, and production has increased fourfold. Announcement of the extent of recently found iron resources, however, was the most spectacular development in the Canadian iron ore industry in 1963. Crest Exploration Ltd., a subsidiary of Standard Oil of California, described a multibillion-ton deposit on the boundary between Yukon and Northwest Territories. British Ungava Exploration Ltd. described four large high-grade deposits on Baffin Island in the Northwest Territories in an iron-bearing region possibly surpassing that of the Quebec-Labrador Trough.

Canadian pelletizing capacity was increased from 1.5 million tons annually at the end of 1962 to 7.6 million tons at the end of 1963. Completion of plants under construction in 1963 will bring the capacity to 8.2 million tons by the end of 1964 and 15.7 million tons by the end of 1965.

British Columbia.—Zeballos Iron Mines Ltd. suspended operations in February at its Ford iron deposits on the northwest coast of Vancouver Island because the stripping ratio proved too high. The company was reorganized and at the end of the year was planning to convert to underground mining. Texada Mines Ltd. converted to underground mining while maintaining production from its Yellow

TABLE 21 —World trade of iron ore, iron-ore concentrates, and iron-ore agglomerates in 1962

(Thousand long tons)

Exports by countries of origin	Fe (percent)[1]	Production	Exports	Exports by countries of destination																	
				North America		South America	Europe													Asia	
				Canada	United States	Argentina	Austria	Belgium-Luxembourg	Czechoslovakia	France	Germany, East	Germany, West	Hungary	Italy	Netherlands	Poland	Rumania	United Kingdom	Other Europe	Japan	Other countries
North America:																					
Canada	55	24,428	21,646		16,944			262		23		[2] 919		89	195			1,669		1,545	
Mexico	60	1,790	145		145																
United States	50	[3] 71,829	5,897	4,780								64		2	1			64	(4)	981	5
South America:																					
Brazil	67	10,608	7,529	244	1,222	212		123	541	184		2,850		632	85	293	174	405	115	449	
Chile	60	7,964	7,184	69	3,446	125						291		194						2,836	223
Colombia	45	669																			
Peru	60	5,855	5,068		[2] 573	309				[2] 184		[2] 881		236				[2] 388		2,406	91
Venezuela	64	13,057	13,100		10,213							1,052		658				1,177			
Europe:																					
Austria	30	3,692	(4)									(4)						(4)			
Belgium-Luxembourg	30	6,484	232							232											(4)
Bulgaria	41	618	28										18				10				
Finland	30	292	172						41							131					
France	35	65,254	25,278					16,008				8,927						321			22
Germany, West	32	16,380	278				268	2		3				(4)	3			(4)	2		(4)
Greece	46	[1] 295	244				145					94			5						
Italy	47	1,133	(4)																		(4)
Norway	60	1,919	1,248				32	4				797			6	111		297			1
Poland	35	2,398	576												25				551		
Portugal	50	229	98					28				2						65	3		
Spain	50	5,670	1,874				50	46	30	140		896	26	52	39	26		554			15
Sweden	60	21,675	19,090		29		50	4,196	223	489		7,828	22	392	748	538		4,180	381		14
Switzerland	40	[1] 100	74							(4)		74									
U.S.S.R	60	[5] 126,079	18,636				311		5,894		2,481		1,968			6,330	1,364				288
United Kingdom	30	15,277	(6)																		
Yugoslavia	45	2,155	100										100								
Other East Europe		7,840	(6)																		

Asia:																					
China	50	[1] 29,500	[1] 98													[1] 98					
Goa	55	5,354	5,195				10		166	21		1,089		977	74			15	28	2,815	
Hong Kong	56	111	115																	115	
India	61	13,151	3,390				22	10	771		33	26	31	113		198	330	(4)	176	1,669	11
Japan	55	2,546	(4)																		(4)
Korea, Republic of	50	464	358																	357	1
Malaya	55	6,508	6,441																	6,392	49
Philippines	55	1,365	1,314																	1,314	
Thailand	55	44	27																	27	
Turkey	60	800	169					3	40			19		94					13		
Other Asia		3,312	(6)																		
Africa:																					
Algeria	55	2,029	2,098					21		105		189		462				1,300			21
Angola	65	740	439							25		358		22						20	14
Guinea, Republic of	53	689	659						118		19					492	10		20		
Liberia	66	3,550	2,844		495					42		[2] 1,049		441	31	10		746	30		
Morocco	60	1,131	1,130				(4)	(4)	149	219		165			48			270	279		
Rhodesia and Nyasaland, Federation of	58	609	119				4													115	
Sierra Leone	65	1,983	1,983				28			43		708		(4)	626			578			
South Africa, Republic of	60	4,263	732				60	8		35		26		1	19					583	(4)
Tunisia	50	749	702						30	99		27		170		39		337			
Other Africa		1,458																			
Oceania:																					
Australia	63	4,843																			
Fiji	55	6	7																	7	
New Caledonia	55	298	290																		290
Other countries		170	(7)																		
Total		499,363	156,607	5,093	33,067	646	980	20,711	8,003	1,844	2,533	28,331	2,165	4,535	1,905	8,266	1,888	12,366	1,598	21,631	1,045

[1] Estimate.
[2] From import detail of customs returns of the respective country.
[3] Includes byproduct ore.
[4] Less than 500 tons.
[5] U.S.S.R. in Asia included with U.S.S.R. in Europe.
[6] Data not available.
[7] Incomplete data.

Kid open-pit mine. Long-term sales contracts to the Japanese steel industry provided the incentive for both companies to develop underground mines.

Newfoundland-Quebec.—Iron ore developments in the Quebec-Labrador Trough area proceeded on schedule as the Iron Ore Company of Canada began producing pellets at its Carol Lake plant and the Wabush mine plant completed its second full year under construction. Apparently this area is destined for another large iron ore development project; Japanese iron ore consumers negotiated with Canadian Javelin Ltd. for delivery of 7 million tons of high-grade concentrate annually.[9]

The Quebec and Newfoundland Governments, Wabush Iron Co., Ltd., and British Newfoundland Corp., Ltd., reached agreement whereby a $50 million plant to pelletize Wabush iron ore will be built in Quebec at Pointe Noire near Sept Iles.

Dominion Steel and Coal Corp., Ltd., shutdown its Wabana mine from mid-June to mid-September because markets for the ore slackened in Europe. This shutdown probably reflected a trend away from Wabana's high-phosphorus ore caused by Europe's increasing use of basic oxygen steelmaking processes.

Ontario.—Caland Ore Co., Ltd., announced that it plans to build a $15 million iron ore processing and pelletizing plant at Steep Rock Lake near Atikoken, Ontario. The new plant will have capacity to process 2.5 million tons of ore per year to yield coarse-sized ore, and 1 million tons of pellets. It will be the first plant to pelletize raw ore in its natural state, without prior concentration.

Lowphos Ore Ltd. started up a 600,000-ton-per-year pelletizing plant at its Moose Mountain mine 30 miles north of Sudbury. The company provided facilities to store 300,000 tons of pellets at Depot Harbor, the shipping point on Lake Huron for Moose Mountain ore, thus enabling the pelletizing plant to work steadily year-round.

Mexico.—A Presidential decree creating exceptions to the prohibition against exporting iron ore mined in Baja California was published August 17, 1963, in Diario Oficial. The decree established an export quota not to exceed 10 million tons within 11 years from its effective date, and limited export license to those who hold concessions to exploit Baja California mineral deposits and who make the necessary investment in plant and loading equipment within 24 months.[10]

If iron ore deposits that might make a steel complex in Baja California economic are found within the 11-year period, the Secretary of Industry and Commerce, after consultation with the Secretary of National Patrimony, is authorized to prohibit exports entirely or to enlarge the export quota.

The Sheffield Division of Armco Steel Corp. announced that effective December 28, 1963, it would discontinue importing iron ore from Mexico for its works at Houston, Tex.[11]

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[9] Bureau of Mines. Mineral Trade Notes. V. 57, No. 4, October 1963, p. 26.
[10] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, pp. 19–20.
[11] Blast Furnace & Steel Plant. Armco To Discontinue Usage of Mexican Iron Ore. V. 51, No. 1, January 1963, p. 68.

SOUTH AMERICA

Bolivia.—Officials of the Bolivian Government discussed the possibility of exploiting iron deposits at Mutun with Argentinian representatives of Mercedes-Benz.[12] The Mutun deposits are in the Department of Santa Cruz, Province of Chequitos, 27 kilometers south of Puerto Suárez, near the Brazilian border. Their existence has been known since 1826, and they have been studied by 15 special commissions, including 2 of the United Nations. At times they have been described as the largest iron deposits in the world. According to information presented at the Third Latin American Iron Congress in Caracas, Venezuela, however, the deposits contain 3 billion tons to a depth of 100 meters, if judged with the Urucum deposits in Brazil.

Brazil.—Companhia Vale do Rio Doce started construction of new port facilities at Ponta de Tubarão, 13 kilometers from Vitória.[13] Ponta de Tubarão facilities were being built to accommodate 100,000 ton, 17-meter-draft ships. The port also was being equipped to unload 1,200 tons of coal per hour.

Central do Brasil Railroad freight rate increases of 30 percent resulted in closing 42 of 54 independent iron-mining operations in the Paraopeba Valley of the "Iron Quadrilateral" in Minas Gerais.

Chile.—Channels at the ports of Chanaral and Caldera were deepened to 13 meters to accommodate iron ore carriers such as the 51,000-ton Japanese ship *Homei Maru*.[14] Chilean iron-ore production leveled off after the fifth consecutive year of increase, with only slightly more ore being produced in 1963 than in 1962.

Peru.—An agglomerating plant built by Marcona Mining Co. at San Nicolas, Peru, as an adjunct to its concentrating plant, began producing iron ore pellets in June.[15] Pellets produced contain 68 to 69 percent iron. The new plant has capacity to produce 1 million tons annually.

Venezuela.—The Ministry of Development created an Advisory Committee for the Metallurgical Industry consisting of The Director of Industries or his designate and representatives from the Venezuelan Development Corporation, the Central Office of Coordination and Planning, the Venezuelan Corporation of the Guayana area, the Orinoco Steel Mill, and the Association of Metallurgical Industries.

EUROPE

European Coal and Steel Community.—Iron ore production of the six-nation ECSC was 13 percent less than in 1962. West Germany's production dropped 23 percent reflecting less total consumption and more use of high-grade imported ore. France's production was 13 percent less than in 1962, owing principally to a strike at the Lorraine mines. The strike in the French mines enabled Luxembourg to increase its output 7 percent, to 7 million tons.

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[12] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, p. 17.
[13] Bureau of Mines. Mineral Trade Notes. V. 57, No. 6, December 1963, pp. 21–22.
[14] Mining Engineering. V. 15, No. 9, September 1963, p. 26.
[15] Bureau of Mines. Mineral Trade Notes. V. 57, No. 4, October 1963, p. 27.

Productivity in the Community iron ore mines has steadily increased, but the resulting cost saving falls far short of offsetting the grade advantage of foreign ores. Therefore, Community iron-ore output should continue to decline unless economic techniques are found to upgrade the ores. Lorraine district ores so far have proved the exception because of their proximity to steel mills.

Germany, West.—The steel industry of West Germany received its first shipment of ore from Mauritania. The industry was changing from domestic mines for its iron because the Krupp-Renn plants treating Salzgitter ore were shut down early in the year.

Sweden.—Swedish iron ore prices were reduced 7 percent, critically affecting the small independent producers. The State-owned Luossavaara-Kiirunavaara (LKAB) set a new production record of 13 million tons. Contract prices for 1964 delivery to West Germany were 2 percent below 1963 prices. Nevertheless, LKAB planned construction of a 750,000-ton-per-year iron ore concentrating plant and a 1.5-million-ton-per-year pelletizing plant at Kiruna. The new facilities were to be completed in 1965.

A commission formed by the Swedish Ministry of Trade to study ways of developing further the northern provinces that contain most of Sweden's iron resources advocated intensifying prospecting in the area and a comprehensive survey of the iron deposits. The work would be done by the State Geological Survey.[16] Although the commission recommended limiting prospecting rights granted to private concerns, it recognized that exceptions should be made to at least guarantee the rights of private companies presently engaged in mining. These exceptions would be made to prevent splitting of ore reserves into uneconomic units.

U.S.S.R.—Iron ore resources of the U.S.S.R. were reported to be 46,220 million tons averaging 40 percent iron, a late review reported 41,000 million tons averaging 38.7 percent.[17] The difference was caused by interpretation and refinement. To these totals can be added mineral finds in 1963, of 1,000 million tons of 50 percent iron in the Peshemsk and Boguchansk regions of Siberia, and of more than 300 million tons equal in quality to the best Ural ores in northern Tajikistan. Soviet 7- and 20-year plans were to deplete iron ore reserves at the rate of 210 million tons annually by 1965 and of 800 to 900 million tons annually by 1980. These production rates are in terms of crude ore and are not incompatible with the size and grade of known resources. They are compatible with the existing trend toward concentration.

Yugoslavia.—The Yugoslavian Government arranged to increase its iron ore supply from domestic mines and from imports. Work was started on expansion, modernization, and mechanization of the Ljubija mine in the Sava and Una River basins. Two shafts were planned at Tomasica and Redka in the same area. The Damjan mine near Skopje was reactivated to produce magnetite concentrate. These mines together were expected to produce 3 million tons of high-grade ore per year by 1964. Reportedly, this quantity would

[16] Mining Journal (London). Sweden's Iron Ore Industry Looks Ahead. V. 260, No. 6660, Apr. 12, 1963, pp. 337–339.

[17] Kowalewski, Jan. Russia's Iron Ore Reserves. Min. J. (London), v. 261, No. 6684, Sept. 27, 1963, pp. 279–282.

Mine and Quarry Engineering. Iron Ore in the U.S.S.R. V. 29, No. 8, August 1963, pp. 353–357.

meet the needs of the Yugoslavian steel industry for several years. Nevertheless, an agreement was signed with the Minerals and Metals Trading Corp. of India to purchase 300,000 tons of iron ore in 1964.

The director-general of the Port of Rijeka, Yugoslavia, signed an agreement with the president of Cia Vale do Rio Doce, Brazil, permitting Brazilian iron ore shipments through the Rijeka to central Europe. This arrangement could also facilitate Yugoslavian use of Brazilian ore.

ASIA

Burma.—Accessible iron ore deposits of 63 million tons were reported in the Shan States of Burma by a German survey group.[18] Exploratory work delineated about 3 million tons of material which could be mined in an open pit and upgraded to 60 percent iron by simple washing.

Ceylon.—The first significant discovery of iron ore in Ceylon was made in the Chilaw district less than 10 miles northeast of Chilaw.[19] The ore was magnetite averaging 65 to 70 percent iron with some sulfide minerals and a small quantity of phosphorus. It occurred in a band of varying thickness 30 to 40 feet wide, and 70 to more than 400 feet underground. Approximately 4 million tons was delineated by drilling half the deposit. The total deposit may contain more than 10 million tons.

China.—Reliable iron ore production data for China were not available. Judging from the rather sketchy economy reports, production was less than in 1960, the last year for which official figures were released.

Goa.—Minimum prices, depending on grade and shipping conditions, ranging from $4.85 to $5.70 per ton were established for which iron ore could be sold to other countries.[20] If 50 percent or more of the ore under one contract was shipped in vessels owned by seven specified companies, the total of the contract could be sold for $0.25 per ton less than if only 20 to 30 percent were shipped in these vessels.

Hong Kong.—Production capacity of the Ma On Shan iron mine in Hong Kong was expected to be more than doubled by a 10- by 10-foot, mile-long tunnel completed in 1963.[21]

India.—The Indian Government announced that with Japanese technical and financial help it would develop iron mines in the Tanka-Dadarai-Nayagor area and construct an ore dock at Paradip in Orissa. The first stage of development was to cost $63 million and provide capacity for exporting 2 million tons of iron ore annually. The dock was to have three berths for carriers of 40,000- to 60,000-ton capacity. Subsequent improvements in the second stage were to provide capacity to export 5 to 10 million tons per year.

India's State Trading Corp., which holds a monopoly in iron ore exports, reduced prices on high-grade ore to Japan from $11.90 to $10.78 per ton and on medium-grade ore from $11.34 to $10.36 per ton in 1963, and agreed to a further decrease of $0.14 per ton in each

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[18] Metal Industry (London). Exploiting Burma's Iron Ores May Provide Steel Industry. V. 103, No. 19, Nov. 7, 1963, p. 690.
[19] Bureau of Mines. Mineral Trade Notes. V. 57, No. 4, October 1963, pp. 26–27.
[20] Bureau of Mines. Mineral Trade Notes. V. 56, No. 6, June 1963, pp. 20–21.
[21] Bureau of Mines. Mineral Trade Notes. V. 58, No. 2, February 1964, p. 16.

category in 1964. In protest against this reduction, Indian mine owners in some areas stopped loading ore for the corporation and suggested that the Government reorient export contracts to the private sector. Under the suggested change the corporation would be paid a margin of $0.14 sales commission.[22]

Japan.—Japanese steel companies contracted for 20,000 tons of iron ore from Hainan Island. This was the first iron ore imported into Japan from China since 1949.[23] Yawata Iron and Steel Co., Ltd., contracted to use the R–N direct reduction process for treating iron-bearing concentrate from beach sands, prior to smelting it in an electric furnace.

AFRICA

Algeria.—The limited world market for iron ore continued to affect Algerian iron mines; sales were irregular and relatively small. Failure to find export outlets forced the Mokta Co. to abandon its concession at the Beni Saf mines and the Société Anonyme des Mines de Zaccar to abandon its concession at the Zaccar mine. The Algerian Government took over both properties and entered a trade agreement with Bulgaria providing iron ore shipments from Beni Saf and to a lesser extent from the Zaccar and Rouina mines. The quantity involved was not specified publicly, but is believed to have been 250,000 tons. The new steelworks at Bone, which was scheduled earlier to begin operations in 1963, making Algerian iron-ore mining less dependent on the world market, was not expected to operate until the end of 1964. Thus, the outlook for iron ore mines in Algeria was not encouraging.

Angola.—Angola's iron ore mining industry was changed little in 1963, although it was reported that expansion of loading and transportation facilities was continued throughout the year.[24]

Gabon, Republic of.—Bureau de Recherche Géographique et Minière (BRGM) was engaged in a 3-year aerial-magnetic survey of the northern half of Gabon and the lower part of the Cameroon. The survey was financed jointly by BRGM and the European Coal and Steel Community. Northern Gabon is of interest principally because of the proposed railroad to Mékambo, where an iron-ore reserve of 946 million tons averaging 64 percent was reported in 1962.[25] The Government of Gabon, the United Nations Special Fund, and the World Bank agreed to conduct a survey of iron ore transport in Gabon.[26] The survey was to determine the technologic and economic feasibility of constructing a railroad from the Makokou-Mékambo iron-ore deposits to a suitable seaport near Libreville and to determine the impact of the proposed railroad on the economy of the country. The railroad would pass through the heart of Gabon and thus open the country for other possible development.

Liberia.—Liberian American Swedish Minerals Co. (LAMCO) made its first shipment of ore by railroad from its Nimba mine to the new port under construction at Lower Buchanan on May 3, 1963.[27]

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[22] Mining Journal (London). Indian Mine Owners Demand Higher Price. V. 261, No. 6680, Aug. 30, 1963, p. 195.
[23] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, p. 18.
[24] Bureau of Mines. Mineral Trade Notes. V. 58, No. 2, February 1964, p. 15.
[25] Bureau of Mines. Mineral Trade Notes. V. 57, No. 1, July 1963, p. 24.
[26] Steel & Coal (London). Iron-Ore Transport Survey in Gabon. V. 187, No. 4955, July 5, 1963, p. 27.
[27] Bureau of Mines. Mineral Trade Notes. V. 57, No. 3, September 1963, pp. 29–30.

The first commercial iron ore shipment through Lower Buchanan was made July 18, 1963, when 20,000 tons was loaded on MS *Virihaure* for Rotterdam, Holland. The cargo was discharged in Rotterdam for transshipment to the German Ruhr on July 29. LAMCO's operation was officially inaugurated by President William V. S. Tubman on November 15.

Construction of the railroad from the free port of Monrovia to the Bong Range iron ore project continued through 1963. A tracklaying contract was let, with completion scheduled by April 1964. The Bong Range deposits were being developed by the German Liberian Mining Co. First production was scheduled for 1966 at which time the West German steel industry will become Liberia's best iron ore customer.

Mauritania.—Société Anonyme des Mines de Fer de Mauritania (MIFERMA) mining facilities near Fort Gouraud and an iron ore dock near the Port of Etienne were officially dedicated June 15 and 16, 1963, in the presence of the President of Mauritania and European guests. The first ore shipment through the new facilities was 16,000 tons to the Thyssen-Hutte works in West Germany.

OCEANIA

Australia.—Western Australia's iron ore reserve was officially estimated at 8 billion tons, 12 times the known economic reserve in 1960.[28] Most of this ore was in the Pilbara district in deposits containing 48 to 68 percent iron discovered within the last 2 years as a result of collaboration between the State and Commonwealth Governments and Australian and foreign mining companies. The tremendous increase in known Australian ore reserve and the competition existing in the world iron ore market influenced the Government to relax iron ore export controls. Under new regulations, total export of ore in any deposit containing not more than 5 million tons was allowed at an unrestricted rate. Larger deposits were to be considered on their individual merits and ore from them became eligible for export in its entirety at an annual rate of 4 million tons.

The Commonwealth Government approved export of 64 million tons of iron ore from a deposit in the Mount Goldsworthy area of Western Australia. Mount Goldsworthy Mining Associates, was a joint enterprise of Consolidated Gold Fields (Australia) Pty., Ltd., of Sydney, Cyprus Mines Corp. of Los Angeles, and Utah Construction and Mining Co. of San Francisco.

The Western Australian Government agreed to give Hamersley Holdings Pty., Ltd., prospecting rights over 2,600 square miles with subsequent leasing rights up to a maximum of 300 square miles. In return Hamersley Holdings agreed to expend $175 million over 30 years in developing the area. At least $90 million of this amount was to be expended for an integrated steel industry and at least $67 million was to be expended on facilities for exporting iron ore. Hamersley Holdings was 60 percent owned by Conzinc Rio Tinto of Australia Ltd. and 40 percent owned by Kaiser Steel Corp. The foregoing undertakings were based principally on anticipation of supplying iron ore to the Japanese steel industry.

[28] Engineering and Mining Journal. V. 164, No. 1, January 1963, p. 133.

Western Mining Corp., Ltd. however, working with Hanna and Homestake mining companies, received the first major contract to ship Australian iron ore to Japan. After more than a year of negotiations the corporation obtained an agreement to supply 5.1 million tons of 60 percent iron ore to Japanese steel mills at a price of $12.60 per ton. Shipments were to begin in 1966; delivery was to be spread over 8 years.[29]

TECHNOLOGY

Science and technology continued to lead the industrial revolution in the iron ore industry. Geologists investigated low-grade taconite-type deposits in Western States. Mining engineers improved practice in operating mines through research on drilling, blasting, and system analysis. Ore dressing and beneficiation engineers reported significant refinement in taconite concentrating and agglomerating plants.

Papers presented at the Twenty-Fourth Annual Mining Symposium sponsored jointly by the Minnesota Section of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) and the University of Minnesota effectively measured the progress in taconite mining and processing and reported technological investigations. Cold weather taconite mining and milling and a study in pipeline transportation of solids as applied to iron ore concentrates were outstanding among the papers not covered in the following discussion.

Taconite deposits near Atlantic City, Wyo., being exploited by the Columbia Geneva Steel Division, United States Steel Corp., were mapped and described by the Geological Survey.[30] The iron formation at Atlantic City typifies the classic taconite; that is, dense, hard, banded, metamorphosed, iron-bearing, siliceous Precambrian rock. It contains about 30 percent iron, principally in magnetite, very little phosphorous, and no sulfur.

Bureau of Mines engineers in reconnoitering the iron resources of New Mexico and Arizona found evidence of similar taconite formations. Their work in New Mexico was described in the Bureau's Information Circular series.[31] A report on the work in Arizona was prepared for publication in this series but was not issued in 1963.

Engineers at the Erie Mining Company taconite mine at Hoyt Lakes, Minn., described improved drilling and blasting practice which allowed them to change dippers on the loading shovels from 5 cubic yards to 8 cubic yards.[32]

Experiments with large-diameter blastholes and drill patterns, use of slurry-type blasting agent, and delayed ignition to maximum relief of burden in the direction of bedding resulted in improved fragmentation while controlling fly rock at the Moose Mountain mine of Lowphos Ores, Ltd., north of Sudbury, Ontario, Canada.[33]

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[29] Mining Journal (London). West Australian Iron Contract. V. 261, No. 6697, Dec. 27, 1963, p. 617.
[30] Bayley, Richard W. A Preliminary Report on the Precambrian Iron Deposits Near Atlantic City, Wyo. Geol. Survey Bull. 1142-C, 1963, 23 pp.
[31] Harrer, C. M., and F. J. Kelly. Reconnaissance of Iron Resources in New Mexico. BuMines Inf. Circ. 8190, 1963, 112 pp.
[32] Thomte, Walter L. Mining Methods at Erie Mining Co. Proc. 24th Ann. Min. Symp. and Ann. Meeting of Minnesota Sec., AIME, Jan. 14-16, 1963, pp. 1-6.
[33] Jarman, Hugh G. Blasting at a Canadian Iron-Ore Mine. Min. Mag. (London), v. 108, No. 5, May 1963, pp. 271-274.

Union Carbide Canada Ltd. and Gardner-Denver Company Canada Ltd. demonstrated a jet-piercing machine using compressed air instead of oxygen.[34] The machine, while drilling a 24-inch-diameter hole in quartzite, consumed 32 gallons of fuel oil per hour at the burner, 10 gallons per hour at the compressor, and 350 to 400 gallons of water. Nozzle temperature was 3,200° F, compared with the normal 4,500° F using oxygen. The machine required 800 cubic feet per minute of air at 100 pounds per square inch.

Systems analysis studies at Steep Rock Iron Mines Ltd., Ontario, Canada, indicated that variation in individual elements of the concentrating process had very little effect in the overall economics of an open-pit iron mining and processing operation.[35] Stripping costs and recovery of undiluted ore on the other hand proved critical elements, in that relatively small variations produced substantial change in the end results. The investigators concluded, therefore, that methods study, work organization, geologic investigation, and other engineering techniques could be applied to obtain savings much greater than their cost.

In the United States iron ore beneficiation technology was examined critically in two comprehensive papers and studies.[36] The authors, although recognizing that changes in technology have been evolving over a number of years, marked 1963 as the year of wide acceptance of autogenous grinding, spiral concentrators, and the principal of anonic floatation.

In France at the Sixth International Mineral Processing Congress at Cannes, cationic floatation of siliceous gangue was proposed as a means of concentrating certain Lorraine iron ores in one of four papers dealing with iron ore flotation.[37] With a feed containing 29 percent iron and 26 percent silica, a concentrate containing 40 percent iron and 9 percent silica was produced with 69 percent iron recovery in a continuous circuit.

In Canada at the annual general meeting of the Canadian Institute of Mining and Metallurgy in Ottawa, laboratory research on cationic flotation of silica from siderite was described.[38] A concentrate containing 38 percent iron and 1.8 percent silica was produced with 91 percent recovery from feed containing 38 percent iron, 9 percent silica, and 2.8 percent sulfur.

Beneficiation by magnetized roasting and magnetic separation continued to intrigue and occupy the iron ore researchers. Many apparently were on the verge of success, but a commercial process was not yet developed. The staff at the Institut de Recherches de la Siderurgie, Maizières-lès-Metz, France, successfully completed a laboratory-scale, 1-ton-per-hour pilot test of a fluidized-bed roasting

[34] Candian Mining Journal (Quebec). Jet Piercing With Compressed Air. V. 84, No. 12, December 1963, p. 35.
[35] Bannister, Walter S. Systems Analysis at Steep Rock. Min. Cong. J., v. 49, No. 5, May 1963, pp. 39–42.
[36] Cofield, G. E., and D. F. MacKnight. Iron Ore Flotation—Past, Present and Future. Skillings' Min. Rev., v. 52, No. 10, Mar. 9, 1963, pp. 6–9.
Scott, Donald W. A Review and Appraisal of Iron Ore Beneficiation. Pt. I, Min. Cong. J., v. 49, No. 5, May 1963, pp. 56–59; pt. II, v. 49, No. 6, June 1963, pp. 78–83; pt. III, v. 49, No. 7, July 1963, pp. 53–56.
Thompson, James V. Fantastic Changes in Iron Ore Industry. Mines Mag., v. 53. No. 5, May 1963, pp. 22–24.
[37] Durand, M., F. Gauthier, and R. Guyot. Beneficiation of Certain Lorraine Iron Ores by Flotation of the Siliceous Gangue (Sixth International Mineral Processing Congress, Cannes, France. Paper 26F). Mine and Quarry Eng., v. 29, No. 11, November 1963, p. 497.
[38] Morrow, J. G., M. H. Cleary, and C. Guarnaschelli. Cationic Flotation of Silica From Algoma Siderite. Canadian Min. and Metal. Bull. (Montreal, Canada), v. 56, No. 620, December 1963, pp. 868–873.

process to treat the minette ores of the Lorraine district. At yearend it was planned to scale the process up to 10 tons per hour.

Northern Natural Gas Co. and W. S. Moore Company announced plans to build a half-million-dollar pilot plant at Duluth, Minn., to investigate a magnetizing-roasting-magnetic separation process on Lake Superior district nonmagnetic iron-bearing materials.[39] This is the district's third large-scale research operation based on conversion of iron minerals to artificial magnetite.

A blast-furnace symposium was held at the Carnegie Institute of Technology under the sponsorship of AIME. Although the principal purpose of the symposium was to discuss manuscripts for a forthcoming comprehensive book on blast-furnace theory and practice, the participants took the opportunity to analyze the alternatives to the blast furnace. They concluded that the alternatives are less efficient and should be considered only under special local requirements and conditions.

European and U.S. metallurgists described commercial experience, which confirmed results of research in small-scale experimental furnaces, in injecting auxiliary fuel into the combustion zone of the blast furnace, in increasing the blast temperature, and in upgrading the physical and chemical characteristics of the burden. Widely expanded use of natural gas as a blast-furnace fuel was described as among the most successful technical developments of the Soviet Union's steel industry in recent years.

The Bureau of Mines experimental blast furnace operated in cooperation with 22 major iron and steel private concerns until July when it was shut down for rebuilding to accommodate high top pressure research.

A study of direct reduction processes and a comparative economic and energy consumption analysis of direct reduction plants versus blast-furnaces plants confirmed the findings of metallurgists at the Carnegie Blast Furnace Symposium.[40] Blast furnaces in most circumstances are more efficient. Consideration of possible modifications of both processes, however, indicates that there may be economic advantage in partial reduction of iron minerals in mining districts in close proximity to low-cost oil, natural gas, or noncoking coals.

Stora Kopparbergs Bergslags a.-b. of Sweden announced successful production of pig iron directly from ore in a 13-ton-per-day pilot operation. The ore was reduced with coal or coke breeze and oxygen in a rotating furnace similar to the type used in the company Kaldo oxygen steelmaking process. The company also announced plans to build a 130-ton-per-day pilot plant at Domnarvet, Sweden, to investigate the process on a large scale.

Bureau of Mines Research.—Bureau of Mines field engineers examined iron resources in Arizona, South Dakota, Nevada, Montana, Idaho, and Washington. The work in these States was part of a nationwide resource study to determine the quality, extent, and potential of iron deposits and thus delineate the problems that must

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[39] Mining Journal (London). Iron Ore Beneficiation, $500,000 Pilot Plan To Test New Process. V. 260, No. 6662, Apr. 26, 1963, p. 387.

[40] Chase, P. W., and D. L. McBride. Present and Future of Direct Reduction Processes in Latin America. Blast Furnace and Steel Plant, v. 51, No. 10, October 1963, pp. 868–878, 897.

be solved to exploit them. Field engineers also examined and sampled iron resources in Michigan and Wisconsin. The work in these States, however, was part of a comprehensive study of the Lake Superior district to determine trends in mineral assemblage and concentrating characteristics of the deposits over wide areas, thus providing continuity of data across private property lines. The engineers in the Western States were concerned with long-range problems, while those in the Lake Superior district were concerned with the immediate problem of assisting the domestic iron-mining industry in its competition with imported ore.

Iron ore beneficiation studies were conducted at the Bureau's Minneapolis and Tuscaloosa Metallurgy Research Centers. Metallurgists at Minneapolis published a report describing one phase of an investigation of anionic flotation of silica as a means of concentrating iron ore.[41] They continued the flotation investigations on a pilot-plant scale throughout the year. The objective of the research at Tuscaloosa was to investigate and develop new or improved methods for treating calcareous hematitic ores to produce enriched iron oxide concentrate while simultaneously reducing the phosphorus content. In small-scale laboratory tests it was proved technically feasible to treat Birmingham district red iron ores by a combination of flotation, sizing, sink-float, roasting, and leaching to obtain a product containing 66 percent iron, 0.02 percent calcium oxide, 0.033 percent phosphorus, and 3.5 percent insoluble. However, the process was not developed to the point of possible commercial application.

Research on preparation of prereduced iron ore pellets was continued using anthracite and lignite coal to reduce four types of concentrates in a 36-foot rotary kiln. Results indicated that the Bureau's process can probably be adapted to treat most iron ore concentrates. Studies with specularite, however, were not particularly successful.

The Bureau's experimental blast furnace was operated in cooperation with 22 major iron and steel companies from January through June and then shut down for rebuilding to accommodate high top-pressure studies. Cooperative investigations on fuel-oil injection into the smelting zone and examination of the furnace after quenching with nitrogen were described in Bureau publications.[42] Other Bureau publications dealing with blast-furnace research described progress in developing a thermochemical model of a furnace and an improved gravimetric method for analyzing top gas.[43]

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[41] Wasson, P. A., R. T. Sorensen, and D. W. Frommer. Anionic Flotation of Silica From Goethitic Iron-Bearing Materials, Cuyuna Range, Minn. BuMines Rept. of Inv. 6199, 1963, 11 pp.

[42] Morris, J. P., and P. L. Woolf. Examination of an Experimental Iron Blast Furnace After Quenching With Nitrogen. BuMines Rept. of Inv. 6217, 1963, 36 pp.

Woolf, P. L., and W. M. Mahan. Fuel-Oil Injection in an Experimental Blast Furnace. BuMines Rept. of Inv. 6150, 1963, 23 pp.

[43] Kusler, David J. An Improved Gravimetric Method for Analyzing Blast Furnace Top Gas. BuMines Rept. of Inv. 6168, 1963, 21 pp.

St. Clair, Hillary W. Developing a Thermochemical Model for the Iron Blast Furnace. BuMines Rept. of Inv. 6233, 1963, 38 pp.

Iron and Steel

By Robert A. Whitman [1]

Contents

STEEL production during 1963 was about 11 percent above the 1962 rate. Pig iron production increased more than 9 percent, and shipments of steel products increased 7 percent. The automobile industry continued to be the largest customer, but its share of the business was the same as in 1962, when it was 22 percent. There was a significant gain in imports of major iron and steel products from 4.3 million tons in 1962 to 5.6 million in 1963. The European Coal and Steel Community supplied 44 percent, and Japan 36 percent of imports.

Through negotiations, the steel industry's human relations committee resolved areas of conflict which might have resulted in a strike. Early settlement of these industry problems was without precedent and had a steadying influence which was reflected in a smaller drop in summer orders and a larger increase in fall steel buying than had been expected.

There was an increase in the average composite price of steel which just equaled the raise in total employment costs per hour, according to the American Iron and Steel Institute (AISI). The 1963 payroll was $3.9 billion as compared with $3.8 billion in 1962. The net billing value of products shipped and other services was $14.4 billion, compared with $13.8 billion in 1962. Net income was $782 million compared with $566 million in 1962, or a 38-percent increase.

The producing industry was getting acquainted with the many new facets of steel technology. New basic oxygen converters were being installed, continuous casting of steel began commercial operation, more oxygen was being used in open hearth and blast furnaces, and prepared charges of higher iron content were used more widely.

[1] Commodity specialist, Division of Minerals.

747-149—64——41

TABLE 1.—Salient iron and steel statistics

(Thousand short tons)

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Pig iron:						
Production	69,077	60,210	66,501	64,853	65,638	71,840
Shipments	68,800	61,245	65,612	65,307	65,727	72,211
Imports for consumption	267	700	331	377	500	645
Exports	260	10	112	416	154	70
Steel:[1]						
Production of ingots and castings (all grades):						
Carbon	94,955	84,539	[2] 90,862	[2] 89,338	[2] 89,160	98,714
Stainless	1,055	1,131	1,004	1,137	1,085	1,204
All other alloy	7,697	7,776	[2] 7,416	[2] 7,539	[2] 8,083	9,343
Total	103,707	93,446	99,282	98,014	98,328	109,261
Capacity, annual Jan. 1	130,545	147,634	148,571	(3)	(3)	(3)
Percent of capacity	79.4	63.3	66.8	(3)	(3)	(3)
Index (1954-58=100)	100.0	90.1	95.7	94.5	94.8	105.4
Total shipments of steel mill products	74,186	69,377	71,149	66,126	70,552	75,555
Imports for consumption of major iron and steel products [4] [5]	1,308	4,615	3,570	3,308	[2] 4,297	5,582
Exports of major iron and steel products	4,281	1,973	3,247	2,221	[2] 2,266	2,664
World production:						
Pig iron [6]	209,970	247,230	285,270	282,370	291,820	308,970
Steel ingots and castings	293,580	336,510	381,560	386,780	[2] 396,260	425,310

[1] American Iron and Steel Institute.
[2] Revised figure.
[3] Data not available.
[4] Data not comparable for all years.
[5] Bureau of the Census.
[6] Includes ferroalloys.

PRODUCTION AND SHIPMENTS OF PIG IRON

U.S. production of pig iron was 9-percent higher than in 1962 and 4-percent higher than the 5-year average of 1954–58. There were 9 more blast furnaces in operation at the end of 1963 than in January. According to AISI, the average production of pig iron per blast-furnace day was 1,427 tons, compared with 1,349 tons in 1962 and 1,305 tons in 1961. All producing areas except Illinois improved production with the Lake Superior region showing the best gain. With 24, 18, and 14 percent, respectively, Pennsylvania, Ohio, and Indiana continued to be the best producers.

There were three fewer blast furnaces at the end of 1963 than at the start. The Armco Steel Corp. completed a new blast furnace at Ashland, Ky., and the Jones and Laughlin Steel Corp. completed one at Cleveland, Ohio; but one furnace was dismantled and four were abandoned.

Metalliferous Materials Consumed in Blast Furnaces.—There were 111.8 million tons of ores and agglomerates, 3.5 million tons of scrap, and 7.1 million tons of miscellaneous materials consumed in pig iron production in 1963. The combined net charge was 1,703 tons of material per ton of pig iron produced, compared with 1,715 tons of charge per ton of pig iron produced in 1962.

The agglomerate charge consisted of 38.3 million tons of sinter, 11.3 million tons of self-fluxing sinter, 19.4 million tons of pellets, 263,000 tons of self-fluxing nodules, 1.6 million tons of unclassified agglomerates, 1.2 million tons of foreign agglomerates, and only 12,577 tons of nodules.

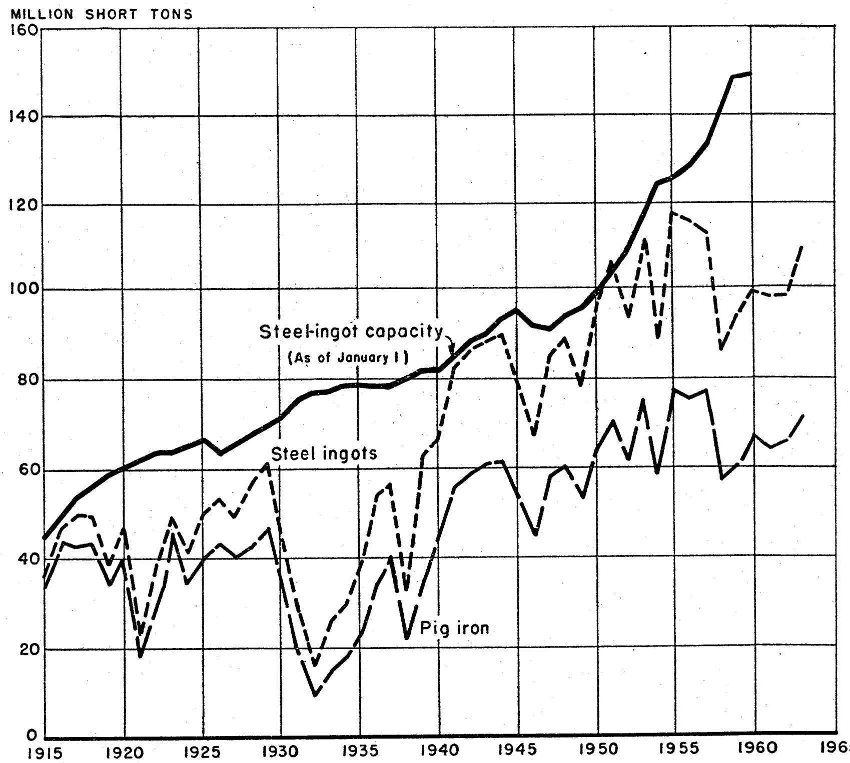

FIGURE 1.—Trends in production of pig iron and steel ingots, 1915–63, and steel-ingot capacity in the United States, 1915–60.

Consumption of miscellaneous materials included 3 million tons of mill cinder and roll scale and 3.9 million tons of open-hearth and Bessemer slag.

Canada, Venezuela, and Chile furnished 94 percent of the foreign iron ore and manganiferous iron ore consumed in U.S. blast furnaces.

TABLE 2.—Pig iron produced and shipped in the United States, by States

(Thousand short tons and thousand dollars)

State	Produced		Shipped from furnaces			
	1962	1963	1962		1963	
	Quantity		Quantity	Value	Quantity	Value
Alabama	3,628	3,908	3,595	$206,565	3,899	$217,020
Illinois	4,715	4,476	4,775	282,210	4,541	261,186
Indiana	8,817	9,957	8,796	504,326	10,050	564,355
Ohio	11,548	12,734	11,470	686,860	12,772	737,990
Pennsylvania	15,726	17,290	15,886	936,184	17,338	1,028,796
California, Colorado, Utah	3,708	4,044	3,719	191,866	4,062	204,378
Kentucky, Tennessee, Texas	1,499	1,759	1,507	81,396	1,782	91,314
Maryland and West Virginia	6,650	6,948	6,608	391,136	6,938	466,552
Michigan and Minnesota	5,432	6,451	5,415	307,634	6,523	360,659
New York	3,915	4,273	3,956	233,962	4,306	290,218
Total	65,638	71,840	65,727	3,822,139	72,211	4,222,468

According to the AISI, blast furnaces consumed 10.3 billion cubic feet of oxygen in 1963, a decrease of 11.4 billion cubic feet from 1962. There were 8.9 billion cubic feet used in blast furnaces in 1961. Data collected by the Bureau of Mines showed that 31.6 billion cubic feet of natural gas, 3.8 billion cubic feet of coke-oven gas, and 43.9 million gallons of oil were injected through blast furnace tuyères in the United States. Also, for the first time, companies reported 29,303 tons of bituminous coal and some anthracite coal was used in blast furnaces in 1963.

TABLE 3.—Foreign iron ore and manganiferous iron ore consumed in manufacturing pig iron in the United States, by sources of ore

(Short tons)

Source	1962	1963 [1]	Source	1962	1963 [1]
Brazil	91,804	48,229	Venezuela	4,299,230	4,749,444
Canada	4,652,643	5,829,190	Other countries	133,772	526,359
Chile	1,117,112	1,220,384			
Peru	363,348	191,282	Total	10,657,909	12,564,888

[1] Excludes 19,236,790 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	1962			1963		
	Quantity	Value		Quantity	Value	
		Total	Average per ton		Total	Average per ton
Foundry	1, 398	$82, 304	$58. 87	1, 657	$92, 156	$55. 62
Basic	58, 919	3, 412, 990	57. 93	65, 062	3, 803, 535	58. 46
Bessemer	2, 764	166, 105	60. 10	2, 821	171, 317	60. 73
Low-phosphorus	171	10, 846	63. 43	173	10, 554	61. 01
Malleable	2, 295	140, 550	61. 24	2, 299	135, 070	58. 75
All other (not ferroalloys)	180	9, 344	51. 91	199	9, 836	49. 43
Total	65, 727	3, 822, 139	58. 15	72, 211	4, 222, 468	58. 47

[1] Includes pig iron transferred directly to steel furnaces at same site.

TABLE 5.—Number of blast furnaces (including ferroalloy blast furnaces) in the United States, by States

State	January 1, 1963			January 1, 1964		
	In blast	Out of blast	Total	In blast	Out of blast	Total
Alabama	11	10	21	11	10	21
California	3	1	4	3	1	4
Colorado	3	1	4	3	1	4
Illinois	11	11	22	9	13	22
Indiana	17	6	23	21	2	23
Kentucky	2		2	2	1	3
Maryland	6	4	10	6	4	10
Michigan	9		9	9		9
Minnesota	1	1	2	1	1	2
New York	9	8	17	10	7	17
Ohio	25	24	49	27	22	49
Pennsylvania	33	35	68	37	27	64
Tennessee	1	2	3	1	2	3
Texas	2		2	2		2
Utah	2	3	5	2	3	5
Virginia		2	2		2	2
West Virginia	3	1	4	3	1	4
Total	138	109	247	147	97	244

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

(Short tons)

Year and State	Metalliferous materials consumed							Net coke	Fluxes	Pig iron produced	Metalliferous materials consumed per ton of pig iron made				Coke and fluxes consumed per ton of pig iron	
	Iron and manganiferous ores		Agglomerates	Net ores and agglomerates [1]	Net scrap [2]	Miscellaneous [3]	Net total				Net ores and agglomerates [1]	Net scrap [2]	Miscellaneous [3]	Total	Net coke	Fluxes
	Domestic	Foreign														
1962:																
Alabama	3, 697, 017	748, 471	2, 711, 811	6, 985. 348	120. 462	123, 439	7, 229, 249	3, 215, 390	930, 027	3, 628, 060	1. 925	0. 033	0. 034	1. 992	0. 886	0. 256
Illinois	3, 603, 758	(4)	4, 222, 202	7, 533, 847	280. 962	604, 221	8, 419, 030	3, 540, 610	947, 136	4, 715, 200	1. 598	. 060	. 128	1. 786	. 751	. 201
Indiana	5, 048, 076	886, 883	8, 502, 704	13, 783, 844	59, 861	1, 426, 294	15, 269, 999	5, 775, 139	1, 262, 642	8, 816, 526	1. 563	. 007	. 162	1. 732	. 655	. 143
Ohio	5, 625, 619	1, 923, 772	10, 445, 052	17, 229, 531	861, 265	1, 266, 226	19, 357, 022	8, 185, 856	2, 976, 021	11, 547, 845	1. 492	. 074	. 110	1. 676	. 709	. 258
Pennsylvania	5, 066, 984	2, 345, 637	16, 270, 271	22, 943, 918	946, 298	2, 009, 737	25, 899, 953	10, 763, 289	2, 682, 734	15, 725, 819	1. 459	. 060	. 128	1. 647	. 684	. 171
California, Colorado, Utah	(4)	(4)	3, 104, 467	6, 770, 470	494, 582	103, 291	7, 368, 343	2, 350, 123	628, 964	3, 707, 880	1. 826	. 133	. 028	1. 987	. 634	. 170
Kentucky, Tennessee, Texas	538, 569	363, 309	1, 530, 072	2, 393, 757	116, 922	133, 654	2, 644, 333	768, 030	328, 205	1, 498, 471	1. 597	. 078	. 089	1. 764	. 513	. 219
Maryland and West Virginia	(4)	(4)	6, 437 769	10, 134, 669	167, 094	559, 817	10, 861, 580	4, 386, 140	885, 911	6, 650, 302	1. 524	. 025	. 084	1. 633	. 660	. 133
Michigan and Minnesota	(4)	(4)	5, 925, 960	8, 635, 490	216, 942	211, 959	9, 064, 391	3, 532, 664	1, 234, 232	5, 432, 269	1. 590	. 040	. 039	1. 669	. 650	. 227
New York	1, 725, 440	352. 494	4, 263. 264	6. 109, 912	117, 349	243, 536	6, 470, 797	2, 725, 353	1, 003, 797	3, 915, 160	1. 561	. 030	. 062	1. 653	. 696	. 256
Total	32, 291, 374	10, 657, 909	63, 413, 572	102, 520, 786	3, 381, 737	6. 682, 174	112, 584, 697	45, 242, 594	[5] 12, 879, 669	65. 637, 532	1. 562	. 051	. 102	1. 715	. 689	. 196

1963:																	
Alabama	2. 872. 047	4, 129, 847	3, 139, 514	6, 967, 701	119. 372	113, 974	7, 201, 047	3, 240, 051	1, 055, 212	3, 907, 537	1.783	.031	.029	1.843	.829	.270
Illinois	3. 167, 151	(4)	4. 249, 190	7, 222, 567	320, 492	471. 620	8, 014, 679	3, 271. 955	819, 839	4, 476. 337	1.614	.072	.105	1.791	.731	.183
Indiana	6. 095, 289	1, 829, 021	9, 432, 431	16, 632, 897	225, 326	1, 529, 729	18, 387, 952	6, 581, 129	1, 436, 894	9, 957, 082	1.670	.023	.154	1.847	.661	.144
Ohio	5. 119, 029	2, 007, 183	12. 226. 113	18, 558, 176	1, 074, 130	1. 472, 743	21, 105, 049	8, 852, 586	2, 926, 796	12, 733, 837	1.458	.084	.116	1.658	.695	.230
Pennsylvania	5, 424, 093	2, 848, 667	17, 761, 693	25, 335, 965	961, 519	2, 004, 602	28, 302, 086	11, 259, 322	2, 598, 801	17, 289, 805	1, 465	.056	.116	1.637	.651	.150
California, Colorado, Utah	(4)	(4)	4, 249, 452	6, 857, 560	139, 988	131, 051	7, 128, 599	2, 387, 376	703, 462	4, 044, 051	1.696	.035	.032	1.763	.590	.174
Kentucky, Tennessee, Texas	1, 059, 349	353, 062	1, 751, 297	3, 119, 595	60, 720	126, 691	3, 307, 006	1, 182, 501	475, 416	1, 759, 012	1.773	.035	.072	1.880	.672	.270
Maryland and West Virginia	(4)	(4)	6, 732, 922	10, 433, 717	187, 988	599, 636	11, 221, 341	4, 446, 682	676, 751	6. 947, 446	1.502	.027	.086	1.615	.640	.097
Michigan and Minnesota	(4)	(4)	7, 663, 773	10, 032, 859	258, 528	307, 979	10, 599, 366	4, 094. 351	1, 433, 738	6. 451. 261	1.555	.040	.048	1.643	.635	.222
New York	1. 647. 015	280, 503	4, 929, 479	6, 618, 290	116, 476	378, 603	7. 113, 369	2, 845, 734	1. 087. 396	4. 273. 375	1.549	.027	.089	1.665	.666	.254
Total	30, 938, 796	12, 564, 888	72, 135, 864	111, 779, 327	3, 464, 539	7, 136, 628	122, 380, 494	48, 161, 687	[6] 13,214,305	71. 839, 743	1.556	.048	.099	1.703	.670	.184

[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] Included in total.
[5] Fluxes consisted of 9,100,454 tons of limestone and 3,779,215 tons of dolomite, excluding 4,424,975 tons of limestone and 1,629,284 tons of dolomite used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.
[6] Fluxes consisted of 9,066,274 tons of limestone and 4,148,031 tons of dolomite, excluding 4,686,330 tons of limestone and 1,913,125 tons of dolomite used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.

PRODUCTION AND SHIPMENTS OF STEEL

Steel production rose 11 percent in 1963 to 109.3 million short tons. This does not include 1.4 million tons of steel castings made by independent foundries, which produced 1.2 million tons in 1962. Basic oxygen furnaces produced four times as much steel as they had in 1958 and accounted for 7.8 percent of all steel produced in 1963. Open-hearth furnaces accounted for 81.3 percent; electric furnaces 10 percent; and Bessemer 0.9 percent. Pennsylvania, Ohio, Indiana, and Illinois remained the four leading producing States with 23, 17, 14, and 8 percent of production, respectively. Improvement was even throughout the entire Nation. It took 65 years to produce the first billion tons of steel ingots, 18 years to produce the second billion tons, and 10 years to produce the third billion tons of steel ingots.

Total shipments of steel products increased 5 million tons compared with 1962. Automotive uses increased by 1.7 million tons. Construction and contractor's products used 1 million tons more in 1963. Shipments to service centers increased by 1 million tons, while rail transportation accounted for 0.5 million tons of the increase.

Alloy Steel.[2]—The production, 9.3 million tons of alloy steel (excluding stainless), was a 15.6 percent increase over that produced in 1962. This included 50,975 tons of alloy steel for castings. Total stainless production of 1.2 million tons included 1,441 tons of steel for castings, an increase of 10.9 percent over that of 1962. Alloy steel represented 9.7 percent of total steel production.

Austenitic stainless steel (AISI 200 and 300) production was 67.6 percent of total stainless production, an increase of 16.1 percent compared with 1962, whereas production of series 400 steels decreased. Output of AISI 501 and 502 and other high-chromium heat-resisting steels declined nearly 4 percent from 1962.

Open-hearth furnaces produced 59 percent and electric furnaces 40.5 percent of all alloy output. Basic oxygen furnaces accounted for a little over 0.5 percent.

Total output of carbon-steel ingots and castings was 98.7 million tons, nearly an 11-percent improvement compared with 89.2 million tons (revised) for 1962.

Materials Used in Steelmaking.—Consumption of pig iron and scrap for steelmaking totaled 122.7 million tons. Pig iron made up 54 percent of the total, a decrease of 1 percent compared with 1962. Consumption of ore decreased 13 percent, to 5,778,000 tons, of which 69

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[2] The Bureau of Mines uses the American Iron and Steel Institute specifications for alloy steels, which include stainless and any other steel containing one or more of the following elements in the designated percentages: Manganese in excess of 1.65 percent, silicon in excess of 0.60 percent, and copper in excess of 0.60 percent. The specifications also include steel containing the following elements in any quantity specified or known to have been added to obtain a desired alloying effect: Aluminum, boron, chromium, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, and other alloying elements.

Stainless steel includes all grades of steel that contain 10 percent or more of chromium with or without other alloys or a minimum combined content of 18 percent of chromium with other alloys. Valve or bearing steels, high-temperature alloys, or electrical grades with analyses meeting the definition for stainless steels are included. All tool-steel grades are excluded.

Heat-resisting steel includes all steel containing 4 percent cr more but less than 10 percent of chromium (excluding tool-steel grades).

percent was foreign ore. According to the AISI, 232,892 tons of fluorspar, 4,997,931 tons of limestone, 1,883,150 tons of lime, and 492,326 tons of other fluxes were consumed in steelmaking. Total consumption of oxygen in 1963 was 69,761 million cubic feet, 28 percent more than in 1962. Nearly 74 percent of the oxygen was used in open-hearth steelmaking, and 23 percent in basic oxygen converters.

TABLE 7.—Steel production in the United States, by type of furnace [1]

(Thousand short tons)

Year	Open hearth		Bessemer	Basic oxygen process	Electric [2]	Total
	Basic	Acid				
1954-58 (average)	92,685	528	2,594	[3] 488	7,412	103,707
1959	81,225	444	1,380	1,864	8,533	93,446
1960	85,964	404	1,189	3,346	8,379	99,282
1961	84,108	394	881	3,967	8,664	98,014
1962	82,578	379	805	5,553	9,013	98,328
1963	88,437	397	963	8,544	10,920	109,261

[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] Includes crucible, oxygen converter steel, 1954-55.
[3] Data for 3-year period only.

Source: American Iron and Steel Institute.

CONSUMPTION OF PIG IRON

Domestic consumption of pig iron increased 9 percent in 1963. The East North Central and Middle Atlantic States again took 76 percent of the total.

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				
1954-58 (average)	2,860	4,666	1,521	61,224	1,433	53,981
1959	1,690	5,238	961	54,699	1,380	49,794
1960	1,570	6,251	931	60,092	1,395	51,140
1961	1,913	5,277	855	59,418	1,367	49,455
1962	1,875	4,768	[3] [4] 644	60,561	1,408	49,606
1963	1,783	3,995	[5] 885	66,188	1,557	56,506

[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 20,039 tons of sinter, 342,466 tons of pellets, 276,632 tons of nodules, 702 tons of briquets, 3,661 tons of other agglomerates. (532,031 tons of foreign origin.) 1959-62 see Iron and Steel chapter, Minerals Yearbook, v. I, p. 695.
[4] Revised figure.
[5] Includes 71,116 tons of sinter, 487,886 tons of pellets, 300,411 tons of nodules, and 25,189 tons of other agglomerates. (875,573 tons of foreign origin.)

TABLE 9.—Consumption of pig iron in the United States, by type of furnace

Type of furnace or equipment	1962		1963	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Open hearth	54,509	81.8	57,291	78.8
Bessemer	792	1.2	1,603	2.2
Oxygen converter	5,020	7.5	7,082	9.8
Electric [1]	240	.4	212	.3
Cupola	3,402	5.1	3,597	4.9
Air	186	.3	178	.2
Direct castings	2,446	3.7	2,726	3.8
Total	66,595	100.0	72,689	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

(Short tons)

District and State	1962	1963	District and State	1962	1963
New England:			South Atlantic—Con.		
Connecticut	33,024	30,802	North Carolina	29,457	30,213
Maine and New Hampshire	2,251	1,741	South Carolina	18,684	17,949
Massachusetts	59,876	49,025	Virginia and West Virginia	1,950,305	2,229,954
Rhode Island	41,836	42,660			
Vermont	7,288	6,020	Total	6,812,179	7,135,217
Total	144,275	130,248	East South Central:		
			Alabama	3,104,152	3,427,531
Middle Atlantic:			Kentucky, Mississippi, Tennessee	852,388	963,950
New Jersey	119,757	113,289			
New York	3,355,305	3,837,813			
Pennsylvania	15,975,716	17,460,390	Total	3,956,540	4,391,481
Total	19,450,778	21,411,492	West South Central:		
			Arkansas, Louisiana, Oklahoma	8,302	7,990
East North Central:			Texas	780,226	942,427
Illinois	4,932,854	4,837,935			
Indiana	8,972,216	9,863,042	Total	788,528	950,417
Michigan	5,534,555	6,531,984			
Ohio	11,430,509	12,556,922	Rocky Mountain:		
Wisconsin	186,327	173,669	Arizona and Nevada	162	92
Total	31,056,461	33,963,552	Colorado, Idaho, Montana, Utah	2,012,961	2,230,501
West North Central:					
Iowa	71,050	74,685	Total	2,013,123	2,230,593
Kansas and Nebraska	5,337	5,850			
Minnesota	446,331	454,249	Pacific Coast:		
Missouri	29,247	33,490	California and Hawaii	1,817,823	1,891,049
Total	551,965	568,274	Oregon and Washington	3,810	16,417
South Atlantic:			Total	1,821,633	1,907,466
Delaware and Maryland	4,802,288	4,844,795	Grand total	66,595,482	72,688,740
Florida and Georgia	11,445	12,306			

PRICES

There were several changes in pig iron and steel prices during 1963. The composite average price of pig iron was $66.33 per long ton in January, high for the year.[3] It dropped to $63.33 from February

[3] Iron Age. V. 193, No. 1, Jan. 2, 1964, pp. 195, 199.

through August and then to $63.11 for the balance of 1963. The composite price of 6.196 cents per pound for steel, unchanged since 1959, lasted through April. It rose then to 6.279 cents per pound through September and then to 6.368 cents for the balance of the year. This made an annual composite price of 6.273 cents per pound during 1963.

TABLE 11.—Average value of pig iron at blast furnaces in the United States, by States

(Per short ton)

State	1954–58 (average)	1959	1960	1961	1962	1963
Alabama	$50.68	$56.81	$56.52	$56.62	$57.46	$55.66
California, Colorado, Utah	54.20	60.47	59.73	50.50	51.59	50.31
Illinois	54.84	60.12	60.30	60.42	59.10	57.52
Indiana	54.22	58.82	58.90	58.96	57.34	56.15
New York	56.66	61.01	62.54	60.05	59.13	67.40
Ohio	52.68	59.50	57.79	60.78	59.89	57.78
Pennsylvania	55.27	59.84	60.12	59.48	58.93	59.34
Other States [1]	55.47	58.38	58.06	57.44	57.66	60.26
Average	54.40	59.33	59.53	58.51	58.15	58.47

[1] Comprises Kentucky, Maryland, Michigan, Minnesota, Tennessee, Texas, West Virginia, and Massachusetts (1954–60).

TABLE 12.—Average prices of chief grades of pig iron

(Per short ton)

Month	Foundry pig iron at Birmingham furnaces, 1963	Foundry pig iron at Valley furnaces, 1963	Bessemer pig iron at Valley furnaces, 1963	Basic pig iron at Valley furnaces, 1963
January–December	53.13	56.70	57.14	56.25

Source: Metal Statistics.

TABLE 13.—Free-on-board value of steel mill products in the United States, in 1962 [1]

(Cents per pound)

Product	Carbon	Alloy	Stainless	Average
Ingots	4.140	15.905	32.151	13.640
Semifinished shapes and forms	5.767	10.210	40.452	6.530
Plates	6.596	9.711	[3] 60.865	7.724
Sheets and strips	7.012	15.388	48.445	7.912
Tin mill products	9.023			9.023
Structural shapes and piling	6.409	8.552		6.434
Bars	7.517	13.344	66.307	8.967
Rails and railway-track material	8.206			8.206
Pipes and tubes	10.389	18.800	157.762	11.653
Wire and wire products	12.850	37.916	80.811	14.018
Other rolled and drawn products	(2)	37.774	60.154	40.480
Average total steel	7.696	13.737	57.332	8.583

[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] Included with rails and railway-track material.
[3] Includes unknown quantity of hot-rolled bars.

Source: Computed from figures supplied by the Bureau of the Census.

FOREIGN TRADE

For the fifth consecutive year, imports of steel mill products exceeded exports.

Imports.—Imports of iron and steel products totaled 5.6 million tons for 1963. Of these, 80 percent came from the European Coal and Steel Community and Japan. Imports of pig iron were 645,334 tons, compared with 500,074 tons in 1962.

Exports.—Exports of iron and steel products totaled 2.7 million tons, an increase of 17 percent over 1962. Exports of pig iron were 70,154 tons, compared with 154,380 tons in 1962.

TABLE 14.—U.S. imports for consumption of pig iron, by countries

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America: Canada	234,092	437,095	281,593	349,403	[1] 386,296	387,449
South America: Brazil	3,924					
Europe:						
Belgium-Luxembourg			4,408			
Finland		10,253			681	12,123
Germany, West	9,164	[2] 71,805	386	719	56,341	87,435
Netherlands	2,077	4,427	1,575			
Norway	876	168			3,584	3,319
Portugal		4,395				
Spain	4,514	78,499	21,551	19,113	42,416	45,161
Sweden	2,054	1,071	1,445	1,201	1,416	10,146
U.S.S.R.		1,550	1,298	396		
United Kingdom		51			94	8
Total	18,685	172,219	30,663	21,429	104,532	158,192
Asia:						
India	3,805	56	6,742			
Japan		10,674				
Total	3,805	10,730	6,742			
Africa:						
Rhodesia and Nyasaland, Federation of [3]	437	4,863	392			
South Africa, Republic of [4]	1,414	70,519	7,543	4,096	5,030	76,696
Total	1,851	75,382	7,935	4,096	5,030	76,696
Oceania: Australia	4,864	4,167	3,914	2,252	4,216	22,997
Grand total:						
Short tons	267,221	699,593	330,847	377,180	[1] 500,074	645,334
Value	$14,255,010	$35,493,259	$18,351,333	$20,511,391	$24,684,220	$28,936,920

[1] Revised figure.
[2] Includes 110 tons from East Germany.
[3] Classified as Southern Rhodesia through June 30, 1954; 1,562 short tons was produced from January through June 1954.
[4] Effective Jan. 1, 1962, formerly Union of South Africa.

Source: Bureau of the Census.

TABLE 15.—U.S. imports for consumption of major iron and steel products

Products	1962		1963	
	Short tons	Value	Short tons	Value
Iron products:				
Bar iron, iron slabs, blooms, or other forms	211	$64,710	265	$87,906
Pipes and fittings:				
Cast-iron pipe and fittings	35,540	4,043,946	37,949	4,117,651
Malleable cast-iron pipe fittings	3,325	1,304,389	3,936	1,534,890
Castings and forgings	15,056	5,220,909	22,258	7,606,168
Total	54,132	10,633,954	64,408	13,346,615
Steel products:				
Steel bars:				
Concrete reinforcement bars	607,024	44,284,929	545,203	39,254,792
Solid and hollow, n.e.s	[1] 126,356	[1] 17,012,239	206,839	19,504,819
Hollow and hollow drill steel	2,567	1,188,238	2,173	975,144
Wire rods, nail rods, and flat rods up to 6 inches in width	[1] 644,271	[1] 61,985,868	800,994	76,606,414
Boiler and other plate iron and steel, n.e.s	[1] 216,570	[1] 26,399,846	(2)	(2)
Steel ingots, blooms, and slabs; billets, solid and hollow	[1] 174,372	[1] 13,545,558	260,355	24,831,885
Die blocks or blanks, shafting, etc	2,100	828,928	1,757	664,005
Circular saw plates	54	67,991	[3] 146	[3] 70,639
Sheets of iron or steel, common, or black and boiler or other plate of iron or steel	215,179	26,261,302	(2)	(2)
Sheets and plates and steel n.s.p.f	10,976	4,669,932	1,018,299	121,688,057
Tinplate, terneplate, and taggers' tin	52,479	8,586,908	82,941	14,197,413
Structural iron and steel	[1] 708,795	[1] 74,872,972	933,075	89,203,358
Rails for railways	10,560	905,247	6,759	936,452
Rail braces, bars, fishplates, or splice bars and tie plates	268	29,123	638	67,260
Steel pipes and tubes	[1] 635,615	[1] 93,414,620	735,463	103,685,865
Wire:				
Barbed	66,598	8,762,116	90,029	11,522,607
Round wire, n.e.s	242,250	44,608,626	277,874	49,707,055
Telegraph, telephone, etc. except copper, covered with cotton jute, etc	[1] 781	[1] 357,761	1,751	1,012,236
Flat wire and iron and steel strips	86,366	17,337,359	99,607	23,107,292
Rope and strand	39,323	11,958,768	47,561	13,610,182
Galvanized fencing wire and wire fencing	73,042	9,641,734	50,762	6,887,012
Iron and steel used in card clothing	(4)	[1] 241,391	(4)	349,694
Hoop and band iron and steel, for baling	24,694	3,174,978	27,707	3,701,291
Hoop, band and strips, or scroll iron or steel, n.s.p.f	12,909	2,265,682	11,714	2,229,591
Nails	[1] 281,807	[1] 40,085,434	308,274	41,297,304
Steel castings and forgings	8,384	1,490,612	7,443	1,636,589
Total	[1] 4,243,340	[1] 513,978,162	5,517,364	646,746,956
Advanced manufactures:				
Bolts, nuts, and rivets	67,934	20,096,908	70,403	20,227,151
Chains and parts	9,506	6,102,429	9,243	6,200,689
Hardware, builders		2,961,011		2,748,845
Hinges and hinge blanks		1,875,449		2,014,423
Screws (wholly or chiefly of iron or steel)		3,137,480		3,629,403
Tools		20,071,345		18,672,207
Other		1,550,041		923,728
Total		55,794,663		54,416,446
Grand total		[1] 580,406,779		714,510,017

[1] Revised figure.
[2] Due to changes in classification of iron and steel plates by the Bureau of the Census, all classes of iron and steel plates and sheets for this table have been tabulated under "sheets and plates and steel n.s.p.f.", for 1963.
[3] Data are Jan.–Aug.; effective Sept. 1, 1963 saws were reported in number, Sept.–Dec., 127250 ($181,280).
[4] Weight not recorded.

Source: Bureau of the Census.

TABLE 16.—U.S. exports of major iron and steel products

Products	1962		1963	
	Short tons	Value	Short tons	Value
Semimanufactures:				
Steel ingots, blooms, billets, slabs, and sheet bars	[1] 252,998	[1] $20,526,277	304,516	$24,665,086
Iron and steel bars, and rods:				
Carbon-steel bars, hot-rolled, and iron bars	52,491	9,682,725	47,269	9,105,344
Concrete reinforcement bars	22,398	2,950,860	46,009	6,016,137
Other steel bars	27,731	12,037,785	24,901	12,352,386
Wire rods	17,006	3,853,784	24,033	4,145,703
Iron and steel plates, sheets, skelp, and strips:				
Plates, including boilerplate, not fabricated	119,856	26,187,475	139,483	26,389,591
Skelp iron and steel	11,528	1,121,853	2,482	234,626
Iron and steel sheets, galvanized	124,692	25,046,171	108,282	21,601,977
Steel sheets, black, unglavanized	458,073	102,825,501	457,610	114,057,783
Strip, hoop, band, and scroll iron and steel:				
Cold-rolled	33,196	15,784,152	37,732	17,625,323
Hot-rolled	31,617	6,779,069	51,297	11,260,004
Tinplate and terneplate	329,852	53,011,244	342,363	51,059,805
Tinplate circles, cobbles, strip, and scroll shear butts	24,633	2,756,006	23,355	2,489,110
Total	[1] 1,506,071	[1] 282,562,902	1,609,332	301,002,875
Manufactures-steel mill products:				
Structural iron and steel:				
Water, gas, and other storage tanks (unlined), complete and knockdown material	[1] 20,468	[1] 8,611,680	21,031	9,759,863
Structural shapes:				
Not fabricated	145,702	20,841,902	154,229	22,975,571
Fabricated	[1] 58,817	[1] 29,474,702	169,750	37,052,602
Plates and sheets, fabricated, punched, or shaped	[1] 15,945	[1] 5,429,148	16,463	5,645,433
Metal lath	1,215	479,552	1,163	477,968
Frames, sashes, and sheet piling	13,881	2,940,590	8,235	1,953,252
Railway-track material:				
Rails for railways	102,191	12,922,089	44,045	5,970,153
Rail joints, splices bars, fishplates, and tieplates	19,921	4,645,589	45,323	9,183,035
Switches, frogs, and crossings	3,816	1,158,206	3,867	1,582,820
Railroad spikes	381	110,574	3,436	1,071,737
Railroad bolts, nuts, washers, and nut locks	881	445,877	6,023	1,429,887
Tubular products:				
Boiler tubes	[1] 10,470	[1] 7,573,794	11,840	8,066,150
Casing and line pipe	86,083	27,581,701	122,520	34,501,999
Seamless black and galvanized pipe and tubes, except casing, line and boiler, and other pipes and tubes	[1] 32,077	[1] 8,699,114	42,553	12,074,972
Welded black pipe	[1] 10,158	[1] 3,097,688	7,357	2,069,338
Welded galvanized pipe	5,609	1,305,537	12,017	2,610,468
Malleable-iron screwed pipe fittings	1,192	1,389,825	1,279	1,308,765
Cast-iron pressure pipe and fittings	22,630	4,209,718	119,397	15,450,543
Cast-iron soil pipe and fittings	6,373	1,651,629	7,246	1,803,201
Iron and steel pipe, fittings, and tubing, n.e.c	[1] 50,205	[1] 41,929,545	58,743	46,352,732
Wire and manufactures:				
Barbed wire	12,896	2,685,658	23,178	4,294,517
Galvanized wire	10,108	3,116,705	22,492	6,025,095
Iron and steel wire, uncoated	16,206	5,504,412	21,477	6,956,824
Spring wire	1,469	986,920	1,418	915,333
Wire rope and strand	9,553	5,332,085	9,227	5,042,761
Woven-wire screen cloth	1,956	[2] 2,031,332	1,540	[2] 2,138,642
All other	[1] 15,591	[1] 9,680,812	17,160	10,798,742
Nails and bolts, iron and steel, n.e.c.:				
Wire nails, staples, and spikes	[1] 3,591	[1] 2,969,254	4,348	3,587,563
Bolts, screws, nuts, rivets, and washers, n.e.c	15,025	19,210,961	19,580	22,465,248
Tacks	692	455,429	671	455,958
Castings and forgings: Iron and steel, including car wheels, tires, and axles	[1] 64,425	[1] 24,575,538	76,766	25,533,033
Total	[1] 759,527	[1] 261,047,566	1,054,374	309,554,205

See footnotes at end of table.

TABLE 16.—U.S. exports of major iron and steel products—Continued

Products	1962		1963	
	Short tons	Value	Short tons	Value
Advanced manufactures:				
Building (prefabricated and knockdown)	------------	[1] $7,849,479	------------	$6,458,148
Chains and parts	7,993	10,069,098	8,189	11,201,215
Construction material	9,264	6,598,605	8,099	5,888,865
Hardware and parts	------------	23,563,072	------------	24,422,387
House-heating boilers and radiators	------------	6,666,330	------------	6,197,711
Oil burners and parts	------------	8,856,731	------------	9,712,142
Plumbing fixtures and fittings	------------	2,701,981	------------	4,987,304
Tools	------------	[1] 59,146,072	------------	39,725,808
Utensils and parts (cooking, kitchen, and hospital)	------------	3,774,726	------------	3,298,068
Other	------------	[1] 45,447,634	------------	53,391,629
Total	------------	[1] 174,673,728	------------	165,283,277
Grand total	------------	[1] 718,284,196	------------	775,840,357

[1] Revised figure.
[2] Includes wire cloth as follows: 1962, $1,455,917 (7,463,741 square feet); 1963, $1,638,819 (3,404,155 square feet).

Source: Bureau of the Census.

WORLD REVIEW [4]

World production of pig iron (including ferroalloys) reached a new high with a 5-percent increase. The largest increase, 6 million tons, was in the United States. World steel production increased 7 percent compared with 1962. The United States, with an increase in production of nearly 11 million tons, produced nearly 26 percent of the total world amount, but the 14-percent increase in production in Japan was the world's largest.

TABLE 17.—World production of pig iron (including ferroalloys) by countires [1] [2]

(Thousand short tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	3,327	4,318	4,436	5,064	5,427	6,059
Mexico	425	635	756	864	912	947
United States	71,294	62,135	68,620	66,717	67,636	73,853
Total	75,046	67,088	73,812	72,645	73,975	80,859
South America:						
Argentina	36	39	198	437	438	[3] 495
Brazil	1,333	1,750	1,965	2,050	2,064	[3] 2,205
Chile	356	320	293	314	422	461
Colombia	131	160	204	208	164	223
Venezuela	---------	---------	---------	6	136	333
Total	1,856	2,269	2,660	3,015	3,224	[3] 3,717

See footnotes at end of table.

[4] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

TABLE 17.—World production of pig iron (including ferroalloys) by countries [1] [2]—Continued

(Thousand short tons)

Country [1]	1954-58 (average)	1959	1960	1961	1962	1963
Europe:						
Austria	1,846	2,028	2,467	2,500	2,339	2,326
Belgium	5,925	6,575	7,223	7,104	7,439	7,622
Bulgaria	37	195	212	227	246	222
Czechoslovakia	3,613	4,679	5,176	5,480	5,732	5,792
Denmark	56	64	76	73	76	[3] 75
Finland	115	119	151	168	377	413
France	12,312	13,951	15,921	16,372	15,619	15,985
Germany:						
East	1,730	2,092	2,199	2,239	2,287	2,370
West (including Saar)	19,369	23,814	28,372	28,033	26,732	25,253
Hungary	980	1,217	1,373	1,440	1,523	1,530
Italy	2,082	2,416	3,113	3,528	4,054	4,264
Luxembourg	3,494	3,795	4,173	4,226	3,965	3,954
Netherlands	785	1,259	1,485	1,606	1,732	1,884
Norway	472	686	794	834	797	821
Poland	3,709	4,822	5,030	5,258	5,854	5,947
Portugal	[3] [4] 20	40	45	134	248	276
Rumania	662	933	1,118	1,211	1,666	1,881
Spain	1,144	1,889	2,124	2,340	2,374	2,194
Sweden	1,458	1,657	1,799	2,094	2,014	2,075
Switzerland	47	[3] 50	[3] 60	[3] 60	[3] 60	49
U.S.S.R. [5]	38,730	47,368	51,541	56,100	60,919	64,706
United Kingdom	14,511	14,092	17,655	16,517	15,335	16,342
Yugoslavia	676	995	1,123	1,161	1,216	1,168
Total [5]	113,773	134,736	153,230	158,705	162,604	167,149
Asia:						
China	[6] 5,800	[6] 22,600	30,300	[3] 16,500	[3] 16,500	[3] 18,700
India	2,201	3,519	4,705	5,621	6,522	7,431
Japan	6,899	10,908	13,604	18,059	20,325	22,525
Korea:						
North	247	765	940	1,025	1,337	[3] 1,280
Republic of	---------	9	15	10	---------	[3] 6
Taiwan (Formosa)	17	36	26	58	69	60
Thailand	3	8	7	6	6	7
Turkey [7]	235	260	272	260	323	233
Total [5]	15,402	38,105	49,869	41,539	45,082	50,242
Africa:						
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	71	79	95	243	266	276
South Africa, Republic of	1,513	1,992	2,204	2,566	2,680	2,691
United Arab Republic (Egypt)	[8] 17	130	163	[3] 110	[3] 110	---------
Total	1,601	2,201	2,462	2,919	3,056	2,967
Oceania: Australia [9]	2,288	2,829	3,240	3,549	3,879	[10] 4,032
World total (estimate)	209,970	247,230	285,270	282,370	291,820	308,970

[1] Pig iron is also produced in Republic of the Congo, but quantity produced is believed insufficient to affect estimate of world total.
[2] This table incorporates some revisions. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[3] Estimate.
[4] One year only as 1958 was the first year of commercial production.
[5] U.S.S.R. in Asia included with U.S.S.R. in Europe.
[6] Based on figures from Chinese sources. 1958 does not include approximately 4,000,000 tons produced of sub-standard grade iron produced at small plants. 1959 production probably includes pig iron obtained from reworking the low-grade product of 1958 and an unreported quantity (probably relatively small) of sub-standard iron from small plants most of which were shut down early in the year.
[7] Includes foundry iron through 1962.
[8] Average annual production 1955-58.
[9] Includes scrap.
[10] Excludes ferroalloys.

TABLE 18.—World production of steel ingots and castings by countries [1]

(Thousand short tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	4,492	5,901	5,790	6,466	7,173	8,190
Mexico	955	1,473	1,657	1,882	1,896	2,235
United States [2]	103,707	93,446	99,282	98,014	98,328	109,261
Total	109,154	100,820	106,729	106,362	107,397	119,686
South America:						
Argentina	290	236	305	486	711	987
Brazil	[3] 1,519	2,072	2,530	2,756	[4] 2,870	[4] 2,980
Chile	381	457	465	400	546	539
Colombia	88	121	173	194	151	219
Peru	[5] 22	56	66	83	79	80
Venezuela	[4] 55	[4] 55	52	83	248	401
Total	2,355	2,997	3,591	4,002	4,605	5,206
Europe:						
Austria	2,305	2,769	3,487	3,418	3,274	3,249
Belgium	6,509	7,096	7,923	7,728	8,115	8,294
Bulgaria	140	254	279	375	466	508
Czechoslovakia	5,357	6,764	7,460	7,764	8,421	8,375
Denmark	269	322	349	356	405	396
Finland	207	262	285	305	335	346
France	14,306	16,617	18,907	19,211	19,004	19,353
Germany:						
East	2,980	3,535	3,678	3,796	3,993	3,997
West (including Saar)	25,608	32,446	37,589	36,881	35,895	34,830
Greece	85	99	[4] 140	[4] 150	[4] 170	[4] 180
Hungary	1,661	1,939	2,080	2,263	2,572	2,617
Ireland	32	44	44	31	21	22
Italy	6,299	7,454	9,071	10,283	10,755	11,195
Luxembourg	3,611	4,038	4,502	4,534	4,420	4,445
Netherlands	1,231	1,841	2,141	2,173	2,301	2,582
Norway	288	470	540	550	539	599
Poland	5,369	6,790	7,585	7,974	8,470	8,823
Rumania	875	1,565	1,991	2,344	2,702	2,981
Spain	1,469	1,995	2,157	2,579	2,547	2,606
Sweden	2,481	3,155	3,547	3,922	3,982	4,297
Switzerland [6]	213	276	303	327	351	342
U.S.S.R. [7]	53,242	66,107	71,973	77,990	84,106	88,427
United Kingdom	22,452	22,609	27,222	24,737	22,950	25,222
Yugoslavia	987	1,432	1,590	1,689	1,758	1,750
Total [7]	157,976	189,879	214,843	221,380	227,552	235,436
Asia:						
China	5,050	[8] 14,720	[8] 20,340	10,500	11,000	13,000
India	1,939	2,726	3,623	4,488	5,635	6,576
Israel	[9] 14	26	44	68	88	74
Japan	11,673	18,330	24,403	31,160	30,364	34,724
Korea:						
North	226	497	707	855	1,157	1,127
Republic of	13	42	55	73	163	176
Taiwan (Formosa)	80	175	220	218	201	303
Thailand	4	7	8	9	8	[4] 8
Turkey	195	236	292	312	267	365
Total [7]	19,194	36,759	49,692	47,683	48,883	56,353
Africa:						
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	62	51	95	101	88	55
South Africa, Republic of	1,804	2,091	2,328	2,738	2,903	3,124
United Arab Republic (Egypt) [4]	103	110	150	165	165	410
Total	1,969	2,252	2,573	3,004	3,156	3,589
Oceania: Australia	2,934	3,803	4,137	4,351	4,667	5,040
World total (estimate)	293,580	336,510	381,560	386,780	396,260	425,310

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Data from American Iron and Steel Institute. Excludes production of castings by companies that do not produce steel ingots.
[3] Includes iron castings.
[4] Estimate.
[5] One year only as 1958 was the first year of commercial production.
[6] Including secondary.
[7] U.S.S.R. in Asia included with U.S.S.R. in Europe.
[8] Claimed figures. Data appear to be exaggerated by a fifth or more.
[9] Average annual production 1957–58.

NORTH AMERICA

Canada.—The Algoma Steel Corp. at Sault Ste. Marie, Ontario, equipped two blast furnaces with coke oven gas injection to reduce coke consumption and increase hot metal production. They are planning to use screened sinter also.

The Steel Co. of Canada, Ltd., announced plans for the installation of a 148-inch-wide plate mill, claimed to be the widest in Canada. The company also announced plans to build a research center for steel production in Burlington, near Hamilton, Ontario.

Construction started on a steel rolling mill with an annual capacity of 25,000 tons at Calgary, Alberta. The mill will use steel from an electric arc furnace using scrap feed.

Costa Rica.—Costa Rica has issued a charter to Cia. de Hierro del Pacifico, S.A., to exploit the black sand deposits at Caldera on the Pacific Coast. Iron for steelmaking will then be extracted by the R–N process, now used only in Japan, which leaves a titanium-rich slag which will be stockpiled.

SOUTH AMERICA

Argentina.—Construction of a $200 million integrated steel mill at Rio Santiago, in La Plata province, is being considered jointly by Propulsora Siderurgica, S.A., and Italian interests.

Brazil.—Usinas Siderurgicas de Minas Gerais (USMINAS) attained a nominal capacity of 500,000 tons of steel ingots during 1963. Financing from France has been obtained for study of the problems of erecting a 750,000 ingot-ton steel mill at Santa Cruz.

Chile.—The Export-Import Bank has granted a loan of $8.3 million to Cia. de Acero del Pacifico to finance the expansion of its steel mill at Huachipato. An oxygen plant producing 110 tons per day is planned for the mill. In addition, financing has been arranged for 2,000 single-family homes to be erected in the area for steel mill employees.

Venezuela.—Venezuela announced plans to construct a plant to convert ore into reduced or sponge iron, with a projected output of 5 million tons by 1970 and 10 million tons by 1975. About 80 percent of the output will be exported.

EUROPE

European Coal and Steel Community (ECSC).—At the end of 10 years, steel production in the European Coal and Steel Community was nearly double the production in 1953. Internal trade expanded more than five times, constituting over 20 percent of the total ECSC trade.

In December, the ministers of the European Coal and Steel Community decided not to raise tariffs as some member nations had been demanding. Italy, with the highest tariffs, and the Netherlands, with the lowest, both opposed any revision. The ECSC ministers were aware of U.S. opposition to any tariff raise, and fear of U.S. tariff retaliation may have been a factor in their decision.[5]

[5] Wall Street Journal. V. 162, No. 109, Dec. 3, 1963, p. 7.

A rolling mill complex which includes a blooming mill, a continuous billet mill, and a wire rod mill has been started by Cockerill-Ougree at Liege, Belgium. The new complex costs about $40 million and will handle about 792,000 short tons annually.

An inspection technique for continuous cast steel was developed by the National Metallurgy Research Center of Brussels, Belgium. As the cast section emerges from the water-cooled mold, a low-energy gamma ray, like that from cobalt 60, is beamed upon the steel and the results are evaluated automatically.[6]

Allegheny-Longdoz dedicated their new plant at Genk, Belgium, near Liège, on November 7.

Usinor of Dunkirk increased blast furnace capacity by 5,000 tons daily with the addition of two blast furnaces during 1963.

Finland.—Except for a 10-percent gain in pig iron production compared with 1962, the iron and steel industry suffered slight losses in production in 1963.

Sweden.—The iron and steel industry set new records in 1963, producing over 4 million short tons of crude steel and over 2 million tons of pig iron. Exports exceeded imports by 54 percent, a 20-percent gain over that of 1962.

The erection of a new tube rolling mill has been started at Hofors Bruk by A.B. Svenska Kullagerfabriken (SKF). The mill will have an annual capacity of 35,000 to 40,000 tons. The SKF-Hofors Works is installing an IBM 1710 unit to control steel production by electronic data processing from steel furnace to rolling mill.

A research institute in steelmaking processes to be sponsored jointly by the State-owned iron ore mining company and the Swedish Ironmasters' Association is to be erected at Luleå in northern Sweden.

Sandvik Steel Works Co., Ltd., started production of stainless steel tubing by a new process under license from Cefilac of France. The initial capacity is 12,000 tons per year.

United Kingdom.—The English Steel Co.'s new Tinsley Park steelworks in Sheffield was opened October 15. The $73 million plant has a rated capacity of 500,000 ingot tons of alloy steel per year. There are two 100-ton electric arc furnaces with a DH degassing plant. Use of the degassing plant makes possible the production of two different steels from one heat by the addition of alloys under the vacuum.[7]

The British Iron and Steel Research Association (BISRA) has completed experimental work on spray refining as a desiliconizing technique and now intends to investigate the possibilities of developing the process for continuous steelmaking.[8]

BISRA has an agreement with Thomas strip division of the Pittsburgh Steel Co. allowing the latter to use their process of aluminizing steel strip known as Elphal (electrophoretic deposition of aluminum).[9]

Two 100-ton capacity L-D (Linz-Donawitz) basic oxygen steel furnaces built by Head Wrightson & Co., Ltd., were floated down the River Tees to a place where they were loaded on the South Africa

[6] Steel. V. 153, No. 5, July 29, 1963, p. 20.
[7] Metal Bulletin (London). No. 4838, Oct. 15, 1963, p. 9.
[8] Journal of Metals. V. 15, No. 7, July 1963, p. 471.
[9] Steel & Coal (London). V. 186, No. 4941, Mar. 29, 1963, p. 615.

Star for their journey to Australia. The two 90-ton L–D furnaces will be installed at the Broken Hill Pty. Co., Ltd., at Whyalla, Australia.

ASIA

Japan.—Continuous casting has been used in Japan since 1955. Sumitomo Metal Industries purchased a license for the Concast process in 1954. Then, in 1957, Yawata Steel Co. leased the same process. In 1961, four other major producers introduced the Mannesmann continuous casting process. In 1963 Kobe Steel Works signed an agreement with the Soviet license agency for use of the Russian continuous casting process.[10]

Nippon Kokan KK., has an output of 3.3 million tons of steel operating eight L–D basic oxygen converters and six open-hearth furnaces. The company expects to be producing about 90 percent of its steel by using L–D oxygen converters when they complete their modernization.

Yawata Iron & Steel Co., Ltd., has been testing the Nakajima process of producing steel by direct reduction of iron ore for several years in a 5–ton pilot plant. The Nakajima process employs a fluidized bed with heavy oil used for fuel and reduction, although pulverized coal or natural gas can serve also. The process yields molten steel as a final product instead of sponge iron.[11]

Hot-rolled H-shaped steel bars with tapered flanges for higher tensile strength are being produced for the highway construction industry by Nippon Kokan KK.

The Fuji Iron and Steel Co., Ltd. may have come up with a substitute for tinplate. Two investigators found that steel sheet could be plated with about 0.002 mills of chromium then lacquered and deep drawn as easily as tinplate. Successful food packaging tests with the new plate have been carried on since August 1959.[12]

Singapore.—The National Iron and steel Mill dedicated its first steel plant in Singapore. Initial capacity is 70,000 tons annually.

AFRICA

Ethiopia.—An iron and steel foundry producing 25 tons of ingot and 30 tons of iron bar per day was dedicated by the Emperor on February 13, 1963. The new plant is located at Akaki, about 12 miles from Addis Ababa.

Rhodesia and Nyasaland, Federation of.—A steel castings foundry using a three-electrode arc furnace is under construction in Southern Rhodesia. It is planned to make castings for agricultural implements.

Uganda.—The Steel Corp. of East Africa, Ltd., joins the growing list of world producers, announcing production of two heats per day of 10 to 12 tons each. It is expected to produce 24,000 tons of finished steel products annually under full capacity.

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[10] Journal of Metals. V. 15, No. 12, December 1963, p. 881.
[11] Skillings Mining Review. V. 52, No. 38, Sept. 21, 1963, pp. 1, 4.
[12] Metal Progress. V. 83, No. 1, January 1963, p. 113.

OCEANIA

Australia.—Steelmaking capacity in Australia at the beginning of 1963 was 4.9 million tons. A new blast furnace installed at the Broken Hill Pty. Co., Ltd. steel works at Newcastle has a rated capacity of 1,400 tons per day.

The KM-Steel Products Ltd. of Richmond recently commissioned the first continuous casting plant of Australia. The new plant will use the patented operations of Concast A.G. of Zurich, Switzerland, and is designed for casting billets from 2 to 4½ square inches as well as slabs up to a size of 8 by 4½ inches in twin-strand operation.

Australia joined the list of steelmakers using basic oxygen converters when the first of two 200-ton-capacity basic oxygen converters were tapped in recently at the Broken Hill Newcastle steelworks.

TECHNOLOGY

The application of continuous casting to commercial production in the United States was a major highlight of 1963. In Roanoke, Va., Babcock & Wilcox built a continuous casting unit for the Roanoke Electric Steel Corp. Twenty-two tons of low-carbon and medium-carbon steel can be cast into approximately 700 feet of 4½-inch-square ingots in approximately 40 minutes. Surface and subsurface quality of the cast bar is outstanding, the finished product being free of pipe and surface defects. The casting moulds are 42 inches long and are cold drawn from either brass or copper tubing. The plant itself is 45 feet wide by 60 feet long and is built up to 80 feet above ground level.

Also United States Steel Corp. officially announced the development of commercial continuous casting. Another source reported that United States Steel Corp. had changed from a 25-ton electric furnace to a 40-ton basic oxygen furnace to produce the steel for its continuous casting machine. In addition to this, United States Steel used vacuum degassing in the ladles after the furnace tap and before teeming into its continuous casting machine.[13]

Two twin-strand casting units for the Connors Steel Division of the H. K. Porter Co. and one twin-strand casting unit, capable of producing two billets, for the Seaway Steel Division of Roblin-Seaway Steel Industries, Inc., were being designed and built by the Koppers Co. One machine for making large slabs was ordered by McLouth Steel Corp., Detroit, with Concast A.G. of Zurich, Switzerland, as the contractor.

Von Moos'sche Eisenwerke of Lucerne, Switzerland, installed a curved mold in its continuous casting unit. Since the curved mold installation requires much less height and space, as well as less control equipment, the initial cost is said to be 40- to 50-percent lower than that for conventional continuous casting units.[14]

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[13] United States Steel Corp. 1963 Annual Report, 1964.
[14] Shah, Raymond. Curved Mold Lowers Silhouette of Continuous Casting Line. Iron Age, v. 192, No. 5, Aug. 1, 1963, pp. 58–59.

Pressure pouring or pressure casting is another step in the continuous effort to improve efficiency. Pressure casting can be used to cast steel slabs up to 28 feet long weighing up to 20 tons or to cast shapes in permanent graphite molds such as steel wheels for railroad cars. The controlled pressure pouring process was developed by Griffin Wheel Co., a subsidiary of Amsted Industries, Inc. For the past several years Lebanon Steel Co., under license from Amsted, has used the technique to cast items such as turbine blades and valve bodies. Amsted now has Controlled Pressure Pouring license agreements with nine steel producers: United States Steel Corp., Washington Steel Corp., Michigan Seamless Tube Co., Carpenter Steel Co., McLouth Steel Corp., Eastern Stainless Steel Corp., Roblin-Seaway Industries Inc., Youngstown Sheet & Tube Co., and Sharon Steel Corp. Three of these producers; U.S. Steel, McLouth Steel, and Roblin-Seaway Industries, also are already operating or building continuous casting lines. Although Amsted engineers claim that the process can be used to cast any quality steel, including low-carbon, most of the licensees, including for example United States Steel, are planning to use the process for stainless and alloy steel slabs and billets. Among other advantages, Amsted engineers claim that slabs cast with the pressure pouring process have a smooth surface finish which requires little or no conditioning. In addition, less molten metal is wasted with pressure pouring. And finally, tests have given slab yields which average about 95 percent of the melt as compared with lower yields for conventional ingot practice.[15]

Washington Steel Corp. started to break in its new pressure-casting equipment for making steel slabs at its new plant in Houston, Pa. The equipment is said to be capable of producing three 10-ton slabs or a single large slab weighing 20 tons from each pouring of its electric furnaces. The equipment is licensed by Amsted Industries, Inc., which developed the technique for the manufacture of cast steel railroad wheels.

Washington Steel says yield on this process is at least 95 percent from molten metal to finished slab. On conventional processing the yield is a little more than 70 percent. Grinding loss is reckoned at about 1 percent where normal loss in stainless conditioning is from 5 to 8 percent.[16]

Phoenix Steel Corp. awarded an engineering contract to Concast Inc. for a continuous casting machine at its Claymont, Del., plant.

The most rapidly developing segment of the steelmaking industry, however, was the basic oxygen converter. During 1963 the following commitments to install basic oxygen converters were announced: United States Steel, three at Gary, Ind., and Republic Steel, two each at Gadsden, Ala., Cleveland, Ohio, and Warren, Ohio.

Inland Steel Co. started work on the second phase of its expansion program. The major facility will be an oxygen steelmaking shop capable of turning out 230 tons of raw steel every 30 minutes. The new oxygen shop will replace an existing 12-furnace open-hearth shop.

Armco Steel Corp. spent $50 million for the Nation's newest L–D process basic oxygen equipment, constructing a plant consisting of

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[15] Journal of Metals. Pressure Pouring Steel Shapes Now on Stream. V. 15, No. 11, November 1963, p. 814.

[16] McManus, G. J. Washington Praises Pressure Casting. Iron Age, v. 193, No. 4, Jan. 23, 1964, p. 25.

two 140-ton vessels, each equipped with a hot-water-steaming hood and dry electrostatic precipitators at Ashland, Ky. This gives the firm 1.4 million tons per year of basic oxygen capacity. Adjacent to the plant is a 680-ton-per-day oxygen supply plant built and operated by Air Products and Chemicals Inc. This plant is the world's largest single-customer oxygen facility.[17]

Jones & Laughlin in its Cleveland shop on July 17, 1963, produced a 239.4-ton heat in 27 minutes from tap-to-tap. This is equivalent to the exceptionally high rate of 532 tons per furnace hour. Although this is only a one-heat mark, it is a useful gauge of the inherent potential of the basic oxygen process under optimum conditions.[18]

Allegheny Ludlum Steel Corp. of Pittsburgh signed a licensing agreement with Henry J. Kaiser Co., Oakland, Calif., for the experimental use of the L–D process for oxygen steelmaking at its Brackenridge, Pa., works to see if the basic oxygen furnace (BOF) can be used for producing Allegheny alloy steels. The first product to be tried will be silicon electrical steel.[19]

Electric furnaces will be producing 15 percent of the U.S. steel output by 1970 at the present rate of growth. In the last 3 years U.S. steelmakers have installed or are in the process of installing electric-arc furnaces with a combined total capacity of 3,847,000 tons of carbon steel per year.[20]

The Colorado Fuel and Iron Corp. announced plans to replace the nine-furnace open-hearth shop at its Roebling plant in New Jersey with three electric-arc furnaces of 45-ton capacity.

A 100-ton electric steelmaking furnace was put into operation at the Mansfield, Ohio, plant of the Universal-Cyclops Steel Corp. The addition of this new furnace put the company's capacity at between 825,000 and 850,000 tons a year.

The results of two-stage electric furnace smelting tests on high-iron manganiferous materials was reported by Bureau of Mines engineers.[21]

The first U.S. blast furnace controlled by punched paper tape and designed for later installation of a process computer for entirely automated operation was installed at the Duquesne works of the United States Steel Corp. The furnace has a hearth diameter of 28 feet and is expected to reach an output of 4,000 or more tons per day. A major advance in ironmaking practice incorporated in the furnace is an automatic electronically controlled system for weighing, measuring, and feeding iron ore, coke, and other raw materials. The control system was designed to give the operator maximum flexibility in operation and maximum system reliability.[22]

Jones & Laughlin Steel Corp. put a new 29-foot-hearth blast furnace in operation at its Cleveland works. The new furnace has an initial capacity of 2,500 tons per day with an ultimate capacity of 3,500 tons per day. This is one of the first furnaces in the industry to have

[17] Iron and Steel Engineer. Armco's Ashland Works Practically Rebuilt in Last 10 years. V. 40, No. 12, December 1963, pp. 133–140.

[18] Stephens, William J. Technical Advances in Steelmaking. Iron & Steel Eng., v. 40, No. 11, November 1963. pp. 77–80.

[19] Metalworking News. Allegheny Licensed for L–D Process. V. 4, No. 153, Aug. 12, 1963, p. 10.

[20] Journal of Metals. Growing Use of Electrics. V. 15, No. 12, December 1963, pp. 881–882.

[21] Peterman, F. B., and R. S. Lang. Two-Stage Electric Furnace Smelting of High-Iron Manganiferous Materials for Producing Ferromanganese. BuMines Rept. of Inv. 6225, 1963, 10 pp.

[22] Howard, H. Highly Automated "Dorothy" at Duquesne Works Aims at Free World Record in Ironmaking. Am. Metal Market, v. 70, No. 104, May 31, 1963, p. 16. Iron and Steel Engineer. New Blast Furnace Has Unique Control System. V. 40, No. 7, July 1963, pp. 178, 181.

screening in the materials stockhouse for sinter and pellets. Materials are taken from the stockhouse on conveyor belts controlled by a punch-tape system. The principal burden will be sinter with pellets available later. The hot metal will be used to feed basic oxygen converters.[23]

Also Armco put into operation its new 3,340-ton-per-day blast furnace, Amanda. Charging and stockhouse functions are fully automatically programmed.[24]

Solid fuel injection experiments on a commercial blast furnace, the No. 2 blast furnace at the Hanna Furnace Corp., have demonstrated that coal injection is both technically and economically feasible. A one-to-one coal to coke replacement ratio has been obtained when injecting coal into the blast furnace at a rate of about 17 percent of the total blast furnace fuel requirements.[25] The Weirton Steel Co. No. 4 blast furnace is the fifth commercial blast furnace to be equipped with solid-fuel injection system. So far coal has been injected at rates up to 15 percent of the total furnace fuel requirements.[26]

Substantial coke savings with fuel-oil injection was reported by engineers of the Bureau of Mines. Oil-to-coke replacement ratios have been calculated for various conditions, and oil is compared with natural gas.[27]

There have been several modifications of blast furnaces. The Colorado Fuel and Iron Corp. introduced a major modification on blast furnace D at the Pueblo Plant with the installation of Venturi gas washers. This wet cleaning system thoroughly removes the flue dust from the gas, thus considerably reducing stove maintenance.[28] Another trend which seems to be on the increase is the use of pellets. Great Lakes Steel Corp. has slated the use of pellitized iron ore instead of sintered ore as a fuel for its four blast furnaces.

Vacuum melting gained additional recognition. A vacuum induction furnace with a 60,000-pound capacity of hot metal or 30,000 pounds of cold metal is part of a $5.5 million melt shop under construction in Latrobe Steel Co., Latrobe, Pa. The unit is designed to operate at vacuums as low as 1 to 5 microns.[29] A new vacuum-induction furnace with a total melt capacity of 15,000 to 20,000 pounds per heat was put in operation by the Carpenter Steel Co. In full production it will boost Carpenter's total vacuum-melting capacity from 10,000 tons per year to over 20,000 tons per year. This figure includes 11,000 tons from vacuum-induction furnaces and 9,000 tons from vacuum consumable-electrode furnaces. The new furnace can refine and cast hot metal under a vacuum of five microns.[30]

Special Metals, Inc., New Hartford, N.Y., placed a vacuum induction melting furnace in operation. It has a power rating of 1,000

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[23] Iron & Steel Engineer. Jones & Laughlin Dedicates Blast Furnace at Cleveland Works. V. 41, No. 1, January 1964, pp. 115–116.

[24] Steel. Armco Shows Its New Blast Furnace, Oxygen Facilities. V. 153, No. 23, Dec. 2, 1963, pp. 31, 33.

[25] Strassburger, J. R. Experiences With Injection of Coal. Blast Furnace and Steel Plant, v. 51, No. 6, June 1963, pp. 447–457.

[26] Dietz, J. R. Solid Fuel Injection at Weirton. J. Metals, v. 15, No. 7, July 1963, pp. 499–501.

[27] Woolf, P. F., and W. M. Mahan. Fuel-Oil Injection in an Experimental Blast Furnace. BuMines Rept. of Inv. 6150, 1963, 23 pp.

[28] Blast Furnace & Steel Plant. Washers Placed on Blast Furnace. V. 51, No. 1, January 1963, p. 69.

[29] Iron and Steel Engineer. Latrobe Installs Hot Metal Vacuum Induction Steel Unit. V. 40, No. 12, December 1963, pp. 167–168.

[30] Journal of Metals. Largest Vacuum-Induction Furnace on Stream. V. 15, No. 12, December 1963, p. 878.

kilowatts and is capable of melting 16,000 pounds of steel in approximately 3½ hours.[31]

Braeburn Alloy Steel Division of Continental Copper & Steel Industries, Inc., Braeburn, Pa., announced the installation of a new consumable-electrode vacuum arc remelt furnace for the production of clean, superstrength steels and alloys.[32]

A circular describing vacuum melting processes and the applications to the steel industry was issued by the Bureau of Mines.[33]

Sealed Power Corp., Muskegon, Mich., used 85 to 90 percent of borings and turnings in its melting charges for a new induction furnace that operates on 60-cycle line current. The design of the new furnace is such that a high percentage of metal is being recovered from these marginal materials. This means that the company is now using borings which it formerly sold for $10 a ton to replace pig iron and scrap which it had to buy at a much higher price.

Caldwell Foundry and Machinery Co., Inc., Birmingham, Ala., started construction of a stainless steel casting plant in the fall to be completed within 90 days. New equipment to be installed included a $40,000 induction furnace. Vacuum also was being used more after melting. Construction has been started on a 300-ton vacuum degassing unit at United States Steel Corp.'s south works. The quality steel produced in the vacuum degassing unit will be used primarily for high temperature materials, gears, bearings, missile motor cases, forgings, and other applications where exceptional stresses are encountered.[34]

The St. Louis Die Casting Corp., St. Louis, Mo., found that they could increase from 165,000 to 410,000 the number of castings obtained from a single set of dies by using vacuum-melted steel, such as the Carpenter furnace will put out.[35]

Republic Steel Corp. reported the awarding of a contract to build the world's largest waste heat boiler. The boiler is designed to reclaim heat from the waste gases of two oxygen-lanced open-hearth furnaces.[36] Six new waste heat boilers of a type designed to accommodate the larger quantity of higher temperature gases released during oxygen-blown open-hearth steelmaking will bring to 11 the number ordered for United States Steel's Homestead, Pa., district works.[37]

A steam-cooled roof which has been in service for a year on an electric furnace may change the technology not only in electric furnaces but every other type of steelmaking furnace. The construction may make it possible to put a tilting roof on an open hearth and convert it to a top-loading oxygen type. A hybrid furnace of this type would combine the best features of oxygen and open-hearth steelmaking—the fast melting and fast loading of the oxygen furnace and the economies of unlimited scrap usage of the open hearth.[38]

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[31] Iron and Steel Engineer. V. 40, No. 4, April 1963, p. 207.
[32] Iron and Steel Engineer. Braeburn Alloy Steel Division Adds New Units. V. 40, No. 2, February 1963, p. 131.
[33] Kerr, James R. Vacuum Melting of Steel. BuMines Inf. Cir. 8136, 1962, 32 pp.
[34] Iron and Steel Engineer. Vacuum Degassing Unit Is Under Construction. V. 40, No. 12, December 1963, p. 202
[35] Steel. Vacuum Melted Steel Doubles Die Life. V. 152, No. 6, Feb. 11, 1963, p. 101.
[36] Blast Furnace & Steel Plant. V. 51, No. 10, October 1963, p. 920.
[37] Iron and Steel Engineer. To Install Waste Heat Boilers at Homestead. V. 40, No. 4, April 1963, p. 207.
[38] Milhaupt, Thomas. Cooled Roofs May Save Steelmen Buck a Ton. Steel, v. 153, No. 24, Dec. 9, 1963, pp. 96–98.

Sharon Steel Corp., Sharon, Pa., reported its two Stora-Kaldo furnaces differed from other Kaldo operations in that they are equipped with two oxygen lances, a low and a high-pressure lance. This provides better control of carbon, phosphorus, sulfur, hydrogen, oxygen, and nitrogen. Because of the high thermal efficiency which results from the burning of the carbon monoxide formed during the reaction within the furnace, the use of up to 50 percent scrap is permitted in the total metallics charged. This gives about 1⅜ tons of steel per ton of hot metal as opposed to 1 ton of steel per ton of hot metal when iron ore is used.[39] To allow more latitude for ladle additions, the Lynchburg Foundry Co., division of Woodward Iron Co., awarded a contract for the fabricaton of two 11-ton shaking ladles. The shaking ladle achieves high mixing efficiencies because of a patented circular motion which creates a rotating wave and breaker on the surface of the metal bath, thus providing rapid and intimate contact between the metal and added reagents.

Nondestructive testing gained wider acceptance in the steel industry. Efforts were made to apply tests at the assembly line in order to eliminate faulty products at an early stage rather than to reject defects in the finished product. A nondestructive testing technique has been devised to investigate damage of cast iron due to severe nonfracturing impact. Dr. Elizabeth Plénard of the Technical Center of French Foundries, Paris, and Dr. Antoni Karamara of the Polish Foundry Institute, both working at the Paris Center on a joint Franco-Polish research project are reported to have developed methods based on changes in the magnetic properties accompanying alterations in the internal structure of castings under various kinds of impact.[40]

A new sonic testing technique has been devised for routine quality control inspection of ductile iron castings. Although it will not detect tiny flaws it can be used to evaluate physical properties that can be correlated with the elastic moduli.[41]

Bureau of Mines engineers had some degree of success using an electrochemical cell to analyze high-purity iron.[42]

Analyses of samples taken from the stack, bosh, and hearth of an experimental blast furnace quenched with cold nitrogen instead of hot blast air are given in a report by Bureau of Mines engineers.[43]

A method of monitoring the efficiency of iron production in an experimental blast furnace was described by the Bureau of Mines. The technique, called gravimetric because it involves weighing procedures, permits continuous and direct analysis of all constituents in the furnace top or exit gas. When analysis indicates too much or too little of a given substance in this gas, a deficiency in furnace operation is indicated.[44] Much research has been done on continuous monitoring of temperatures in open-hearth blast furnace and electric arc

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[39] Oswald, R. C. Kaldo Operations in North America. Blast Furnace and Steel Plant, v. 51, No. 9, September 1963, pp. 783–786.
[40] Steel & Coal (London). Magnetic Diagnosis of Cast Iron. V. 187, No. 4978, Dec. 13, 1963, p. 1190.
[41] Iron Age. Test Tunes in Tensile Properties. V. 192, No. 5, Aug. 1, 1963, pp. 60–61.
[42] Kilau, H. W., and J. P. Hansen. Experiments in Using an Electrochemical Cell to Analyze High-Purity Iron. BuMines Rept. of Inv. 6183, 1963, 11 pp.
[43] Morris, J. P., and P. L. Woolf. Examination of an Experimental Iron Blast Furnace After Quenching With Nitrogen. BuMines Rept. of Inv. 6217, 1963, 36 pp.
[44] Kusler, David J. An Improved Gravimetric Method for Analyzing Blast Furnace Top Gas. BuMines Rept. of Inv. 6168, 1963, 21 pp.

furnace. Radiation or optical pyrometers or thermocouples are being used. Various types of refractory jackets are being developed in order to protect the instruments during constant immersion.[45]

Nuclear gauging techniques found increased use in the steel industry. Moisture gauges, burden level indicators, bulk density gauges, and bulk flow gauges are some of the new applications using radioisotopes.

Advanced mathematical and computer techniques are being applied to steelmaking research. Scientists of the U.S. Bureau of Mines have issued a report on the development of a thermochemical model of a blast furnace. Analysis is made of the behavior of a hypothetical furnace with contrasting types of air flow, turbulent and nonturbulent.[46]

One mathematical model is used to describe the sources, availability, chemistry, and the cost of iron ores. In 2½ hours on one of the largest digital computors commercially available, the cheapest overall allocation for current requirements for iron ore can be determined. Blast furnace performance improvement has been facilitated by the development of a second mathematical model which simulates the many complex chemical reactions which take place within the furnace. Calculation time is dramatically reduced here by a medium-sized electronic digital computor. A third model which uses an analog computer has been used to describe the operation of blast furnace stoves.[47] Jones & Laughlin Steel Corp. set up a thermochemical model of a blast furnace to predict the performance of blast furnaces. These predictions have shown the significance of high blast temperature in increasing iron production and in reducing coke rate. It was found that instrumentation should be used to give (1) better analysis of burden, (2) top gas analysis, (3) gas pressure at various stack positions, (4) hearth temperatures, and (5) heat balance indications.[48] The increased use of oxygen in open-hearth furnaces even more than the change from open-hearth to basic-oxygen has caused a considerable change in the refractory industry. At first, of course, the use of oxygen greatly increased the burnup of the refractory lining but sheer necessity speeded up the modification and improvement of refractory linings until the cost of bricks per ton of ore has now been decreased because of the increased output of the furnaces.[49]

Nine research projects costing $100,000 were announced by the Steel Founders' Society of America for 1963–64. Among the projects planned are better gating systems for steel castings, destructive testing to determine the influence of surface discontinuities, deoxidation of molten steel to improve ductility and toughness, desulfurization to

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[45] Foundry. Pyrometer Reads Molten Iron Temperatures Continuously. V. 91, No. 11, November 1963, p. 86.
Iron Age. Monitoring Molten-Metal Baths. V. 192, No. 15, Oct. 10, 1963, p. 160.
Sharp, John D. Continuous Temperature Measurement of Molten Steel. J. of Metals, v. 15, No. 12, December 1963, pp. 902–903.

[46] St. Clair, Hillary W. Developing a Thermochemical Model for the Iron Blast Furnace. Model of Ideal Furnace at Equilibrium. BuMines Rept. of Inv. 6233, 1963, 38 pp.

[47] Stephens, William J. Technological Advances in Steelmaking. Iron & Steel Eng., v. 40, No. 11, November 1963, pp. 77–80.

[48] Morgan, E. R., W. F. Huntley, and S. Vajda. The Rejuvenated Blast Furnace, Use of the Thermochemical Model. Steel & Coal (London), v. 186, No. 4942, Apr. 5, 1963, pp. 668–670.

[49] Chesters, J. H. Lining the New Steel Furnaces. New Scientist (London), v. 18, No. 338, May 9 1963, pp. 326–329.

improve mechanical properties, ladle linings and metallic abrasives for blast cleaning.[50]

Automatic programming of rolling mill operation probably represents the most significant advance made in this part of the steel industry.[51] Ninety-percent reductions in a single pass are claimed for a new type of rolling mill that features small diameter rolls that oscillate in the rolling direction 860 times a minute or more. Additional laboratory work is being planned by Dr. Karel Saxel, Imperial Metal Industries, England.[52]

Battelle Memorial Institute studied high-density compacting of iron powder seeking to determine the feasibility of achieving densities of over 99 percent in iron and iron-base compacts as compared with the current upper density limits of about 97.2 percent. A technique of pressing and condensing specimens prior to high-velocity compacting produced densities of 99.3 to 99.9 percent for pure iron and somewhat less for steels. Several electrolytic iron specimens were pressed at 20,000 to 60,000 psi, sintered 1 hour at 2,000° F in hydrogen, and then compacted explosively at about 400 feet per second.[53] The Alberta Research Council process for producing high-purity iron powders from low-grade iron ore will be tested in a large-scale pilot plant to be built this year by Peace River Mining and Smelting Co., Ltd., Edmonton, Alberta.[54]

The high degree of corrosion-resistance of plastic-coated steel was demonstrated under practical conditions at the pickle fan house of the plant of the company producing this steel. Sheets of the plastic-coated steel in position for as long as 14 months were found capable of further prolonged use. This is in contrast to a 5- or 6-week period of total use for galvanized steel sheet.[55]

An improved grade of grain oriented-electrical steel, with the lowest core loss limit ever offered by the steel industry, was claimed by Armco Steel Corp. M-4 oriented steel will be produced in 11-mill thickness and will be available in coils from ⅛ to 31 inches in width. Maximum core loss at 60 cycles and 15 kilogausses for M-4 is 0.53 watts per pound. Base price of the new steel is $21.70 per hundred pounds.

The International Nickel Co., Inc., announced development of a cast maraging steel with a tensile strength of approximately 250,000 psi, a yield strength of 240,000 psi, and a minimum elongation of 8 percent. The strengthening results from the precipitation of intermetallic nickel compounds such as nickel-titanium, nickel-aluminum, or other nickel combinations in a martensitic matrix.[56] International Nickel Co., Inc., has also developed a cryogenic iron alloy. This alloy designated as type D-2M austenitic ductile iron combines excellent castability and ease of manufacture with exceptional low-temperature metallurgical and mechanical properties. At temperatures as low as −423° F, the alloy exhibits superior resistance to brittle fracture.[57]

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[50] Foundry. Steel Founders Add $100,000 to Research Expenditures. V. 91, No. 11, November 1963, p. 119.

[51] Iron Age. Six-Stand Rolling Mill Steps Up Coil Stock Production Rates. V. 192, No. 25, Dec. 19, 1963, pp. 82–83.

[52] Steel. Oscillating Rolling Mill Holds High Speed Promise. V. 153, No. 27, Dec. 30, 1963, pp. 13–14.

[53] Journal of Metals. Dense Metal Compacts. V. 15, No. 12, December 1963, p. 882.

[54] Chemical Engineering. V. 70, No. 10, May 13, 1963, p. 83.

[55] South African Mining & Engineering Journal (Johannesburg). Plastic Coated Steel Resists Acid Fumes. V. 74, pt. 1, No. 3653, Feb. 8, 1963, p. 321.

[56] Journal of Metals. Cast Maraging Steel. V. 15, No. 3, March 1963, p. 179.

[57] Journal of Metals. Cyrogenic Iron Alloy. V. 15, No. 1, January 1963, p. 12.

New York City Transit Authority announced a decision to purchase 600 stainless steel subway cars. The Transit Authority estimated that noncorrosive, lightweight stainless cars will save $6 million in power and maintenance costs over a projected 35-year life. Improved appearance also is achieved. Western Pacific Railroad added 18 stainless steel covered hopper cars to its original 12-car fleet. The decision was prompted by analysis of operating costs. Preparation costs prior to loading foodstuffs average $70 per load for regular cars and $1.50 per load for stainless steel cars. Stainless steel tank trucks also have proved advantageous for transporting alcoholic beverages because of ease of cleaning, lighter weight of metal, and economies of bulk haulage.[58] Type 304 stainless steel was reported to be the most desirable material for cryogenic containers of 1,000-gallon or less capacity. This conclusion is based on reliability, ease of repair and welding, and metal cost.[59]

Stainless steel can be made porous with the internal arrangement of the fibers in random pattern so that densities as low as 5 percent of the solid can be achieved. The porosity can also be controlled up to 95 percent.

Stainless steel double disk gate valves were substituted for groups of steel diaphragm and plug valves in an electrolytic zinc plant. An outstanding record of maintenance-free service has been claimed.[60]

There was renewed interest in the use of stainless steel for razor blades; stainless steel table flatware; stainless steel extrusions used in window mullions; automobile trim both in the domestic and foreign market; automatic home washers made of stainless; copper plated stainless steel coil springs; and explosive-formed denture plates.

Du Pont announced work on the coating of carbon steel with diffused stainless steel which if successful would compete with chromium plating and solid stainless steel. The coating may be applied before or after the steel is fabricated.[61]

The application of new high-strength building steels was recognized in building codes. The city of Chicago amended its code to provide for six grades of structural steel instead of the one approved under the old specification.[62]

Three new high-strength structural steels, ASTM A242, A440, and A441 were accepted by amendments to the New York City building construction code.

Six different grades of structural steel were used in the truss span of the new John Day highway bridge near the Columbia River, to keep the structural members uniform in size and reduce weight and fabrication costs. Engineers specified A441, A7, A36, A373, A440, and a special heat-treated steel.[63]

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[58] Stainless Outlook. (The Committee of Stainless Steel Producers, American Iron and Steel Institute). No. 19, August 1963, pp. 1–2.

[59] Materials in Design Engineering. What Metal for Cryogenic Containers? V. 57, No. 6, June 1963, pp. 162, 164.

[60] Canadian Mining Journal (Canada). Stainless Steel Gate Valves in Zinc Plant. V. 84, No. 1, January 1963, pp. 52–53.

[61] Chemical & Engineering News. V. 41, No. 12, March 25, 1963, p. 39.

[62] Engineering News-Record. V. 171, No. 18, Oct. 31, 1963, p. 9.

[63] Engineering News-Record. Six Kinds of Structural Steel Make a Highway Bridge. V. 170, No. 26, June 27, 1963, pp. 30–32.

Use of two new improved structural vanadium steels was reported to have saved $100,000 in the erection of a new library at Johns Hopkins University in Baltimore.

North American Aviation Inc. plans to use increasingly large amounts of maraging steel in the No. 2 and No. 3 B–70 aircraft in what is probably the first major application of this high-nickel steel.

Inland Steel Co. has produced a new high strength structural steel called INX 70 containing either columbium or vanadium (minimum of 0.01 percent of either element). Copper added as an alloying element boosts corrosion resistance.[64]

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[64] Chemical & Engineering News. V. 41, No. 21, May 27, 1963, p. 39.

Iron and Steel Scrap

By Robert A. Whitman[1]

SCRAP use increased 13 percent during 1963. The results of several research projects were announced during the year. The British Iron & Steel Research Association (BISRA) revealed its fuel-oxygen-scrap process (FOS), which uses up to 100 percent cold scrap. Several proprietary techniques for increasing the use of scrap in basic oxygen converters have been developed in West Germany, Austria, and Spain.

Demand for scrap in the second quarter of 1963 built up to 22 million tons, making this quarter one of the best since 1959. The total charge of scrap iron and steel plus pig iron in steelmaking furnaces increased 11 percent over that of 1962. There was an increase of 14 percent in the amount of scrap in the charge. The ferrous scrap was 46 percent of the total charge. In May, the peak month for steel production, steelmaking furnaces consumed 78 percent of all scrap used.

TABLE 1.—Salient iron and steel scrap, and pig iron statistics in the United States

(Short tons)

	1962	1963
Stocks Dec. 31:		
Scrap at consumer plants	[1] 8,471,472	7,937,166
Pig iron at consumer and supplier plants	[1] 3,067,060	2,806,046
Total	[1] 11,538,532	10,743,212
Consumption:		
Scrap	66,159,747	74,620,730
Pig iron	66,595,482	72,688,740
Imports for consumption, scrap (including tinplate scrap)	210,127	217,207
Exports, iron and steel scrap	[1] 5,112,266	6,363,617
Price: Scrap, No. 1 heavy-melting, Pittsburgh, average—per long ton	[1 2] $28.55	$26.51
Value: Scrap, all grades, for export [3]	[1] $32.65	$30.73

[1] Revised figure.
[2] Iron Age.
[3] As computed from export data obtained from the Bureau of the Census.

[1] Commodity specialist, Division of Minerals.

LEGISLATION AND GOVERNMENT PROGRAMS

Public Law 88–50, enacted June 29, 1963, extended for 1 year from July 1 suspension of duties on imports of scrap metal.

The Business and Defense Services Administration of the U.S. Department of Commerce and the Bureau of Mines of the U.S. Department of the Interior were collaborating on a comprehensive study of the scrap industry's major economic problems.

The Bureau of Mines continued its countrywide study of the effects of the changing technology of steelmaking on the iron and steel scrap industry.

AVAILABLE SUPPLY

There was an increase of 8.2 million tons of iron and steel scrap available in 1963, an increase of over 12 percent above that available in 1962. There was 10 percent more home scrap produced than in 1962. The 32.2 million short tons of scrap received from dealers and all other sources represented a gain of 4.7 million short tons or over 17 percent more than in 1962. Of the total new supply, home-produced scrap represented 2 percent less of the total scrap consumed than in 1962, while that from dealers represented 43 percent of the total scrap charge, a reversal of the recent trend. These data exclude scrap on hand in dealers' yards.

TABLE 2.—Iron and steel scrap supply[1] available for consumption in 1963, by districts and States

(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	76,725	85,416	162,141	6,882	155,259
Maine and New Hampshire	3,933	5,625	9,558	766	8,792
Massachusetts	76,747	111,869	188,616	4,264	184,352
Rhode Island	39,728	58,946	98,674	2,909	95,765
Vermont	8,660	14,426	23,086	185	22,901
Total:					
1963	205,793	276,282	482,075	15,006	467,069
1962	224,887	259,412	484,299	15,412	468,887
Middle Atlantic:					
New Jersey	189,970	520,280	710,250	19,587	690,663
New York	1,991,430	1,091,999	3,083,429	61,322	3,022,107
Pennsylvania	9,621,833	4,804,506	14,426,339	494,802	13,931,537
Total:					
1963	11,803,233	6,416,785	18,220,018	575,711	17,644,307
1962	10,963,659	5,914,735	16,878,394	728,849	16,149,545
East North Central:					
Illinois	4,092,178	3,955,557	8,047,735	162,540	7,885,195
Indiana	5,548,669	3,193,609	8,742,278	164,581	8,577,697
Michigan	4,116,323	3,687,436	7,803,759	61,769	7,741,990
Ohio	8,259,133	5,127,876	13,387,009	881,821	12,505,188
Wisconsin	570,612	440,561	1,011,173	116,761	894,412
Total:					
1963	22,586,915	16,405,039	38,991,954	1,387,472	37,604,482
1962	20,470,219	13,504,556	33,974,775	871,616	33,103,159

See footnotes at end of table.

TABLE 2.—Iron and steel scrap supply [1] available for consumption in 1963, by districts and States—Continued

(Short tons)

District and State	Home production	Receipts from dealers and all others	Total new supply	Shipments [2]	New supply available for consumption
West North Central:					
Iowa	210, 574	310, 261	520, 835	2, 871	517, 964
Kansas and Nebraska	43, 152	81, 909	125, 061	8, 321	116, 740
Minnesota	245, 389	227, 529	472, 918	9, 636	463, 282
Missouri	215, 639	759, 151	974, 790	19, 849	954, 941
Total:					
1963	714, 754	1, 378, 850	2, 093, 604	40, 677	2, 052, 927
1962	653, 971	1, 223, 629	1, 877, 600	28, 253	1, 849, 347
South Atlantic:					
Delaware and Maryland	2, 472, 641	395, 597	2, 868, 238	193, 593	2, 674, 645
Florida and Georgia	92, 136	308, 530	400, 666	1, 112	399, 554
North Carolina	21, 806	56, 924	78, 730	1, 948	76, 782
South Carolina	17, 405	22, 029	39, 434	159	39, 275
Virginia and West Virginia	921, 358	1, 138, 064	2, 059, 422	6, 137	2, 053, 285
Total:					
1963	3, 525, 346	1, 921, 144	5, 446, 490	202, 949	5, 243, 541
1962	3, 287, 803	1, 635, 793	4, 923, 596	154, 436	4, 769, 160
East South Central:					
Alabama	1, 554, 599	1, 358, 030	2, 912, 629	197, 983	2, 714, 646
Kentucky, Mississippi, Tennessee	709, 742	1, 125, 272	1, 835, 014	65, 906	1, 769, 108
Total:					
1963	2, 264, 341	2, 483, 302	4, 747, 643	263, 889	4, 483, 754
1962	2, 027, 769	2, 141, 941	4, 169, 710	236, 164	3, 933, 546
West South Central:					
Arkansas, Louisiana, Oklahoma	60, 729	147, 429	208, 158	1, 552	206, 606
Texas	821, 881	891, 048	1, 712, 929	39, 595	1, 673, 334
Total:					
1963	882, 610	1, 038, 477	1, 921, 087	41, 147	1, 879, 940
1962	708, 371	881, 709	1, 590, 080	6, 466	1, 583, 614
Rocky Mountain:					
Arizona and Nevada	32, 238	131, 529	163, 767	702	163, 065
Colorado, Idaho, Montana, Utah	1, 105, 760	568, 152	1, 673, 912	44, 975	1, 628, 937
Total:					
1963	1, 137, 998	699, 681	1, 837, 679	45, 677	1, 792, 002
1962	913, 856	457, 404	1, 371, 260	8, 364	1, 362, 896
Pacific Coast:					
California and Hawaii	1, 401, 495	1, 232, 893	2, 634, 388	233, 538	2, 400, 850
Oregon and Washington	132, 248	395, 094	527, 342	9, 790	517, 552
Total:					
1963	1, 533, 743	1, 627, 987	3, 161, 730	243, 328	2, 918, 402
1962	1, 394, 105	1, 479, 322	2, 873, 427	165, 223	2, 708, 204
U.S. total:					
1963	44, 654, 733	32, 247, 547	76, 902, 280	2, 815, 856	74, 086, 424
1962	40, 644, 640	27, 498, 501	68, 143, 141	2, 214, 783	65, 928, 358

[1] New supply available for consumption is a net figure computed by adding home production to receipts from dealers and all others and deducting consumers scrap shipped, transferred, or otherwise disposed of during the year. The plus or minus difference in stock levels at the beginning and end of the year are not taken into consideration.
[2] Includes scrap shipped, transferred, or otherwise disposed of during the year.

TABLE 3.—Consumption of iron and steel scrap and pig iron in the United States in 1963, by type of consumer and type of furnace or equipment

(Short tons)

Type of furnace or equipment	Type of consumer		
	Scrap	Pig iron	Total
	Manufacturers of steel ingots and castings [1]		
Open-hearth	40,010,987	57,213,772	97,224,759
Basic oxygen converter	2,776,166	7,082,218	9,858,384
Bessemer	143,191	1,602,801	1,745,992
Electric [2]	10,927,933	149,104	11,077,037
Total steelmaking furnaces	53,858,277	66,047,895	119,906,172
Cupola	1,011,451	286,622	1,298,073
Air	35,772	12,126	47,898
Blast [3]	4,305,584		4,305,584
Direct castings		2,242,503	2,242,503
Miscellaneous	80,115		80,115
Total:			
1963	59,291,199	68,589,146	127,880,345
1962	51,966,442	62,194,729	114,161,171
	Manufacturers of steel castings [4]		
Open-hearth	626,153	77,659	703,812
Bessemer	12,892	71	12,963
Electric	1,832,274	32,418	1,864,692
Total steelmaking furnaces	2,471,319	110,148	2,581,467
Cupola	311,158	14,555	325,713
Air	271,219	45,466	316,685
Miscellaneous			
Total:			
1963	3,053,696	170,169	3,223,865
1962	2,890,672	178,731	3,069,403
	Iron foundries and miscellaneous users		
Bessemer	1,328	195	1,523
Electric [2]	174,875	30,112	204,987
Total steelmaking furnaces	176,203	30,307	206,510
Cupola	10,597,381	3,295,414	13,892,795
Air	1,010,255	119,937	1,130,192
Direct castings		483,767	483,767
Ferroalloy	345,375		345,375
Miscellaneous	146,621		146,621
Total:			
1963	12,275,835	3,929,425	16,205,260
1962	11,302,633	4,222,022	15,524,655
	Total		
Open-hearth	40,637,140	57,291,431	97,928,571
Basic oxygen converter	2,776,166	7,082,218	9,858,384
Bessemer	157,411	1,603,067	1,760,478
Electric [2]	12,935,082	211,634	13,146,716
Total steelmaking furnaces	56,505,799	66,188,350	122,694,149
Cupola	11,919,990	3,596,591	15,516,581
Air	1,317,246	177,529	1,494,775
Blast [3]	4,305,584		4,305,584
Direct castings		2,726,270	2,726,270
Ferroalloy	345,375		345,375
Miscellaneous	226,736		226,736
Total:			
1963	74,620,730	72,688,740	147,309,470
1962	66,159,747	66,595,482	132,755,229

[1] Includes only those castings made by companies producing steel ingots.
[2] Includes small quantities of scrap and pig iron consumed in crucible furnaces and vacuum melting.
[3] Includes consumption in all blast furnaces producing pig iron.
[4] Excludes companies that produce both steel ingots and steel castings.

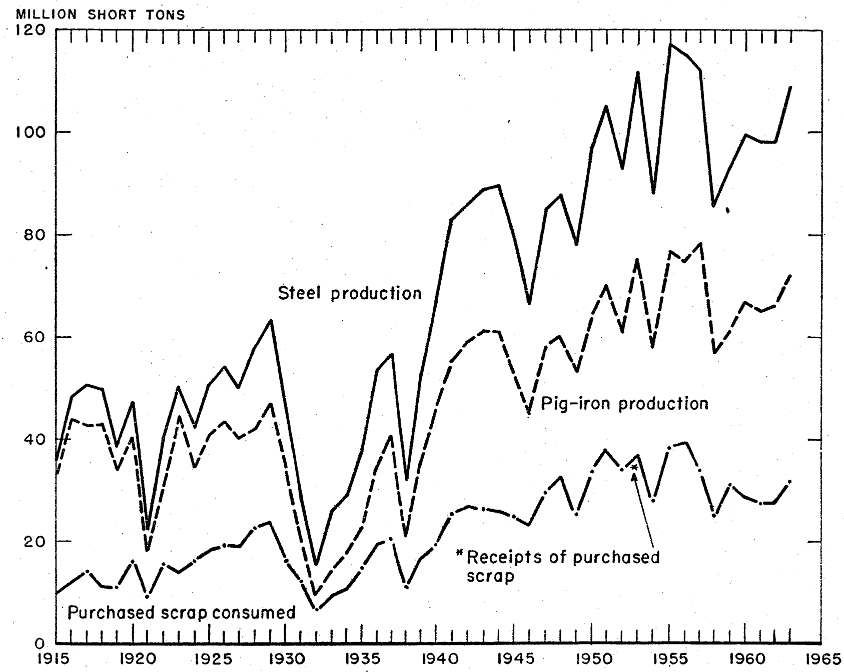

FIGURE 1.—Consumption of purchased scrap in the United States, 1915–52, and output of pig iron and steel, 1915–63. Figures on consumption of purchased scrap from 1915–32 are from *State of Minnesota* v. *Oliver Iron Mining Co., et al.*, Exhibits, v. 5, 1935, p. 328; those for 1933–34 are estimated by author; and those for 1935–52 are based on Bureau of Mines records. Data for 1953–63 represent receipts of purchased scrap by consumers, based on Bureau of Mines records. Data on steel output were supplied by the American Iron & Steel Institute.

TABLE 4.—Proportion of iron and steel scrap and pig iron used in furnaces in the United States

(Percent)

Type of furnace	1962		1963	
	Scrap	Pig iron	Scrap	Pig iron
Open-hearth	40.3	59.7	41.5	58.5
Basic oxygen converter	26.9	73.1	28.2	71.8
Bessemer	11.6	88.4	8.9	91.1
Electric[1]	97.8	2.2	98.4	1.6
Cupola	75.9	24.1	76.8	23.2
Air	86.7	13.3	88.1	11.9

[1] Includes crucible furnaces and vacuum melting.

CONSUMPTION BY DISTRICTS AND STATES

Every geographical district but New England increased consumption of scrap during 1963. The East North Central district had the largest tonnage increase with 4.6 million short tons, but the Rocky Mountain district increased scrap use by 25 percent over 1962. The

East North Central, Middle Atlantic, South Atlantic, and East South Central districts took 88 percent of the total scrap consumed. The four principal consuming States were Pennsylvania, Ohio, Indiana, and Illinois, with 19, 17, 12, and 11 percent, respectively. This order has not changed for the last 5 years.

TABLE 5.—Consumption of iron and steel scrap and pig iron in the United States in 1963, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut	151,574	30,802	182,376
Maine and New Hampshire	9,410	1,741	11,151
Massachusetts	184,057	49,025	233,082
Rhode Island	95,308	42,660	137,968
Vermont	22,232	6,020	28,252
Total:			
1963	462,581	130,248	592,829
1962	465,938	144,275	610,213
Middle Atlantic:			
New Jersey	679,313	113,289	792,602
New York	3,156,230	3,837,813	6,994,043
Pennsylvania	13,856,777	17,460,390	31,317,167
Total:			
1963	17,692,320	21,411,492	39,103,812
1962	16,079,603	19,450,778	35,530,381
East North Central:			
Illinois	8,011,085	4,837,935	12,849,020
Indiana	8,617,150	9,863,042	18,480,192
Michigan	7,689,383	6,531,984	14,221,367
Ohio	12,633,270	12,556,922	25,190,192
Wisconsin	907,647	173,669	1,081,316
Total:			
1963	37,858,535	33,963,552	71,822,087
1962	33,273,089	31,056,461	64,329,550
West North Central:			
Iowa	507,968	74,685	582,653
Kansas and Nebraska	123,805	5,850	129,655
Minnesota	481,715	454,249	935,964
Missouri	908,272	33,490	941,762
Total:			
1963	2,021,760	568,274	2,590,034
1962	1,927,293	551,965	2,479,258
South Atlantic:			
Delaware and Maryland	2,850,601	4,844,795	7,695,396
Florida and Georgia	378,021	12,306	390,327
North Carolina	73,835	30,213	104,048
South Carolina	47,595	17,949	65,544
Virginia and West Virginia	2,029,738	2,229,954	4,259,692
Total:			
1963	5,379,790	7,135,217	12,515,007
1962	4,530,521	6,812,179	11,342,700
East South Central:			
Alabama	2,725,278	3,427,531	6,152,809
Kentucky, Mississippi, Tennessee	1,759,703	963,950	2,723,653
Total:			
1963	4,484,981	4,391,481	8,876,462
1962	4,041,573	3,956,540	7,998,113
West South Central:			
Arkansas, Louisiana, Oklahoma	205,318	7,990	213,308
Texas	1,738,614	942,427	2,681,041
Total:			
1963	1,943,932	950,417	2,894,349
1962	1,698,224	788,528	2,486,752

TABLE 5.—Consumption of iron and steel scrap and pig iron in the United States in 1963, by districts and States—Continued

(Short tons)

District and State	Scrap	Pig iron	Total
Rocky Mountain:			
Arizona and Nevada	167,835	92	167,927
Colorado, Idaho, Montana, Utah	1,625,699	2,230,501	3,856,200
Total:			
1963	1,793,534	2,230,593	4,024,127
1962	1,432,365	2,013,123	3,445,488
Pacific Coast:			
California and Hawaii	2,448,861	1,891,049	4,339,910
Oregon and Washington	534,436	16,417	550,853
Total:			
1963	2,983,297	1,907,466	4,890,763
1962	2,711,141	1,821,633	4,532,774
U.S. total:			
1963	74,620,730	72,688,740	147,309,470
1962	66,159,747	66,595,482	132,755,229

TABLE 6.—Consumption of iron and steel scrap and pig iron by districts and States, by type of manufacturers in 1963

(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:						
Connecticut	48,744		4,712	165	98,118	30,637
Maine and New Hampshire			2,416	135	6,994	1,606
Massachusetts			5,926	485	178,131	48,540
Rhode Island	56,877	26,217			38,431	16,443
Vermont					22,232	6,020
Total:						
1963	105,621	26,217	13,054	785	343,906	103,246
1962	97,189	21,784	13,052	497	355,697	121,994
Middle Atlantic:						
New Jersey	189,161	19,742	54,540	2,073	435,612	91,474
New York	2,422,281	3,661,000	132,992	9,752	600,957	167,061
Pennsylvania	12,796,152	17,249,728	416,875	42,133	643,750	168,529
Total:						
1963	15,407,594	20,930,470	604,407	53,958	1,680,319	427,064
1962	13,807,063	18,484,721	558,688	69,944	1,713,852	896,113
East North Central:						
Illinois	6,470,197	4,409,766	424,158	14,833	1,116,730	413,336
Indiana	7,824,103	9,635,931	170,504	14,399	622,543	212,712
Michigan	4,712,033	5,951,172	131,690	1,890	2,845,660	578,922
Ohio	10,747,238	11,978,054	500,319	54,956	1,385,713	523,912
Wisconsin			291,779	4,966	615,868	168,703
Total:						
1963	29,753,571	31,974,923	1,518,450	91,044	6,586,514	1,897,585
1962	25,981,994	29,071,781	1,404,145	83,757	5,886,950	1,900,923
West North Central:						
Iowa			37,545	357	470,423	74,328
Kansas and Nebraska			88,188	321	35,617	5,529
Minnesota	304,744	408,672	44,103	110	132,868	45,467
Missouri	695,948	2,430	104,668	6,682	107,656	24,378
Total						
1963	1,000,692	411,102	274,504	7,470	746,564	149,702
1962	944,534	401,522	253,613	6,471	729,146	143,972

See footnotes at end of table.

TABLE 6.—Consumption of iron and steel scrap and pig iron by districts and States, by type of manufacturers in 1963—Continued

(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
South Atlantic:						
Delaware and Maryland	2,728,930	4,836,141	31,932	648	89,739	8,006
Florida and Georgia	326,696	----------	14,413	104	36,912	12,202
North Carolina	----------	----------	----------	----------	73,835	30,213
South Carolina	----------	----------	----------	----------	47,595	17,949
Virginia and West Virginia	1,675,985	2,108,598	62,518	8,283	291,235	113,073
Total:						
1963	4,731,611	6,944,739	108,863	9,035	539,316	181,443
1962	3,959,612	6,600,840	107,383	10,064	463,526	201,275
East South Central:						
Alabama	1,791,533	2,623,470	54,277	181	879,468	803,880
Kentucky, Mississippi, Tennessee	1,211,074	760,312	26,479	1,483	522,150	202,155
Total:						
1963	3,002,607	3,383,782	80,756	1,664	1,401,618	1,006,035
1962	2,715,567	3,162,937	100,792	1,371	1,225,214	792,232
West South Central:						
Arkansas, Louisiana, Oklahoma	102,273	----------	54,288	913	48,757	7,077
Texas	1,271,725	874,402	102,654	582	364,235	67,443
Total:						
1963	1,373,998	874,402	156,942	1,495	412,992	74,520
1962	1,188,408	725,079	145,757	1,526	364,059	61,923
Rocky Mountain:						
Arizona and Nevada	89,540	----------	54,279	92	24,016	----------
Colorado, Idaho, Montana, Utah	1,432,808	2,224,066	31,522	835	161,369	5,600
Total:						
1963	1,522,348	2,224,066	85,801	927	185,385	5,600
1962	1,137,939	2,002,109	86,329	1,109	208,097	9,905
Pacific Coast:						
California and Hawaii	1,976,400	1,806,143	127,469	2,133	344,992	82,773
Oregon and Washington	416,757	13,302	83,450	1,658	34,229	1,457
Total:						
1963	2,393,157	1,819,445	210,919	3,791	379,221	84,230
1962	2,134,136	1,723,956	220,913	3,992	356,092	93,685
U.S. total:						
1963	59,291,199	68,589,146	3,053,696	170,169	12,275,835	3,929,425
1962	51,966,442	62,194,729	2,890,672	178,731	11,302,633	4,222,022

[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 the United States in 1963, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England and Middle Atlantic:			
New Jersey and Rhode Island	244, 339	45, 959	290, 298
New York	2, 145, 609	3, 567, 721	5, 713, 330
Pennsylvania	8, 816, 258	14, 124, 359	22, 940, 617
Total:			
1963	11, 206, 206	17, 738, 039	28, 944, 245
1962	10, 360, 862	16, 731, 831	27, 092, 693
East North Central:			
Illinois	3, 968, 002	4, 018, 214	7, 986, 216
Indiana	7, 658, 043	9, 489, 283	17, 147, 326
Michigan and Wisconsin	2, 434, 049	2, 712, 417	5, 146, 466
Ohio	6, 574, 669	9, 930, 651	16, 505, 320
Total:			
1963	20, 634, 763	26, 150, 565	46, 785, 328
1962	18, 783, 393	25, 086, 132	43, 869, 525
West North Central: Minnesota and Missouri	330, 228	414, 858	745, 086
Total:			
1963	330, 228	414, 858	745, 086
1962	396, 823	405, 968	802, 791
South Atlantic: Delaware, Maryland, West Virginia	3, 970, 967	6, 946, 690	10, 917, 657
Total:			
1963	3, 970, 967	6, 946, 690	10, 917, 657
1962	3, 197, 439	6, 604, 207	9, 801, 646
East and West South Central: Alabama, Kentucky, Texas	2, 465, 960	3, 890, 589	6, 356, 549
Total:			
1963	2, 465, 960	3, 890, 589	6, 356, 549
1962	2, 210, 832	3, 555, 734	5, 766, 566
Rocky Mountain and Pacific Coast: California, Colorado, Utah	2, 029, 016	2, 150, 690	4, 179, 706
Total:			
1963	2, 029, 016	2, 150, 690	4, 179, 706
1962	1, 834, 241	2, 125, 398	3, 959, 639
U.S. total:			
1963	40, 637, 140	57, 291, 431	97, 928, 571
1962	36, 783, 590	54, 509, 270	91, 292, 860

TABLE 8.—Consumption of iron and steel scrap and pig iron in Bessemer converters in the United States, by districts

District	Scrap	Pig iron	Total
New England and Middle Atlantic:			
1963	79, 872	772, 918	852, 790
1962	54, 271	269, 510	323, 781
East North Central:			
1963	72, 486	830, 149	902, 635
1962	45, 422	522, 054	567, 476
West South Central and Rocky Mountain:			
1963	5, 053		5, 053
1962	4, 407	10	4, 417
U.S. total:			
1963	157, 411	1, 603, 067	1, 760, 478
1962	104, 100	791, 574	895, 674

TABLE 9.—Consumption of iron and steel scrap and pig iron in electric[1] steel furnaces in the United States in 1963, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut and New Hampshire	61,040	1,367	62,407
Massachusetts	5,926	485	6,411
Total:			
1963	66,966	1,852	68,818
1962	65,005	1,565	66,570
Middle Atlantic:			
New Jersey	29,106	2,653	31,759
New York	204,084	4,499	208,583
Pennsylvania	2,512,691	42,094	2,554,785
Total:			
1963	2,745,881	49,246	2,795,127
1962	2,228,435	41,985	2,270,420
East North Central:			
Illinois	1,983,775	19,266	2,003,041
Indiana	122,701	3,261	125,962
Michigan	525,314	6,142	531,456
Ohio	2,433,470	38,992	2,472,462
Wisconsin	203,560	4,697	208,257
Total:			
1963	5,268,820	72,358	5,341,178
1962	4,388,712	100,769	4,489,481
West North Central:			
Iowa, Kansas, Nebraska	129,278	736	130,014
Minnesota and Missouri	780,587	2,716	783,303
Total:			
1963	909,865	3,452	913,317
1962	783,554	1,933	785,487
South Atlantic:			
Delaware and Maryland	101,165	1,669	102,834
Florida, Georgia, North Carolina	336,503	161	336,664
Virginia and West Virginia	179,536	100	179,636
Total:			
1963	617,204	1,930	619,134
1962	610,844	2,141	612,985
East South Central:			
Alabama	538,539	53,808	592,347
Kentucky, Mississippi, Tennessee	510,451	2,087	512,538
Total:			
1963	1,048,990	55,895	1,104,885
1962	945,511	60,466	1,005,977
West South Central:			
Arkansas, Louisiana, Oklahoma	154,185	2,620	156,805
Texas	614,213	6,019	620,232
Total:			
1963	768,398	8,639	777,037
1962	642,403	22,244	664,647
Rocky Mountain: Arizona, Colorado, Nevada, Utah	164,772	446	165,218
Total:			
1963	164,772	446	165,218
1962	104,527	653	105,180
Pacific Coast:			
California and Hawaii	846,623	3,341	849,964
Oregon and Washington	497,563	14,475	512,038
Total:			
1963	1,344,186	17,816	1,362,002
1962	1,102,172	8,184	1,110,356
U.S. total:			
1963	12,935,082	211,634	13,146,716
1962	10,871,163	239,940	11,111,103

[1] Includes small quantities of scrap and pig iron consumed in crucible furnaces and vacuum melting.

TABLE 10.—Consumption of iron and steel scrap and pig iron in cupola furnaces in the United States in 1963, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut	58, 355	22, 874	81, 229
Maine and New Hampshire	4, 435	353	4, 788
Massachusetts	175, 374	47, 201	222, 575
Rhode Island	28, 468	15, 324	43, 792
Vermont	22, 232	6, 020	28, 252
Total:			
1963	288, 864	91, 772	380, 636
1962	286, 685	108, 402	395, 087
Middle Atlantic:			
New Jersey	402, 496	90, 269	492, 765
New York	529, 681	159, 454	689, 135
Pennsylvania	514, 212	156, 472	670, 684
Total:			
1963	1, 446, 389	406, 195	1, 852, 584
1962	1, 370, 745	420, 141	1, 790, 886
East North Central:			
Illinois	975, 909	174, 848	1, 150, 757
Indiana	563, 765	207, 898	771, 663
Michigan	3, 218, 459	654, 981	3, 873, 440
Ohio	1, 470, 731	352, 771	1, 823, 502
Wisconsin	543, 718	140, 015	683, 733
Total:			
1963	6, 772, 582	1, 530, 513	8, 303, 095
1962	5, 976, 189	1, 525, 499	7, 501, 688
West North Central:			
Iowa	336, 542	72, 191	408, 733
Kansas and Nebraska	35, 572	5, 529	41, 101
Minnesota	141, 662	42, 017	183, 679
Missouri	111, 473	22, 802	134, 275
Total:			
1963	625, 249	142, 539	767, 788
1962	564, 981	136, 921	701, 902
South Atlantic:			
Maryland	113, 702	8, 788	122, 490
Florida	6, 896	3, 104	10, 000
Georgia	29, 037	9, 098	38, 135
North Carolina	73, 616	30, 156	103, 772
South Carolina	38, 207	17, 949	56, 156
Virginia	270, 275	99, 937	370, 212
West Virginia	9, 210	11, 433	20, 643
Total:			
1963	540, 943	180, 465	721, 408
1962	475, 807	199, 658	675, 465
East South Central:			
Alabama	819, 048	809, 980	1, 629, 028
Kentucky	186, 659	48, 494	235, 153
Tennessee	284, 659	154, 650	439, 309
Total:			
1963	1, 290, 366	1, 013, 124	2, 303, 490
1962	1, 132, 798	798, 352	1, 931, 150
West South Central:			
Louisiana and Oklahoma	46, 411	5, 370	51, 781
Texas	361, 846	106, 186	468, 032
Total:			
1963	408, 257	111, 556	519, 813
1962	356, 186	85, 752	441, 938
Rocky Mountain: Colorado, Montana, Utah	169, 873	37, 204	207, 077
Total:			
1963	169, 873	37, 204	207, 077
1962	191, 150	35, 249	226, 399
Pacific Coast:			
California	349, 176	81, 281	430, 457
Oregon and Washington	28, 291	1, 942	30, 233
Total:			
1963	377, 467	83, 223	460, 690
1962	355, 557	92, 390	447, 947
U.S. total:			
1963	11, 919, 990	3, 596, 591	15, 516, 581
1962	10, 710, 098	3, 402, 364	14, 112, 462

TABLE 11.—Consumption of iron and steel scrap and pig iron in air furnaces in the United States in 1963, by districts and States

(Short tons)

District and State	Scrap	Pig iron	Total
New England:			
Connecticut	33,430	6,625	40,055
Massachusetts, New Hampshire, Rhode Island	15,279	3,711	18,990
Total:			
1963	48,709	10,336	59,045
1962	52,731	12,421	65,152
Middle Atlantic:			
New Jersey and New York	25,224	9,448	34,672
Pennsylvania	181,250	43,999	225,249
Total:			
1963	206,474	53,447	259,921
1962	195,735	60,927	256,662
East North Central:			
Illinois	211,051	12,419	223,470
Indiana	75,094	16,789	91,883
Michigan	184,824	4,593	189,417
Ohio	402,665	38,860	441,525
Wisconsin	105,912	26,043	131,955
Total:			
1963	979,546	98,704	1,078,250
1962	886,083	97,391	983,474
West North Central: Iowa, Minnesota, Missouri	10,404	7,290	17,694
Total:			
1963	10,404	7,290	17,694
1962	10,989	7,004	17,993
South Atlantic: West Virginia	10,870	6,132	17,002
Total:			
1963	10,870	6,132	17,002
1962	9,286	6,173	15,459
East and West South Central: Alabama and Texas	54,925	1,261	56,186
Total:			
1963	54,925	1,261	56,186
1962	49,630	1,153	50,783
Pacific Coast: California	6,318	359	6,677
Total:			
1963	6,318	359	6,677
1962	8,305	779	9,084
U.S. total:			
1963	1,317,246	177,529	1,494,775
1962	1,212,759	185,848	1,398,607

TABLE 12.—Consumption of iron and steel scrap in blast furnaces in the United States in 1963, by districts and States

(Short tons)

District and State	Scrap	District and State	Scrap
Middle Atlantic:		South Atlantic, East and West:	
New York	193,506	South Central:	
Pennsylvania	1,246,152	Alabama	140,053
Total:		Kentucky, Maryland, Tennessee, Texas, West Virginia	346,852
1963	1,439,658	Total:	
1962	1,360,171	1963	486,905
East and West North Central:		1962	535,564
Illinois	471,465	Rocky Mountain; Colorado and Utah	135,911
Indiana	168,310	Total:	
Michigan and Minnesota	313,450	1963	135,911
Ohio	1,289,885	1962	73,705
Total:		U.S. total:	
1963	2,243,110	1963	4,305,584
1962	1,812,118	1962	3,781,558

TABLE 13.—Consumption of iron and steel scrap by ferroalloy producers in the United States in 1963, by districts

(Short tons)

District	Scrap	District	Scrap
Middle Atlantic:		East South Central:	
1963	44,763	1963	85,031
1962	31,881	1962	72,591
East North Central:		Pacific Coast:	
1963	58,231	1963	7,746
1962	51,893	1962	9,538
West North Central:			
1963	129,669	U.S. total:	
1962	122,530	1963	345,375
South Atlantic:		1962	302,150
1963	19,935		
1962	13,717		

TABLE 14.—Consumption of iron and steel scrap in miscellaneous uses [1] in the United States in 1963, by districts and States

(Short tons)

District and State	Scrap	District and State	Scrap
New England and Middle Atlantic:		East and West South Central: Alabama and Texas	10,646
New York	14,833	Total:	
New Jersey	59,135	1963	10,646
Pennsylvania	1,489	1962	7,960
Total:		Rocky Mountain: Arizona, Colorado, Idaho, Montana, Utah	29,475
1963	75,457	Total:	
1962	219,358	1963	29,475
East North Central:		1962	32,125
Illinois, Indiana, and Michigan	46,228	Pacific Coast: California and Washington	41,473
Ohio	4,972	Total:	
Total:		1963	41,473
1963	51,200	1962	47,154
1962	191,345	U.S. total:	
West North Central: Minnesota and Missouri	11,217	1963	226,736
Total:		1962	547,539
1963	11,217		
1962	43,888		
South Atlantic: Florida, Georgia, and Virginia	7,268		
Total:			
1963	7,268		
1962	5,709		

[1] Excludes rerolling rails during 1963.

TABLE 15.—Consumption of iron and steel scrap by type of manufacturers by grades, in 1963

(Short tons)

Grades of scrap	Steel ingots and castings	Steel castings	Iron foundries and miscellaneous users
Steel scrap, excludes rerolling rails:			
Carbon	51,206,449	2,559,759	3,826,273
Alloy, excludes stainless	2,398,984	126,902	129,301
Stainless	665,906	28,575	21,675
Cast iron, includes borings	5,019,860	338,460	8,298,586
Total	59,291,199	3,053,696	12,275,835

TABLE 16.—Consumption of iron and steel scrap, by grades, by districts and States in 1963

(Short tons)

District and State	Carbon steel (excludes rerolling rails)	Alloy steel (excludes stainless)	Stainless steel	Cast iron (includes borings)
New England:				
Connecticut	79,104			44,371
Maine and New Hampshire	2,978			6,432
Massachusetts	30,092	10,875	21,909	152,741
Rhode Island	57,161			34,686
Vermont	3,163			19,069
Total	172,498	10,875	21,909	257,299

TABLE 16.—Consumption of iron and steel scrap, by grades, by districts and States in 1963—Continued

(Short tons)

District and State	Carbon steel (excludes rerolling rails)	Alloy steel (excludes stainless)	Stainless steel	Cast iron (includes borings)
Middle Atlantic:				
New Jersey	301,346	10,197	6,069	361,701
New York	2,465,773	81,050	55,549	553,858
Pennsylvania	10,585,632	1,190,795	333,681	1,746,669
Total	13,352,751	1,282,042	395,299	2,662,228
East North Central:				
Illinois	6,372,018	173,738	29,673	1,435,656
Indiana	7,582,842	87,923	16,977	929,408
Michigan	4,895,027	38,324	95,678	2,660,354
Ohio	9,887,482	830,634	76,223	1,838,931
Wisconsin	460,667	4,711	2,884	439,385
Total	29,198,036	1,135,330	221,435	7,303,734
West North Central:				
Iowa	278,744	-----		228,584
Kansas and Nebraska	90,173		1,965	33,600
Minnesota	339,117	11,612		136,931
Missouri	748,546			152,488
Total	1,456,580	11,612	1,965	551,603
South Atlantic:				
Delaware and Maryland	2,523,671	20,519	[1] 60,051	248,159
Florida and Georgia	345,527	-----	-----	32,494
North Carolina	4,821	-----	-----	69,014
South Carolina	3,866	9,399	(1)	33,995
Virginia and West Virginia	1,831,332		-----	196,942
Total	4,709,217	29,918	60,051	580,604
East South Central:				
Alabama	1,980,763	20,777	(2)	723,605
Kentucky, Mississippi, Tennessee	1,282,215	59,795	(2)	409,343
Total	3,262,978	80,572	(2)	1,132,948
West South Central:				
Arkansas, Louisiana, Oklahoma	165,579	126	-----	39,613
Texas	1,316,626	30,636	(2)	390,403
Total	1,482,205	30,762	(2)	430,016
Rocky Mountain:				
Arizona and Nevada	159,186	215	-----	8,434
Colorado, Idaho, Montana, Utah	1,309,859	39,822	-----	276,018
Total	1,469,045	40,037	-----	284,452
Pacific Coast:				
California and Hawaii	2,007,865	19,327	1,595	420,074
Oregon and Washington	481,306	14,712	4,470	33,948
Total	2,489,171	34,039	6,065	454,022
U.S. total	57,592,481	2,655,187	716,156	13,656,906

[1] Data for South Carolina included in total for Delaware and Maryland.
[2] Figures withheld to avoid disclosing individual company confidential data; included in U.S. total.

TABLE 17.—Home scrap produced by source, by type of manufacturers, in 1963

(Short tons)

	Source of scrap			Total
	Recirculating[1]	Obsolete[2]	Other, including slag	
Manufacturers of steel ingots and castings	33,586,471	2,714,119	1,336,994	37,637,584
Manufacturers of steel castings	1,346,938	5,654	306	1,352,898
Iron foundries and miscellaneous users	5,632,182	27,611	4,458	5,664,251
Total	40,565,591	2,747,384	1,341,758	44,654,733

[1] Includes home, plant, or recycled iron and steel scrap.
[2] Includes molds, stools, machinery, and buildings; excludes rerolling rails.

TABLE 18.—Consumers receipts and total consumption of iron and steel scrap, by grades, in 1963

(Short tons)

Grades of scrap (excludes rerolling rails)	Receipts during the month			Total consumption
	From dealers	From others	Total	
Carbon steel:				
Low phosphorus plate and punchings	1,926,143	556,548	2,482,691	3,218,774
Cut structurals and plate	609,827	59,277	669,104	822,179
Steel car wheels	72,081	54,162	126,243	129,650
No. 1 heavy melting	4,636,737	1,313,462	5,950,199	25,180,798
No. 1 and electric furnace bundles	4,419,620	1,369,140	5,788,760	6,439,008
No. 2 and all other bundles	4,338,997	369,054	4,708,051	5,896,620
Turnings and borings	2,011,782	253,957	2,265,739	2,600,096
Slag scrap (Fe content)	191,052	209,409	400,461	2,013,579
All other carbon steel scrap	2,828,835	884,348	3,713,183	11,665,831
Alloy steel, excludes stainless	310,962	155,101	466,063	2,627,436
Stainless steel	218,614	31,530	250,144	718,846
Cast iron: Borings	663,782	328,405	992,187	1,491,449
All other cast iron scrap	3,780,306	654,416	4,434,722	11,816,464
Total:				
1963	26,008,738	6,238,809	32,247,547	74,620,730
1962	22,884,339	4,614,162	27,498,501	66,159,747

TABLE 19.—Iron and steel scrap production, receipts, consumption, consumer stocks, imports and exports

(Short tons)

Year	Home scrap produced	Purchased scrap received from dealers and all others	Consumption	Stocks Dec. 31	Imports[1]	Exports[2]
1959	37,418,199	31,128,252	66,061,516	9,993,488	309,448	4,939,043
1960	39,632,100	28,469,125	66,468,708	9,287,881	179,401	7,054,964
1961	38,475,062	27,552,939	64,326,698	8,823,815	268,389	9,713,863
1962	40,644,640	27,498,501	66,159,747	[3] 8,471,472	210,127	[3] 5,112,266
1963	44,654,733	32,247,547	74,620,730	7,937,166	217,207	6,363,617

[1] Includes tinplate scrap.
[2] Excludes circles, cables, strip, and scroll shear butts from tinplated scrap.
[3] Revised figure.

STOCKS

Total stocks of iron and steel scrap at the end of 1963 were 6 percent below those for 1962 and represented only a 39-day supply at the annual consumption rate of 204,000 tons per day. Three districts showed an increase in stocks of scrap, with the West North

Central having a 13-percent increase. Of the six districts showing a decrease, the West South Central had the greatest drop, 23 percent. Stocks of pig iron held by consumers and suppliers at yearend were 8.5 percent below those of December 31, 1962.

TABLE 20.—Consumer stocks of iron and steel scrap and pig iron Dec. 31, in the United States, by districts and States

(Short tons)

District and State	1962		1963	
	Scrap	Pig iron	Scrap	Pig iron
New England:				
Connecticut	14,925	4,542	14,416	4,331
Maine and New Hampshire	1,338	293	722	326
Massachusetts	24,157	8,385	14,446	6,926
Rhode Island	12,230	6,119	13,763	6,741
Vermont	974	232	1,254	562
Total	53,624	19,571	44,601	18,886
Middle Atlantic:				
New Jersey	58,382	24,414	70,252	18,397
New York	671,199	384,471	536,594	349,625
Pennsylvania	[1] 1,773,580	[1] 548,051	1,909,843	559,859
Total	[1] 2,503,161	[1] 956,936	2,516,689	927,881
East North Central:				
Illinois	1,004,255	215,429	833,357	164,289
Indiana	770,540	143,698	742,300	55,525
Michigan	442,012	257,619	476,231	207,378
Ohio	1,207,789	624,909	1,060,827	632,908
Wisconsin	54,257	24,915	51,972	20,821
Total	3,478,853	1,266,570	3,164,687	1,080,921
West North Central:				
Iowa	33,451	18,757	44,905	7,136
Kansas and Nebraska	20,155	654	13,520	589
Minnesota	77,524	43,625	66,416	27,241
Missouri	158,214	16,714	202,756	15,675
Total	289,344	79,750	327,597	50,641
South Atlantic:				
Delaware and Maryland	484,508	74,487	312,326	60,361
Florida and Georgia	42,650	1,540	63,640	1,379
North Carolina	3,685	1,417	6,633	1,775
South Carolina	4,703	1,969	2,851	2,198
Virginia and West Virginia	95,274	58,076	120,443	89,084
Total	630,820	137,489	505,893	154,797
East South Central:				
Alabama	301,360	328,705	287,551	317,752
Kentucky, Mississippi, Tennessee	188,274	81,264	201,063	63,999
Total	489,634	409,969	488,614	381,751
West South Central:				
Arkansas, Louisiana, Oklahoma	34,304	1,506	28,652	1,428
Texas	248,943	41,209	190,464	30,873
Total	283,247	42,715	219,116	32,301
Rocky Mountain:				
Arizona and Nevada	21,505	62	18,441	35
Colorado, Idaho, Montana, Utah	203,651	82,605	209,658	91,842
Total	225,156	82,667	228,099	91,877
Pacific Coast:				
California and Hawaii	400,085	56,847	334,204	43,465
Oregon and Washington	117,548	14,546	107,666	23,526
Total	517,633	71,393	441,870	66,991
U.S. total	[1] 8,471,472	[1] 3,067,060	7,937,166	2,806,046

[1]Revised figure.

TABLE 21.—Consumer stocks of iron and steel scrap, by grades, by districts and States, Dec. 31, 1963

(Short tons)

District and State	Carbon steel (excludes rerolling rails)	Alloy steel (excludes stainless)	Stainless steel	Cast iron (includes borings)
New England:				
Connecticut	6,642			5,911
Maine and New Hampshire	143			579
Massachusetts	5,104	803	1,376	9,252
Rhode Islsnd	10,550			2,987
Vermont	428			826
Total	22,867	803	1,376	19,555
Middle Atlantic:				
New Jersey	28,467	1,952	232	39,601
New York	450,254	12,812	15,204	58,324
Pennsylvania	1,418,446	184,681	37,707	269,009
Total	1,897,167	199,445	53,143	366,934
East North Central:				
Illinois	676,369	20,892	6,549	129,547
Indiana	570,909	9,745	5,457	156,189
Michigan	295,672	2,983	10,093	167,483
Ohio	758,673	115,849	31,037	155,268
Wisconsin	32,958	102	80	18,832
Total	2,334,581	149,571	53,216	627,319
West North Central:				
Iowa	30,330			14,237
Kansas and Nebraska	12,078			1,442
Minnesota	53,960	1,404	407	11,440
Missouri	136,598			65,701
Total	232,966	1,404	407	92,820
South Atlantic:				
Delaware and Maryland	262,768	6,081	[1] 10,629	32,893
Florida and Georgia	61,828			1,812
North Carolina	357			6,276
South Carolina	248	1,354	(1)	1,204
Virginia and West Virginia	105,867	115		14,461
Total	431,068	7,550	10,629	56,646
East South Central:				
Alabama	219,481	706	(2)	67,315
Kentucky, Mississippi, Tennessee	173,678	14,115	(2)	11,573
Total	393,159	14,821		78,888
West South Central:				
Arkansas, Louisiana, Oklahoma	22,096			6,556
Texas	158,713	8,134	(2)	23,332
Total	180,809	8,134	(2)	29,888
Rocky Mountain:				
Arizona and Nevada	16,595	230		1,616
Colorado, Idaho, Montana, Utah	163,128	9,160		37,370
Total	179,723	9,390		38,986
Pacific Coast:				
California and Hawaii	278,721	2,767	487	52,229
Oregon and Washington	99,032	3,052	379	5,203
Total	377,753	5,819	866	57,432
U.S. total	6,050,093	396,937	121,668	1,368,468

[1] Data for South Carolina included in total for Delaware and Maryland.
[2] Figures withheld to avoid disclosing individual company confidential data.

TABLE 22.—Consumer stocks, production, receipts, consumption, and shipments of iron and steel scrap, by grades, in 1963

(Short tons)

	Stocks Jan. 1 [1]	Home scrap produced	Receipts from dealers and all others	Total consumption	Shipments	Stocks Dec. 31
Steel scrap, excludes rerolling rails:						
Carbon	6,544,265	33,267,462	25,678,699	57,592,481	1,847,852	6,050,093
Alloy, excludes stainless	421,955	2,213,470	506,773	2,655,187	90,074	396,937
Stainless	139,343	470,258	251,814	716,156	23,591	121,668
Cast iron, includes borings	1,365,909	8,703,543	5,810,261	13,656,906	854,339	1,368,468
Total	8,471,472	44,654,733	32,247,547	74,620,730	2,815,856	7,937,166

[1] Revised figures.

TABLE 23.—Stocks of iron and steel scrap and pig iron at major consuming industries plants, Dec. 31

(Short tons)

Year	Manufacturers of steel casting	Manufacturers of steel ingots and castings	Iron foundries and miscellaneous users	Total
	Scrap stocks			
1963	6,698,411	346,593	892,162	7,937,166
1962	[1] 7,179,608	426,736	865,128	[1] 8,471,472
	Pig iron stocks			
1963	2,369,597	31,396	405,053	2,806,046
1962	[1] 2,590,897	27,514	448,649	[1] 3,067,060

[1] Revised figure

PRICES [2]

During 1963, the composite average price per long ton for No. 1 Heavy Melting scrap was estimated at $27.08, a drop of $1.15 from the average for 1962. There was much less fluctuation in price during the year. Using composite quotations, for example, the high was $28.67 in May, and the low $25.33 in July, for a spread of only $3.34 per long ton of No. 1 heavy melting scrap.

In Pittsburgh, the average price per long ton for No. 1 Heavy Melting was estimated at $26.51 in 1963, $2.04 less than 1962. The high for the year was April at $29.50, and the low in July and November was $24.50.

In Chicago, the estimated price for the year was $29.45, a gain of $0.76 over that of 1962. The price in May was high for the year at $31.25, and the low for 1963 was in July at $27.50.

[2] Iron Age. V. 193, No. 1, Jan. 2, 1964, p. 202.

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The composite price for No. 2 bundles was estimated at $19.84 for 1963, with the high of $21.25 in February, and the low of $18.66 in July.

The average value of all grades of scrap exported from the United States during 1963 (see table 1) was $30.73, $1.92 lower than the revised figure for 1962.

TABLE 24.—Average monthly price and composite price for No. 1 heavy melting scrap in 1963

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price [1]
January	$29.50	$27.50	$24.50	$27.17
February	29.25	28.00	26.50	27.92
March	28.50	28.00	26.25	27.58
April	29.90	29.50	25.50	28.30
May	31.25	29.25	25.50	28.67
June	28.10	24.90	24.50	25.83
July	27.50	24.50	24.00	25.33
August	31.10	25.50	24.50	27.01
September	30.50	25.50	24.50	26.83
October	30.25	25.50	24.50	26.75
November	28.50	24.50	26.50	26.50
December [2]	29.10	25.50	26.50	27.03
Average:				
1963 [2]	29.45	26.51	25.27	27.08
1962	[3] 28.69	[3] 28.55	27.47	[3] 28.23

[1] Composite price, Chicago, Pittsburgh, Philadelphia.
[2] Estimate.
[3] Revised figure.

FOREIGN TRADE

Imports.—Total imports of iron and steel scrap in 1963, including tinplate, rose 3 percent in quantity but less than 1 percent in price in comparison with 1962. Canada supplied most of the scrap that was imported. About 10 percent of the imports consisted of tinplate.

Exports.—A greatly increased demand for iron and steel scrap accounted for a 24-percent increase in total exports from the United States in 1963. In contrast to this, exports to European nations dropped by 40 percent in 1963 as compared with 1962. Exports of iron and steel scrap, excluding rerolling materials, rose 24 percent in quantity and 16 percent in value. Japan, Italy, Canada, and Mexico, in that order, accounted for 95 percent of the U.S. total.

TABLE 25.—U.S. imports for consumption of iron and steel scrap, by countries

(Short tons)

Country	1962	1963
North America:		
Bahamas	368	90
Canada	205,593	209,116
Canal Zone	4	—
Dominican Republic	896	—
French West Indies	562	555
Mexico	1,878	805
Netherlands Antilles	—	3,660
Trinidad and Tobago	—	785
Total	209,301	215,011
South America:		
Brazil	56	—
British Guiana	—	535
Colombia	39	35
Ecuador	132	—
Total	227	570
Europe:		
France	114	8
Germany, West	45	694
Netherlands	—	84
Norway	—	45
Sweden	389	2
Switzerland	—	67
United Kingdom	13	546
Total	561	1,446
Asia:		
India	33	12
Japan	4	38
Total	37	50
Africa: South Africa, Republic of	—	103
Oceania: Australia	1	27
Grand total:		
Short tons	210,127	217,207
Value	[1] $6,067,233	$6,103,825

[1] Adjusted by Bureau of Mines.

Source: Bureau of the Census.

TABLE 26.—U.S. exports of iron and steel scrap, by countries

(Short tons)

Destination	Iron and steel scrap including tinplate and terneplate scrap [1]		Rerolling material	
	1962	1963	1962	1963
North America:				
Canada	360,946	531,851	2,527	74
Mexico	306,150	468,955	3,042	101
Nicaragua	17,532	14,140	—	—
Other	162	67	—	—
Total	684,790	1,015,013	5,569	175
South America:				
Argentina	50	13,674	—	—
Bolivia	—	58	—	—
Brazil	1,283	1,044	—	—
Chile	—	4,361	—	30
Colombia	467	30	—	—
Peru	209	10,641	—	—
Venezuela	32,787	10,807	—	—
Total	34,796	40,615	—	30

See footnote at end of table.

TABLE 26.—U.S. exports of iron and steel scrap, by countries—Continued

(Short tons)

Destination	Iron and steel scrap including tinplate and terneplate scrap [1]		Rerolling material	
	1962	1963	1962	1963
Europe:				
Belgium-Luxembourg	2,464			
France	22,640	6,475		
Germany, West	38,098	13,442		
Greece	74			
Italy	[2] 1,507,578	951,034		
Netherlands	1,855	140		
Spain	74,807	34,090		
Sweden	5,343	15		
United Kingdom	1,257	366	138	103
Yugoslavia	37,475			
Other	15	11		
Total	[2] 1,691,606	1,005,573	138	103
Asia:				
Hong Kong	16	2,197	980	6,496
India	4,564	590		
Israel	2,013	3,556		
Japan	[2] 2,474,828	3,929,124	73,085	109,775
Korea, Republic of	19,999	54,316		4,712
Nansei and Nanpo Islands			6,991	6,297
Taiwan	[2] 91,011	113,591	11,357	18,858
Turkey	40	10,672		
Other	236	419		
Total	[2] 2,592,707	4,114,465	92,413	146,138
Africa:				
United Arab Republic (Egypt)	9,882	41,335		
Other	343	57		
Total	10,225	41,392		
Oceania: Australia	22	113		
Grand total:				
Short tons	[2] 5,014,146	6,217,171	98,120	146,446
Value	[2] $144,023,090	$167,710,745	$5,014,390	$6,900,424

[1] Excludes circles, cobbles, strip, and scroll shear butts from tinplated scrap.
[2] Revised figure.
Source: Bureau of the Census.

TABLE 27.—U.S. imports for consumption and exports of iron and steel scrap by classes

Class	1962		1963	
	Short tons	Value	Short tons	Value
Imports:				
Iron and steel scrap	189,035	[1] $5,726,353	195,383	$5,700,646
Tinplate scrap	21,092	340,880	21,824	403,179
Total	210,127	[1] 6,067,233	217,207	6,103,825
Exports:				
Nos. 1 and 2 heavy-melting steel scrap	[2] 2,676,029	[2] 82,206,648	3,636,851	104,377,652
Nos. 1 and 2 baled steel scrap	[2] 1,525,675	[2] 37,339,152	1,621,047	36,578,611
Borings, shovelings, and turnings	186,232	3,932,823	196,603	4,175,651
Iron scrap	312,890	9,396,565	345,831	9,380,408
Rerolling material	98,120	5,014,390	146,446	6,900,424
Other steel scrap (terneplate and tinplated) [3]	313,320	11,147,902	416,839	13,198,423
Total	[2] 5,112,266	[2] 149,037,480	6,363,617	174,611,169

[1] Adjusted by Bureau of Mines.
[2] Revised figure.
[3] Excludes circles, cobbles, strip, and scroll shear butts from tinplated scrap.
Source: Bureau of the Census.

WORLD REVIEW

European Coal and Steel Community (ECSC).—The Council of Ministers of the ECSC approved a High Authority recommendation to allow the export of ferrous scrap to third countries beginning April 1, 1963, for a period of 6 months. Formerly such exports had been under embargo. By the end of December 1963, the embargo had not been reimposed.[3]

International markets for scrap iron and steel were thoroughly examined and discussed at a meeting of the scrap iron and steel section at the General Congress of the Bureau International de la Récupération (BIR) on May 30. Delegates reported that more quality scrap is being purchased in most countries for the production of raw steel. It was noted that the ratio of use of scrap in the production of raw steel had risen in most countries, and the general opinion was that this reflected scrap price levels. The use of low-grade scrap was greatly reduced.[4]

France.—The iron and steel scrap market was remarkably stable both as to prices and tonnages handled during 1963. However, the emphasis was more and more on high-quality scrap, particularly as a coolant in the oxygen steelmaking process.[5]

Germany, West.—Steel's changing technology and new steelmaking processes such as the LD method did not affect consumption of scrap in West Germany during 1963. However, the use of high-grade ore and cheaper coal adversely affected the charging of scrap in blast furnaces. It was thought that a stable and attractive price would immediately bring scrap back as a steelmaking raw material. The lifting of the ECSC ban on scrap exports to third countries had little effect on West Germany's export business. Italy continues to be the best customer for German scrap.[6]

India.—Indian iron and steel scrap exports in 1963 should more than double the volume of 1962. Export trade is the main outlet for the scrap industry of India. A significant development was the formation of the Iron & Steel Scrap Association of India. The comparatively high cost of scrap collection and the proportionately high incidence of ocean freight for India gave their scrap export industry an unfavorable price comparison on the world market.[7]

Japan.—Japan continued to be the principal customer of the scrap dealers of the United States and United Kingdom. The Japanese had offers of a total of 600,000 tons of scrap steel from the Soviet Mineral Product Trading Corp. of the U.S.S.R.[8]

United Kingdom.—Great Britain extended the open general license to export scrap to any destination for 2 months from January 1 to February 28, 1963. Later the general license was extended indefinitely beyond March 1, and had not been rescinded at the end of the year.[9]

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[3] International Commerce. Ferrous Scrap Export Ban Lifted by ECSC Council. V. 69, No. 16, Apr. 22, 1963, p. 16.
[4] American Metal Market. International Scrap Market Discussed at Meeting in France. V. 70, No. 119, June 21, 1963, p. 17.
[5] Metal Bulletin (London). No. 4857, Dec. 20, 1963, p. 23.
[6] Metal Bulletin (London). No. 4853, Dec. 6, 1963, p. 18.
[7] Nathani, Sultan A. Ferrous Scrap Exports From India Register Moderate Recovery. Secondary Raw Materials, v. 1, No. 10, November 1963, pp. 10, 13.
[8] Metal Industry (London). Japan: Scrap from U.S.S.R. V. 102, No. 23, June 6, 1963, p. 795.
[9] Steel and Coal (London). V. 186, No. 4934, Feb. 8, 1963, p. 295.

It was reported that the British Iron & Steel Corp. (Salvage), Ltd., was discontinuing its scheme of supplying obsolete ships to the British shipbreaking industry as part of the operation controlling the cost and supply of scrap to British steelworks.[10]

Meanwhile, in Scotland, the seven remaining ships of the German Imperial Fleet scuttled at Scapa Flow in 1919 were scheduled to be raised by Nundy Marine Metals, Ltd., of Glasgow, from about 100 feet of water with the help of frogmen.[11]

Toward the end of the year, one company reported its shipbreaking activities were operating at less than 50 percent capacity, with stiff competition from continental and Far Eastern buyers for the limited number of ships being offered.[12]

As in the United States, Great Britain also had problems with lighter scrap metal. Old cars became an increasing source of concern as they were being abandoned on the streets and highways for lack of a junk market.[13]

The hearing in the Restrictive Practices Court on the agreement between the British Iron & Steel Federation and the Scrap Federation on price stability was concluded. Judgment was not expected before the end of the first quarter of 1964.[14]

The market had improved considerably by the end of the year, and worry over high shipping rates hurting the scrap export trade was balanced by fear by the steel industry of a scrap shortage.

TECHNOLOGY

A new iron and steel scrap metal disintegrator built to process from 60 to 100 tons of whole car bodies in an hour was announced by a California steel company. The 8,000-horsepower machine will hammer, cut, shred, and separate magnetic metals from other metallic and nonmetallic material. The machine is expected to be in operation 8 hours a day, 6 days a week in the spring of 1964.[15]

A German technique for the conversion of scrap steel into metallurgically controlled pig and basic iron is scheduled to begin operation in the spring of 1964. The plant, in East Greenville, Pa., plans to sell the resulting product to foundries and steel mills throughout the eastern United States.[16]

The FOS (fuel-oxygen-scrap) steelmaking process was announced at Le Touquet, France, on September 24, 1963, by Dr. J. Pearson, assistant director of the British Iron & Steel Research Association (BISRA). The process uses a vessel essentially the same shape as an electric arc furnace, although of somewhat greater height-to-diameter ratio. The charge may consist of scrap and pig iron, but can be entirely of scrap. All forms of scrap, from heavy to light, have proved to be usable.[17]

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10 Metal Bulletin (London). Harder Times for UK Shipbreakers. No. 4795, May 10, 1963, p. 23.
11 Metal Bulletin (London). Return to Scapa. No. 4780, Mar. 15, 1963, p. 23.
12 Metal Bulletin (London). TWW Hit by Foreign Competition. No. 4846, Nov. 12, 1963, p. 16.
13 Metal Bulletin (London). Abandoned Cars Problem. No. 4797, May 17, 1963, p. 19.
14 Metal Bulletin (London). Scrap Hearing Over. No. 4854, Dec. 10, 1963, p. 15.
15 American Metal Market. Pacific States Steel Installing New Disintegrator. V. 70, No. 141, July 24, 1963, p. 16.
16 Metalworking News. Plan New Firm To Convert Scrap Steel Into Pig Iron. V. 4, No. 165, Oct. 23, 1963, p. 15.
17 Metal Bulletin (London). New Steel Processes. No. 4834, Oct. 1, 1963, pp. 7-8, 11-14.

The Institute of Scrap Iron & Steel, Inc., reported that during 1963 over 260 guillotine shears were placed in operation throughout the country in scrap processing yards.[18]

The Steelmaking Research Group has been formed to study the technological and economic impact of new methods of steelmaking. Among the organizations concerned are United States Steel Corp., Esso Research, Detroit Edison, the Association of Iron & Steel Engineers, and the Institute of Scrap Iron & Steel, Inc. The group is sponsoring a broad research program by a private research institute to study the effects of the new methods of steelmaking on suppliers to the steel industry.[19]

A novel use for scrap has been developed through Bureau of Mines research. Lower grades of scrap, such as borings and turnings, when heated with taconite, or other low-grade nonmagnetic ores partially reduce the ore permitting magnetic beneficiation. This is the first time that scrap has been used to precondition ore for beneficiation.

Procedures were developed for reclaiming high-temperature alloy scrap. A cobalt-base, multicomponent, high-temperature alloy, such as S–816, was successfully melted from scrap, and its specific chemical composition retained. Induction furnace melting in a controlled atmosphere was used to obtain ingots that were subsequently fabricated by impact forging to provide specimens for heat treatment and testing.[20]

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[18] Institute of Scrap Iron & Steel, Inc. Special Letter to Institute Members. No. 1861, Oct. 8, 1963, pp. 1-2.

[19] American Metal Market. Battelle To Study How Steel's New Technology Will Affect Suppliers. V. 70, No. 115, June 17, 1963, p. 4.

[20] Higley, L. W., Jr. Reclaiming S-816 High-Temperature Alloy Scrap. BuMines Rept. of Inv. 6230, 1963, 12 pp.

Iron Oxide Pigments

By Horace T. Reno[1]

SALES of iron oxide pigments in the United States in 1963 totaled a record 118,800 short tons valued at over $21 million. Domestic mine production was 12 percent less than in 1962.

TABLE 1.—Salient iron oxide pigments statistics in the United States

	1954–58 (average)	1959	1960	1961	1962	1963
Mine production short tons	52,000	53,900	70,300	46,000	57,500	50,100
Crude pigments sold or used do	49,300	54,000	71,100	45,900	60,100	55,900
Value thousands	$433	$470	$635	$453	$500	$500
Finished pigments sold short tons	106,000	117,600	106,000	106,500	113,000	118,800
Value thousands	$16,156	$19,037	$17,948	$18,345	$19,798	$21,135
Imports for consumption short tons	12,500	14,800	14,500	10,000	13,100	13,700
Value thousands	$1,144	$1,495	$1,422	$1,059	$1,295	$1,469
Exports short tons	4,200	4,300	3,900	3,200	3,800	4,200
Value thousands	$918	$1,040	$1,113	$855	$1,076	$1,306

DOMESTIC PRODUCTION

Finished iron oxide pigments were sold by 13 companies with 18 plants in 9 States. Seven companies in seven States mined and sold or used iron oxide pigments. The Bureau of Mines received permission from industrial producers to report sales in 1962 and 1963 by kinds, as was done in the Yearbook in 1961 and prior years, thus reestablishing detailed continuity in the series.

[1] Commodity specialist, Division of Minerals.

TABLE 2.—Finished iron oxide pigments sold by processors in the United States by kinds

Pigment	1962		1963	
	Short tons	Value	Short tons	Value
Natural:				
Brown:				
Iron oxide (metallic)[1]	7,565	$886,200	7,789	$923,500
Umbers:				
Burnt	3,064	511,300	3,237	554,800
Raw	662	109,000	672	111,200
Vandyke brown	404	73,600	256	61,300
Red:				
Iron oxide	15,012	766,200	14,769	764,400
Sienna, burnt	1,056	245,100	1,114	257,000
Pyrite cinder	2,146	91,700	1,613	86,400
Yellow:				
Ocher [2]	3,868	185,300	3,419	173,700
Sienna, raw	782	166,300	701	155,500
Total natural	34,559	3,034,700	33,570	3,087,800
Manufactured:				
Black: Magnetic	2,272	677,300	2,278	683,900
Brown: Iron oxide	2,225	818,300	2,509	949,000
Red:				
Pure red iron oxides:				
Calcined copperas	16,174	4,602,700	16,936	4,802,400
Other chemical processes	9,506	2,716,800	10,553	3,007,600
Other manufactured red iron oxides	20,519	2,283,100	21,518	2,426,900
Venetian red	2,329	286,500	1,645	220,100
Yellow: Iron oxide	16,611	4,084,500	18,082	4,502,700
Total manufactured	69,636	15,469,200	73,521	16,592,600
Unspecified including mixtures of natural and manufactured red iron oxides	8,770	1,294,100	11,756	1,454,600
Grand total	112,965	19,798,000	118,847	21,135,000

[1] Includes some black magnetite.
[2] Includes some yellow iron oxide.

PRICES

Fluctuations in the quoted prices shown in table 3 were the result of different methods used by various trade journals in obtaining data. Some changes in prices were also caused by differences in quantity, quality, locality, or individual suppliers' views. The variation in high and low prices of Venetian red was due to different grades ranging from 20 to 40 percent iron oxide. Prices were not quoted for Turkish umber, burnt and raw, and for natural and Spanish red.

TABLE 3.—Prices quoted on finished iron oxide pigments, per pound, in bags, unless otherwise specified, in 1963

Pigment	High	Low	Pigment	High	Low
Black:			Red:		
Pure	$0.1500	$0.1475	Domestic (pure)	$0.1450	$0.1425
Synthetic	.1500	.1475	Persian Gulf	.0950	.0950
Brown:			Sienna, burnt	.0725	.0725
Pure	.1600	.1575	Venetian	.0675	.0525
Metallic	.0625	.0600	Yellow:		
Umber, American, burnt	.0850	.0850	Ocher, natural, French	.0700	.0700
Umber, American, raw	.0850	.0850	Ocher, natural, Peruvian	.0250	.0250
Vandyke	[1] .1200	.1100	Ocher, hydrated, pure	.1275	.1250
			Sienna, raw	.0750	.0750

[1] Barrels.

Source: Oil, Paint and Drug Reporter and Chemical &Engineering News.

FOREIGN TRADE

All ocher imported for consumption in the United States originated in the Republic of South Africa, and all Vandyke brown originated in West Germany. Italy and Cyprus together supplied essentially all the crude and washed sienna; and Cyprus supplied all except 115 of the total 2,641 short tons of crude and washed umber. United Kingdom, Italy, and Malta supplied the remainder.

West Germany supplied 66 percent of the synthetic iron oxide pigments imports, Canada supplied 20 percent, United Kingdom 12 percent, and France and Sweden supplied the remaining 2 percent.

Exports of iron oxide pigments were valued at an average of 15.5 cents per pound in 1963, compared with 14 cents in 1962.

TABLE 4.—U.S. imports for consumption of selected iron oxide pigments

Pigments	1962		1963	
	Short tons	Value	Short tons	Value
Natural:				
Ocher, crude and refined	146	$8,585	144	$8,397
Siennas, crude and refined	879	83,941	610	61,825
Umber, crude and refined	2,663	94,497	2,641	94,543
Vandyke brown	256	20,663	217	17,516
Other [1]	2,937	127,536	2,877	136,996
Total	6,881	335,222	6,489	319,277
Manufactured (synthetic)	6,206	960,073	7,215	1,149,507
Grand total	13,087	1,295,295	13,704	1,468,784

[1] Classified by the Bureau of the Census as "Natural iron-oxide and iron-hydroxide pigments, n.s.p.f."

Source: Bureau of the Census.

TABLE 5.—U.S. imports for consumption of iron-oxide and iron-hydroxide pigments, n.s.p.f.,[1] by countries

Country	Natural				Synthetic			
	1962		1963		1962		1963	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America: Canada	3	$509	5	$786	1,143	$218,725	1,429	$300,196
Europe:								
Belgium-Luxembourg					13	2,000		
France			165	12,600	39	5,944	138	20,035
Germany, West			66	9,065	3,918	565,148	4,747	685,038
Netherlands					26	4,020		
Portugal			112	2,807				
Spain	2,835	117,762	2,438	105,646				
Sweden					1	993	10	8,530
United Kingdom	99	9,265	40	4,812	1,066	163,243	891	135,708
Total	2,934	127,027	2,821	134,930	5,063	741,348	5,786	849,311
Asia: India			51	1,280				
Grand total	2,937	127,536	2,877	136,996	6,206	960,073	7,215	1,149,507

[1] Not specifically provided for.

Source: Bureau of the Census.

TABLE 6.—U.S. exports of iron oxide pigments, by countries

Destination	1962		1963	
	Short tons	Value	Short tons	Value
North America:				
Canada	1,987	$455,367	2,047	$480,864
Costa Rica	6	1,787	8	2,589
Guatemala	37	9,073	39	9,837
Mexico	68	20,109	37	16,765
Netherlands Antilles	10	4,062	13	4,606
Panama	5	2,329	19	6,979
Other	49	14,642	13	4,809
Total	2,162	507,369	2,176	526,449
South America:				
Argentina	5	4,160	6	1,990
Bolivia			2	650
Brazil	34	10,766	15	4,829
Chile	7	1,704	11	2,805
Colombia	75	27,443	109	39,027
Ecuador	12	3,613	8	2,300
Peru	11	4,567	18	5,403
Venezuela	63	15,545	112	35,709
Total	207	67,798	281	92,713
Europe:				
Belgium-Luxembourg	31	17,845	42	16,694
France	79	28,882	84	28,151
Germany, West	66	26,121	109	41,689
Iceland	5	1,772	1	290
Italy	4	1,828	137	81,500
Netherlands	35	3,317	56	2,562
Portugal	10	3,078	19	6,209
Sweden	8	5,663	30	7,615
Switzerland	30	8,926	51	16,129
United Kingdom	132	38,579	154	86,156
Other	15	4,641	17	5,972
Total	415	140,652	700	292,967
Asia:				
Hong Kong	4	1,801	6	2,433
Indonesia			36	10,240
Japan	290	82,500	345	96,089
Pakistan	27	5,961	20	7,673
Philippines	140	45,239	168	53,086
Taiwan	27	14,900		
Other	34	17,638	34	16,953
Total	522	168,039	609	186,474
Africa:				
Congo, Republic of the, and Ruanda-Urundi	16	4,656	8	4,484
South Africa, Republic of	12	5,188	53	14,297
United Arab Republic (Egypt)	53	12,090		
Other	1	716		
Total	82	22,650	61	18,781
Oceania	366	169,275	362	188,786
Grand total	3,754	1,075,783	4,189	1,306,170

Source: Bureau of the Census.

WORLD REVIEW [2]

Canada.—Canada produced 1,004 tons of iron oxide pigments valued at Can$73,886 in 1963, compared with 771 tons (revised) valued at Can$58,363 (revised) in 1962. All the Canadian iron oxide pigments were mined in Quebec Province.[3]

[2] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board, unless otherwise specified.

[3] Mineral Resources Division, Department of Mines and Technical Surveys (Ottawa, Canada). The Canadian Mining Industry in 1963. Preliminary, 1964, pp. 2–3.

India.—India produced 23,138 tons of ocher valued at $102,060 in 1963 compared with 16,920 tons valued at $63,630 in 1962.

Morocco.—Production of iron oxide pigments in Morocco totaled 958 tons in 1963. Sales totaled 1.110 tons. Prices were not disclosed. Domestic consumers bought 225 tons; consumers in France bought 825 tons; those in Australia, 33 tons; and those in Algeria, 28 tons.

South Africa, Republic of.—In 1963 3,142 tons of ocher and 1,230 tons of iron oxide pigments were produced. Sales of ocher totaled 2,491 tons, 102 tons sold locally for $818, and 2,389 sold to foreign consumers for $80,026. Sales of iron oxide pigments totaled 1,214 tons, 1,191 tons sold locally for $27,109 and 23 tons sold to foreign consumers for $908.

TECHNOLOGY

Pilot plant experiments in calcination of ferrous sulfate heptahydrate ($Fe_2So_4 \cdot 7H_2O$) showed the feasibility of shortening and improving production of red oxide pigments using fluidized bed furnaces.[4]

A Russian chemist described experimental and pilot plant continuous preparation of red iron oxide pigments from $Fe_2SO_4 \cdot 7H_2O$ obtained as a byproduct of titanium dioxide (TiO_2) production.[5] The red oxide (Fe_2O_3) was obtained by sucking hot flue gases premixed with air to obtain approximately 12 percent oxygen through the sulfate which was moved in small carts through a roasting oven.

Synthetic yellow, red, brown, and black iron oxide pigments were found to impart light and weather-stable full and pastel color to both rigid and highly plasticized vinyl chloride in tests conducted in Italy.[6]

[4] Pechkovskii, V. V., S. A. Amirova, and N. I. Vorob'ev. (Calcination of Green Vitrol (ferrous sulfate heptahydrate) in a Fluidized Bed (pilot-plant experiments).) Izvestiya Vysshikh Uchebnyich Zavedenii, Khimiya i Khimicheskaya Tekhnologiya, v. 6, No. 2, 1963, pp. 268–273.

[5] Malkin, S. A. (Continuous Preparation of Red Iron Oxide Pigments in an Oven With Moving Carts.) Lakokrasochnye Materialy i ikh Primenenie, No. 4, 1963, pp. 56–60.

[6] Reiner, Gian Maurizo. (Use of Iron Oxides As Stable Pigments in Poly (vinyl chloride).) (Ricerca Ditta Silo.) Atti del Congresso Internazionale delle Materie Plastiche (Turin, Italy), v. 14, 1962, pp. 360–368.

Kyanite and Related Minerals

By James D. Cooper[1]

PRODUCTION and apparent consumption of kyanite and of synthetic mullite in the United States attained record highs in 1963. Output of kyanite was 18 percent above the previous record achieved in 1962, and production of synthetic mullite was 23 percent above the previous record reached in 1956. Apparent consumption of kyanite group minerals and mullite was 20 percent greater than in 1962. One new kyanite producer and one manufacturer of synthetic mullite reported domestic production for the first time in 1963.

Kyanite, sillimanite, andalusite, dumortierite, topaz, and synthetic mullite are included in this chapter because all are aluminum silicates with similar properties, which can be used to produce mullite refractories.

DOMESTIC PRODUCTION

Production of minus 35-mesh kyanite concentrate in 1963 was 18 percent more than that of 1962—the third successive record high. Output of crude kyanite ore was 18 percent above that of 1962. Quantitative production data for kyanite concentrate cannot be published because to do so would divulge confidential data of the producing companies—Aluminum Silicates, Inc., with a mine near Lincolnton, Ga.; Commercialores, Inc., with mines near Clover, S.C.; and Kyanite Mining Corp., with mines near Farmville and Dillwyn, Va. Commercial production by Aluminum Silicates, Inc., started at the end of 1962 and was reported for the first time in 1963.

Electrically fused and sintered synthetic mullite was produced from various alumina and silica mixtures using such raw materials as bauxite, Bayer process alumina, silica sand, and clay. Output of synthetic mullite increased by 56 percent over that of 1962 and the value increased by 69 percent. Seven firms furnished data to the Bureau of Mines in 1963, with Norton Co. reporting domestic production for the first time:

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.).

Harbison-Walker Refractories Co., Pittsburgh, Pa. (plant at Eufaula, Ala.).

Norton Co., Worcester, Mass. (plant at Huntsville, Ala.).

[1] Commodity specialist, Division of Minerals.

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 same address).

The Chas. Taylor Sons Co., subsidiary of National Lead Co., Cincinnati, Ohio (plant at South Shore, Ky.).

TABLE 1.—Synthetic mullite production in the United States

Year	Short tons	Value (thousands)
1954–58 (average)	[1] 18,200	[1] $1,850
1959	18,218	2,017
1960	21,497	2,212
1961	14,798	1,720
1962	19,021	2,090
1963	29,588	3,529

[1] Estimate.

CONSUMPTION AND USES

The principal use of kyanite group minerals and mullite was in production of mullite refractories, including bricks and other shapes, mortars, plastics and ramming mixes. The use of kyanite concentrate in ceramic mixes for volume stability of the fired products appeared to be increasing. The expansion of the kyanite on conversion to mullite is used to compensate for the firing shrinkage of the other components in the ceramic mixes.

About 90 percent of the mullite refractories were used in metallurgical and glass industries. Kiln furniture, boiler linings, and miscellaneous applications accounted for the balance.

The initial cost of mullite refractories is greater than that of fire clay products. However, the lower maintenance cost for mullite refractories under severe operating conditions encountered in many high-temperature furnaces more than offsets the higher initial cost.

PRICES

Prices for domestic and imported kyanite reported in E&MJ Metal and Mineral Markets remained unchanged throughout 1963: Domestic kyanite concentrates, per short ton, f.o.b. point of shipment, 35 mesh, carlots, in bulk—$44 to $45, in bags—$47; 200 mesh, carlots, in bags—$53 to $55 (additional cost for calcining, per ton, $9 to $10). Prices for imported kyanite (60-percent grade) in bags were $76 to $81 per ton, c.i.f. Atlantic ports.

FOREIGN TRADE

Imports of kyanite group minerals decreased about 50 percent both in quantity and in value in 1963. Essentially all of the imported material was Indian lump kyanite. Imports of African sillimanite were only about 5 percent of the 1962 figure.

Exports of domestic kyanite and mullite exceeded 5,000 tons for the first time in 1963. The previous record was 4,000 tons exported in

1961. West Germany continued to be the largest importer, but all other major foreign markets also were expanded in 1963.

TABLE 2.—U.S. imports for consumption and exports of kyanite and related minerals

Imports

Year and country	Short tons	Value
1954–58 (average)	5,464	[1]$240,129
1959	5,633	251,638
1960	6,052	265,364
1961	5,415	244,189
1962:		
North America: Canada	108	9,980
Asia: India	3,845	174,948
Africa: South Africa, Republic of	1,328	49,483
Total	5,281	234,411
1963:		
North America: Canada	59	5,287
Asia: India	2,500	110,532
Africa: South Africa, Republic of	65	3,299
Total	2,624	119,118

Exports

Year and country	Short tons	Value
1954–58 (average)	1,855	$93,057
1959	2,734	167,432
1960	3,255	209,950
1961	4,000	317,633
1962:		
North America:		
Canada	611	100,480
Dominican Republic	2	208
Mexico	587	33,073
South America:		
Argentina	53	3,028
Colombia	15	757
Venezuela	81	3,782
Europe:		
Belgium-Luxembourg	30	1,377
Finland	30	1,746
France	99	7,012
Germany, West	719	45,464
Italy	424	28,426
Portugal	3	384
Sweden	20	1,020
United Kingdom	530	30,754
Yugoslavia	22	5,452
Asia:		
Hong Kong	4	1,000
Indonesia	57	3,248
Japan	242	15,792
Oceania: Australia	39	3,737
Total	3,568	286,740
1963:		
North America:		
Canada	765	133,360
Mexico	698	42,952
Trinidad and Tobago	6	1,156
South America:		
Argentina	44	2,500
Brazil	2	586
Uruguay	3	667
Venezuela	228	16,409
Europe:		
Finland	40	2,304
France	204	38,669
Germany, West	939	53,524
Italy	459	42,535
Netherlands	18	1,007
Spain	53	5,491
United Kingdom	625	40,782
Asia: Japan	862	53,203
Africa: Sudan	1	252
Oceania: Australia	103	6,673
Total	5,050	442,070

[1] 1954 data known to be not comparable with other years.

Source: Bureau of the Census.

WORLD REVIEW

Australia.—Sillimanite output was 2,953 short tons in 1962, an increase of 47 percent over that of 1961. None was exported.[2]

[2] Australia, Bureau of Mineral Resources, Geology and Geophysics. The Australian Mineral Industry, 1962 Review, 1963, p. 230.

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India.—Production of kyanite in 1962 was 54,693 short tons, an increase of 83 percent over the previous year and a record high. Production of sillimanite in 1962 was 9,100 short tons, about 2 percent above that in 1961.

Korea, Republic of.—The output of andalusite decreased from 562 short tons in 1961 to 504 tons in 1962.

South Africa, Republic of.—Production of sillimanite during the first 9 months of 1963 was 45,324 short tons, a slight increase from 1962. Andalusite output in the same period was 8,231 tons, only about 50 percent of the 1962 rate.[3]

Swaziland.—Large deposits containing several million tons of sillimanite-quartz rock have been discovered in Swaziland. This ore could be mined by open pit methods and would require simple beneficiation for removal of the quartz.[4]

TECHNOLOGY

Thin mullite films of uniform composition were produced by sputtering aluminum-silicon alloy electrodes and subsequent heat treatment. Nucleating agents were added to reduce the reaction of supported films with the substrates during firing and to produce a more uniform dense mullite structure composed of many crystallites.[5]

The results of tests using domestic kyanite and mullite in tile body mixes were published. Principal benefits were increased production rates, fewer rejects, greater green strength, and greater fired strength. No significant disadvantages were noted.[6]

Over 1 hundred brands of high-alumina refractory brick from 60 to 100 percent Al_2O_3, including 24 brands of mullite, were evaluated for use in steel plants. Wide variations were found in the properties for each alumina range tested; but with exception of resistance to alkali attack mullite refractories with superior performance characteristics were available for all properties tested.[7]

The mining and processing methods used for production of kyanite concentrate from deposits near Cullen and Dillwyn, Va., were described. The ore is mined from open pits, is crushed, and is ground to minus 28 mesh; pyrite and silica sand are removed by flotation; the kyanite-rich fraction is roasted under reducing conditions to convert iron oxides to magnetite and is subjected to magnetic separation processes for the removal of iron to produce a concentrate with less than 0.5 percent iron. Part of the concentrate is calcined at 2,750° F to convert it to mullite. Products ranging from 35 to 325 mesh are produced.[8]

A patent was issued for production of mullite fibers less than 5 microns in diameter and up to 1 centimeter long. The fibers, made by

[3] Republic of South Africa, Department of Mines. Quarterly Inf. Cir., Minerals, July to September, 1963, pp. 63–64.

[4] South African Mining & Engineering Journal. Swaziland Mineral Prospects Must Be Regarded as Bright. V. 74, pt. 1, No. 3653, Feb. 8, 1963, pp. 307–308.

[5] Williams, J. C., W. R. Sinclair, and S. E. Koonce. Preparation of Thin Mullite Films. J. Am. Ceram. Soc.—Ceram. Abs., v. 46, No. 4, April 1963, pp. 161–167.

[6] Hill, R. G. Kyanite Increases Tile Manufacturing Speed. Ceram. Age, v. 79, No. 5, May 1963, pp. 58–59.

[7] Kappemeyer, K. K., and R. H. Manning. Evaluating High-Alumina Brick. Am. Ceram. Soc. Bull., v. 42, No. 7, July 1963, pp. 398–403.

[8] Mohler, Neal F. Moving a Mountain of Kyanite. Brick and Clay Record, v. 143, No. 2, August 1963, pp. 40–41.

firing a proportioned mixture of SiO_2, aluminum dust, and aluminum sulfide in a hydrogen-containing atmosphere, were for use in ceramics, cermets, plastics, and other materials.[9]

A process for removal of TiO_2 from finely ground kyanite concentrate by heating to cause differential thermal expansion and cleavage of the components and recovery of kyanite by sink-float method was patented.[10]

A mullite porcelain which shows little tendency to form cristobalite was made from a mixture of 20 to 30 percent clay and 70 to 80 percent of high-purity synthetic mullite.[11]

Kyanite and andalusite were listed as starting materials in the production of synthetic crystalline zeolites of the molecular sieve type in a patented process.[12]

The results of beneficiation tests on kyanite-quartzite rock from Graves Mountain in Lincoln County, Ga., were published. The tests demonstrated that a concentrate containing 94 percent kyanite could be produced by flotation. Acid soluble Fe_2O_3 was reduced to 0.6 percent by high-intensity magnetic separation and to 0.1 percent or less by acid leaching. The pyrometric cone equivalent of the concentrates was 37 to 38.[13]

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[9] Berry, K. L. (assigned to E. I. duPont de Nemours & Co., Inc., Wilmington, Del.). Spinnable Mullite Fibers and Their Preparation. U.S. Pat. 3,104,943, Sept. 24, 1963.

[10] Bennett, P. J. (assigned to Reynolds Metals Corp., Richmond, Va.) Method of Refining Kyanite Ore, U.S. Pat. 3,116,140, Dec. 31, 1963.

[11] Bissell, D. W., and C. D. Bruner (assigned to Ipsen Industries, Inc., Pecatonica, Ill.). Mullite Porcelain. U.S. Pat. 3,103,443, Sept. 10, 1963.

[12] Howell, P. A. (assigned to Union Carbide Corp., New York). Process for Producing Molecular Sieves. U.S. Pat. 3,101,251, Aug. 20, 1963; Canadian Pat. 667,751, July 30, 1963; British Pat. 938,104, Sept. 25, 1963.

[13] McVay, Thomas L., and James S. Browning. Flotation of Kyanite-Quartzite Rock, Graves Mountain, Lincoln County, Ga. BuMines Rept. of Inv. 6268, 1963, 9 pp.

Lead

By Donald E. Moulds [1]

Contents

INDUSTRIAL requirements for lead in 1963 exceeded the supply from all sources and resulted in a significant reduction in primary producer stocks and a rising metal price. Although mine production and primary refinery output were disrupted by the continuation of the labor closure of the largest domestic producer through the first quarter of the year, domestic output of recoverable lead in ore increased 7 percent to 253,400 tons and production of primary refined and antimonial lead increased 6 percent to 426,200 tons. Recovery of secondary lead from scrap materials was 11 percent above the 1962 level but the other major source of lead, imports of metal for consumption, declined about 15 percent to 220,400 tons. Consumption of lead increased 5 percent to 1,163,400 tons with major gains occurring in gasoline antiknock additivies and storage batteries. Stocks of refined lead at producers' plants declined to 49,300 tons by yearend, and stocks of primary lead in all categories decreased 75,800 tons during the year while consumer stocks increased 26,400 tons to 119,900 tons, last exceeded in 1959. The price of common lead in New York increased in the second half of the year in six increments from 10.00 cents to 12.50 cents on November 21.

LEGISLATION AND GOVERNMENT PROGRAMS

Import quotas on lead ores and metal, established October 1, 1958, continued in effect. The quota, subdivided into quarterly quotas for specified countries were filled for lead ores only in the first quarter while lead metal quotas were filled except for the fourth quarter. The U.S. Tariff Commission submitted a report reviewing the trade

[1] Commodity specialist, Division of Minerals.

and related developments in the lead-zinc industry to the President on October 1 in accordance with Executive Order 10401, establishing the quotas. The Commission concluded that conditions had not changed sufficiently to warrant, at that time, a formal investigation directed toward revision of the quotas. Legislation was introduced in Congress proposing establishment of a flexible import quota system for lead and zinc and was still pending at yearend.

The Government did not acquire lead for the stockpile during the year. A small tonnage of lead in the Defense Production Act stockpile was released for use by Government agencies during the year, thereby reducing total inventory to 1,378,000 tons. The Office of Emergency Planning devoted major attention to two major stockpile programs during the year—the development of disposal procedures for surplus materials and the development of new stockpile objectives. In relation to supply-requirements for conventional war, the stockpile objective for lead was established at zero on June 17. Legislation was introduced in Congress in October to revise procedures for disposal of surplus material by the Government and was still awaiting action at yearend.

The small mines stabilization program, authorized by Public Law 87–374 enacted in October 1961, applied to eligible production during the year. As of December 31, 1963, a total of 125 applications from small mines in 13 States has been received of which 98 were certified as eligible and 5 were being reviewed. In 1963 a total of 6,529 tons of lead qualified under provision of the act for stabilization payments amounting to $356,916.

Government participation in exploration projects for lead and zinc under the program of the Office of Minerals Exploration (OME) was withdrawn at the end of June 1962. Five projects approved prior to this action were active during 1963 and one of these projects, United Park City mine, was completed and certified as a discovery.

The International Lead and Zinc Study Group held its seventh session in Geneva, Switzerland, from October 28 to November 7. The Government of Austria was admitted to membership and the Group now has 26 governments participating. The Group concluded that new supplies of lead were then in reasonable balance with consumption but the rising trend in lead consumption, estimated at 2.8 million tons in 1963 and expected to rise in 1964, could result in a supply shortfall in 1964. A Special Working Group, which met in Geneva in March, examined and reported to the Study Group on the various aspects of intergovernment arrangements for lead and zinc and it was decided to continue study in this area.

TABLE 1.—Salient lead statistics

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Production:						
Domestic ores, recoverable lead content..short tons..	324,373	255,586	246,669	261,921	236,956	253,369
Value........thousands..	$91,996	$58,785	$57,722	$53,956	$43,602	$54,727
Primary lead (refined):						
From domestic ores and base bullion short tons..	321,870	225,270	228,899	288,078	245,645	239,660
From foreign ores and base bullion short tons..	180,503	115,661	153,537	161,487	130,418	155,072
Antimonial lead (primary lead content)..short tons..	15,471	12,402	2,385	24,966	27,383	31,515
Secondary lead (lead content)..........short tons..	476,149	451,387	469,903	452,792	444,202	493,471
Imports, general:						
Lead in ores and matte short tons..	187,054	138,834	145,692	147,186	[1]138,631	147,742
Lead in base bullion...do....	123	80	293	422	4,599	5,437
Lead in pigs, bars, and old short tons..	311,715	271,695	213,671	261,794	259,522	235,902
Exports of refined pig lead.do....	2,265	2,756	1,967	2,133	2,108	1,088
Stocks December 31 (lead content):						
At primary smelters and refineries..........short tons..	140,346	171,079	250,142	262,102	196,661	120,836
At consumer plants...do....	123,661	126,496	97,268	99,140	93,496	119,930
Consumption of metal, primary and secondary.....short tons..	1,128,347	1,091,149	1,021,172	1,027,216	1,109,635	1,163,358
Price: New York, common lead, average, cents per pound.......	14.39	12.21	11.95	10.87	9.63	11.14
World:						
Production:						
Mine.......................	2,484,000	2,570,000	2,630,000	2,630,000	2,760,000	2,800,000
Smelter....................	2,380,000	2,410,000	2,560,000	2,665,000	2,655,000	2,795,000
Price: London, common lead, average, cents per pound.......	11.99	8.88	9.04	8.03	7.06	7.93

[1] Revised figure.

DOMESTIC PRODUCTION

MINE PRODUCTION

The domestic output of 253,400 tons of recoverable lead represented an increase of 7 percent over the 1962 amount. The strike at the Missouri mines of St. Joseph Lead Co., which began on July 27, 1962, was not ended until April 1, 1963. Following settlement of the strike and reopening of the St. Joseph mines in April, output during the last 8 months of the year was at a level equivalent to an annual production of 284,000 tons.

Missouri regained the position of the leading lead-producing State with 79,800 tons followed by: Idaho 75,800 tons; Utah 45,000 tons; and Colorado 19,900 tons. These four States contributed 220,500 tons, or 87 percent of the U.S. total. The remaining 32,900 tons represented the output of 15 States.

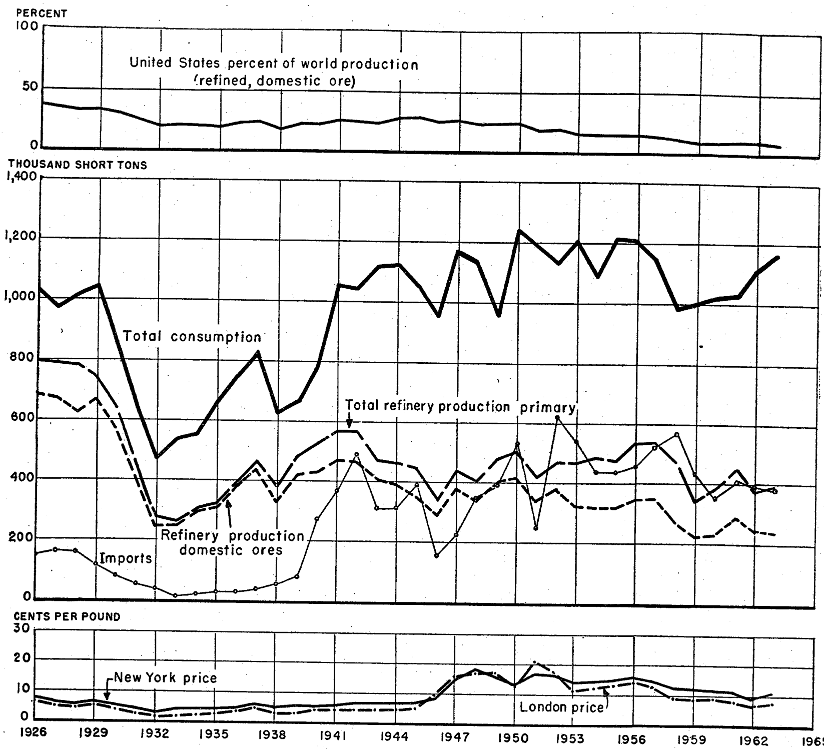

FIGURE 1.—Trends in the lead industry in the United States, 1926–63. Consumption includes primary refined, antimonial, and secondary lead, and lead in pigments made directly from ore. Imports are factored to include 95 percent of lead content or ores, mattes, and concentrates and 100 percent of pigs, bars, base bullion, and scrap.

TABLE 2.—Mine production of recoverable lead in the United States, by States

(Short tons)

State	1954–58 (average)	1959	1960	1961	1962	1963
Arizona	10, 906	9, 999	8, 495	5, 937	6, 966	5, 815
Arkansas	----------	38	----------	----------	----------	----------
California	4, 766	227	440	103	455	823
Colorado	17, 720	12, 907	18, 080	17, 755	17, 411	19, 918
Idaho	64, 605	62, 395	42, 907	71, 476	84, 058	75, 759
Illinois	3, 238	2, 570	3, 000	3, 430	3, 610	2, 901
Kansas	4, 544	481	781	1, 449	970	1, 027
Kentucky	247	409	558	656	743	831
Missouri	122, 783	105, 165	111, 948	98, 785	60, 982	79, 844
Montana	14, 445	7, 672	4, 879	2, 643	6, 121	5, 000
Nevada	4, 569	1, 357	987	1, 791	771	1, 126
New Mexico	3, 327	829	1, 996	2, 332	1, 134	1, 014
New York	1, 216	481	775	879	1, 063	1, 009
North Carolina	5	----------	424	318	219	62
Oklahoma	10, 311	601	936	980	2, 710	3, 192
Utah	45, 961	36, 630	39, 398	40, 894	38, 199	45, 028
Virginia	3, 286	2, 770	2, 152	3, 733	4, 059	3. 500
Washington	10, 738	10, 310	7, 725	8, 053	6, 033	5, 374
Wisconsin	1, 698	745	1, 165	680	1, 394	1, 116
Other States	8	----------	23	27	58	30
Total	324, 373	255, 586	246, 669	261, 921	236, 956	253, 369

Improvement in the market for lead, zinc, and silver during 1963 resulted in expansion of activity in exploration and development of lead deposits, as well as rehabilitation of old mines and expansion of current production facilities. Production from a large part of this activity will not be forthcoming until 1964 or later. Some of the activity is, however, reflected in the following comment by States.

The new lead belt in southeast Missouri continued to receive the major lead exploration attention in the United States. Sixteen major companies were actively engaged in prospecting and development in this area during the year and the most favorable area now appears to be a belt some 50 miles long and 5 miles wide extending through Washington, Iron, Reynolds, and Shannon Counties. During 1963 the St. Joseph Lead Co. centralized the operation of eight mines in the old lead belt under the Federal Division. A third production shaft was bottomed at the Viburnum mine and began installation of production facilities. The capacity of the Viburnum concentrator was increased to 7,000 tons of ore per day. Construction of the new Fletcher plant located in the new lead belt in Reynolds County began on June 27 with a planned capacity of 5,000 tons of ore per day and initial production expected in 1966.[2]

The 25 leading lead-producing mines accounted for 92 percent of the total domestic mine production; the 10 leading mines yielded 77 percent and the 4 largest units 53 percent.

Production of lead by Idaho mines decreased 10 percent. Most of the production came from the Coeur d'Alene district with the largest output by the Bunker Hill and Lucky Friday mines, followed by the Star (Star unit area) and Page mines. The accelerated program of development in the Coeur d'Alene area, initiated in 1961, continued and progress was made in expanding ore reserves. The Bunker Hill Co. continued driving a crosscut from the Bunker Hill mine to connect with the 3100 level of the Crescent mine and also accomplished deeper development work in the Star-Morning and Noonday veins. Lucky Friday Silver-Lead Mines Co. extended the main shaft of the Lucky Friday mine to the 3250 level and began a crosscut to the adjoining Jutila property.

Mines situated in Utah reported output of 45,000 tons, an 18-percent increase compared with 1962. The following mines were the significant producers: United States and Lark (United States Smelting, Refining & Mining Co. (USSR & M Co.)), United Park City mines (United Park City Mines Co.), Mayflower (Hecla Mining Co.), and Ophir (USSR & M Co.). Kennecott Copper Corp. began sinking a 1,500-foot production shaft in the Gurgin area of the East Tintic district and shipped development ore to the International Smelting & Refining Co. lead smelter at Tooele. The crosscut driven by USSR & M Co. from the United States and Lark mine toward the Butterfield mine of Kennecott was extended. New Park Mining Co. deepened the Mammoth mine shaft in the Tintic district and completed a crosscut to an ore shoot previously indicated by drilling.

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[2] St. Joseph Lead Co. Annual Report. 1963, p. 12.

TABLE 3.—Ores yielding lead and zinc in the United States in 1963

(Short tons)

State	Lead ore			Zinc ore			Lead-zinc ore			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	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc
Arizona	2,127	178	11	8,454	42	1,099	293,021	5,553	16,266	116,251	29	7,788	25,899,785	13	255	26,319,638	5,815	25,419
Arkansas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
California	1,294	436	2	-	-	-	3,043	383	95	-	-	-	4,510	4	4	8,847	823	101
Colorado	453	84	11	(2)	-	(2)	[2] 444,202	8,473	32,345	501,069	11,043	15,521	25,590	318	232	971,314	19,918	48,109
Idaho	183,337	19,217	1,627	(2)	(2)	(2)	[2] 899,682	53,437	56,004	-	-	-	412,708	3,105	5,636	1,495,727	75,759	63,267
Illinois	-	-	-	282,617	171	8,960	68,030	298	1,829	-	-	-	400,283	2,432	9,548	750,930	2,901	20,337
Kansas	-	-	-	(2)	(2)	(2)	[2] 133,060	1,027	3,508	-	-	-	-	-	-	133,060	1,027	3,508
Kentucky	-	-	-	-	-	-	-	-	-	-	-	-	107,553	831	1,461	107,553	831	1,461
Missouri	3,253,245	79,844	321	-	-	-	-	-	-	-	-	-	-	-	-	3,253,245	79,844	321
Montana	2,593	288	51	1,206,614	3,185	24,140	154	59	12	-	-	-	8,291,764	1,468	8,738	9,501,125	5,000	32,941
Nevada	352	48	11	1,573	56	499	112	5	3	-	-	-	13,313,213	1,017	58	13,315,250	1,126	571
New Mexico	51	6	1	187,486	944	12,898	21	1	-	-	-	-	7,216,308	63	39	7,403,866	1,014	12,938
Oklahoma	-	-	-	280,038	1,216	8,324	199,764	1,976	4,921	-	-	-	-	-	-	479,802	3,192	13,245
Tennessee	-	-	-	2,809,788	-	87,377	-	-	-	1,431,270	-	8,470	-	-	-	4,241,058	-	95,847
Utah	6,583	1,439	113	-	-	-	539,125	42,991	33,826	1,081	156	79	39,781	442	2,161	586,570	45,028	36,179
Washington	-	-	-	-	-	-	810,284	5,374	22,270	-	-	-	-	-	-	810,284	5,374	22,270
Wisconsin	-	-	-	445,742	1,116	15,114	-	-	-	-	-	-	-	-	-	445,742	1,116	15,114
New Jersey						32,738		-	-					-	-		-	32,738
New York						10,232		1,009	43,263					-	-		1,009	53,495
North Carolina	-	-	-	961,794	-	-	1,150,739	-	-	-	-	-	18,614	62	13	2,131,147	62	13
Pennsylvania						27,389		-	-					-	-		-	27,389
Virginia						3,124		3,500	20,864					-	-		3,500	23,988
Other States	33	4	-	-	-	-	-	-	-	-	-	-	4,558	26	3	4,591	30	3
Total	3,450,068	101,544	2,148	6,184,106	6,730	231,894	4,541,237	124,086	235,206	2,049,671	11,228	31,858	55,734,667	9,781	28,148	71,959,749	253,369	529,254

[1] Lead and zinc recovered from other ores (copper, gold, silver, etc.) and from mill slags, tailings, and dumps.
[2] Combined with lead-zinc ore to avoid disclosing individual company confidential data.

TABLE 4.—Mine production of recoverable lead in the United States, by months

(Short tons)

Month	1962	1963	Month	1962	1963
January	22,726	15,476	August	16,641	24,470
February	21,994	13,180	September	13,932	22,511
March	23,675	14,772	October	15,092	25,241
April	23,943	20,786	November	14,284	22,999
May	24,984	24,083	December	14,551	23,930
June	23,955	22,322			
July	21,179	23,599	Total	236,956	253,369

TABLE.—Twenty-five leading lead-producing mines in the United States in 1963, in order of output

Rank	Mine	District or region	State	Operator	Source of lead
1	Federal	Southeastern Missouri.	Missouri	St. Joseph Lead Co.	Lead ore.
2	Bunker Hill	Coeur d'Alene	Idaho	The Bunker Hill Co.	Lead-zinc ore.
3	Viburnum	Southeastern Missouri.	Missouri	St. Joseph Lead Co.	Lead ore.
4	United States & Lark.	West Mountain (Bingham).	Utah	United States Smelting, Refining & Mining Co.	Lead-zinc ore.
5	Lucky Friday	Coeur d'Alene	Idaho	Lucky Friday Silver-Lead Mines Co.	Lead ore.
6	Star-Morning Unit.	Coeur d'Alene	Idaho	The Bunker Hill Co. and Hecla Mining Co.	Lead-zinc ore.
7	Idarado	Upper San Miguel.	Colorado	Idarado Mining Co.	Copper-lead-zinc ore.
8	Indian Creek	Southeastern Missouri.	Missouri	St. Joseph Lead Co.	Lead ore.
9	Page	Coeur d'Alene	Idaho	American Smelting & Refining Co.	Lead-zinc ore.
10	United Park City.	Blue Ledge	Utah	United Park City Mines Co.	Lead-zinc, lead ore.
11	Iron King	Big Bug	Arizona	Shattuck Denn Mining Corp.	Lead-zinc ore.
12	Pend Oreille	Metaline	Washington	Pend Oreille Mines & Metals Co.	Do.
13	Mayflower Unit	Blue Ledge	Utah	Hecla Mining Co.	Do.
14	Austinville & Ivanhoe Mines.	Austinville	Virginia	The New Jersey Zinc Co.	Zinc-lead ore.
15	Eagle	Red Cliff (Battle Mountain).	Colorado	do	Lead-zinc, copper ore.
16	Badger State	Summit Valley	Montana	The Anaconda Co.	Zinc ore.
17	Sunnyside	Eureka	Colorado	Standard Metals Corp.	Lead-zinc ore.
18	Ophir Unit	Ophir	Utah	United States Smeltting, Refining & Mining Co.	Do.
19	Tintic	Tintic	Utah	Kennecott Copper Corp.	Lead, lead-zinc ore.
20	Deardorff Group	Upper Mississippi Valley.	Illinois	Ozark-Mahoning Co.	Fluorspar-lead-zinc ore.
21	Emperius	Creede	Colorado	Emperius Mining Co.	Lead-zinc ore.
22	Balmat	St. Lawrence County.	New York	St. Joseph Lead Co.	Zinc-lead ore.
23	Three Kids	Las Vegas	Nevada	Manganese, Inc.	Lead residue.
24	Kearney	Central	New Mexico	American-Peru Mining Co.	Zinc ore.
25	Keystone	Elk Mountain	Colorado	McFarland & Hullinger.	Copper-lead, zinc ore.

Output of lead from mines in Colorado totaled 19,900 tons, a 14-percent increase. Activity increased at numerous mines throughout the mineral area. Major production was from Eagle mine at Gilman, operated by The New Jersey Zinc Co., and the Idarado Mine at Telluride, operated by Idarado Mining Co. Standard Metals Corp.

continued activity at the Sunnyside and Shenandoah mines at Silverton. Consolidated Parnett Co. continued operations at the Wellington mine and concentrator at Breckenridge. The Emperius mine at Creede was reopened, and the Keystone mine at Crested Butte resumed operations. Humphreys Engineering Co. operated the Cascade mine in Clear Creek County.

Lead production of Washington again declined to 5,400 tons. The Metaline district was the main producing area with mines operated by Pend Oreille Mines & Metals Co. and American Zinc, Lead & Smelting Co. Production from the Grandview mine and adjoining Mineral Rights property was substantially reduced in order to augment underground development.

Arizona production declined to 5,800 tons. The principal producer continued to be the Iron King mine of Shattuck Denn Mining Corp. Nash & McFarland increased output from the Flux mine in Santa Cruz County.

Montana production decreased to 5,000 tons. The reduction was due, in part, to decreases in production at the Badger mine at Butte and to decreases in lead recovered as a byproduct of manganese operations in Philipsburg, slag fuming at East Helena, and other small dump reprocessing operations.

The Hanover mine in New Mexico was reopened in October by The New Jersey Zinc Co., and the Kearney mine was a major producer in the State.

Production from the Kansas-Oklahoma area of the Tri-State district, processed principally at the Central Mill operated by The Eagle-Picher Co., increased about 15 percent.

The Illinois-Wisconsin area output decreased from 5,000 tons to 4,000 tons. A fire at the Shullsburg mine operated by The Eagle-Picher Co., necessitated suspension of operations until July when mill rebuilding and a new incline shaft were completed. Eagle-Picher also opened the Booty-Thompson mine in April and trucked the ore to the Graham mill near Galena, Ill. American Zinc, Lead & Smelting Co. operated the Hancock-Winskell and the Thompson-Temperly mines with the ore treated in the Vinegar Hill mills near Shullsburg, Wis. The Ivey Construction Co. operated a mine at Linden, Wis., under lease from The Eagle-Picher Co., and the Grimes Mining Co. began production from a mine and mill on the Burnshaw property.

Nevada increased production although byproduct lead from the Three Kids manganese operation was terminated in 1962. California output was almost double that achieved in 1962.

Lead produced as a byproduct of predominately zinc ore in Kentucky, New York, North Carolina, and Virginia was some 11 percent below the 1962 output.

SMELTER AND REFINERY PRODUCTION

Refined lead was produced in the United States at primary refineries that processed ore and concentrate, base bullion, and small quantities of scrap as well as at secondary smelters that process scrap almost exclusively. The lead was derived from three principal sources—domestic mine production, imports of foreign ore and base bullion, and scrap materials. Refined lead and antimonial lead were produced at both primary and secondary plants. The following plants comprise the domestic primary lead production facilities:

Smelters:
- American Smelting and Refining Co.
  - East Helena, Mont.
  - El Paso, Tex.
- International Smelting & Refining Co.
  - Tooele, Utah

Smelter-refineries:
- American Smelting and Refining Co.
  - Selby, Calif.
  - Perth Amboy, N.J.
- The Bunker Hill Co.
  - Kellogg, Idaho
- St. Joseph Lead Co.
  - Herculaneum, Mo.
- The Eagle-Picher Co.
  - Galena, Kans.

Refineries:
- United States Smelting Lead Refinery, Inc.
  - East Chicago, Ind.
- American Smelting & Refining Co.
  - Omaha, Nebr.

Major secondary smelting firms that report to the Bureau of Mines are as follows:

- American Smelting & Refining Co. (including Federated Metals Division) plants:
  - Los Angeles, San Francisco, and Selby, Calif.
  - Whiting, Ind.
  - Omaha, Nebr.
  - Newark and Perth Amboy, N.J.
  - Houston, Tex.
- Bers & Co., Inc., Philadelphia, Pa.
- The Bunker Hill Co., Seattle, Wash.
- Continental Smelting & Refining Co., McCook, Ill.
- Electric Storage Battery Co., Philadelphia, Pa.
- General Battery & Ceramic Corp., Reading, Pa.
- Goldsmith Bros. Division of National Lead Co., Chicago, Ill.
- Gopher Smelting & Refining Co., St. Paul, Minn.
- Gulf Coast Lead Co., Tampa, Fla.
- Imperial Type Metals Co., plants: Chicago, Ill., and Philadelphia, Pa.
- Industrial Metal Melting Co., Inc., Baltimore, Md.
- Inland Metals Refining Co., Chicago, Ill.
- Nassau Smelting & Refining Co., Inc., Tottenville, N.Y.
- National Lead Co. (including Magnus Metal Division, Morris P. Kirk & Son, Inc., and Master Metals, Inc.), plants:
  - Los Angeles, Calif.
  - Atlanta, Ga.
  - Chicago and Granite City, Ill.
  - Indianapolis, Ind.
  - Topeka, Kans.
  - Baltimore, Md.
  - St. Louis Park, Minn.
  - St. Louis, Mo.
  - Fremont, Nebr.
  - Perth Amboy, N.J.
  - Depew, N.Y.
  - Cincinnati and Cleveland, Ohio
  - Portland, Oreg.
  - Pittsburgh, Pa.
  - Dallas and Houston, Tex.

National Metal & Smelting Co., Fort Worth, Tex.
North American Smelting Co., Wilmington, Del.
Price Battery Corp., Hamburg, Pa.
Revere Smelting & Refining Co., Newark, N.J.
Schuylkill Products Co., Baton Rouge, La.
Southeastern Lead Co., Tampa, Fla.
Southern Lead Co., Dallas, Tex.
United States Smelting Lead Refinery, Inc., East Chicago, Ind.
Hyman Viener & Sons, Richmond, Va.
Western Lead Products Co., City of Industry, Calif.
Winston Lead Smelting Co., Winston-Salem, N.C.

Refined Lead, Primary and Secondary.—Production of refined lead in the United States produced from all sources—primary, secondary, and remelt—amounted to 529,300 tons compared with 494,500 tons in 1962. Primary refineries produced 394,700 tons from primary sources of which domestic ores supplied 61 percent and 3,800 tons were from secondary materials. Secondary plants produced 130,800 tons from processed secondary materials. Remelt lead from all sources totaled 25,600 tons for the year.

Antimonial Lead, Primary and Secondary.—The lead content of antimonial lead produced in the United States totaled 276,300 tons. Of this total, 237,100 tons, or 86 percent, came from secondary plants and the remaining 39,200 tons from primary plants. Scrap was the source of 20 percent, domestic ore 42 percent, and foreign ores 38 percent of the primary smelter output.

Raw Material Source.—Primary lead materials smelted in primary plants provided 394,700 tons of refined lead and 31,500 tons of lead in antimonial lead. Domestic sources contributed 60 percent of the total and foreign sources the remaining 40 percent.

Secondary lead recovered from scrap amounted to 493,500 tons. Of this, 134,500 tons was in the form of refined and remelt soft lead; 244,800 tons in antimonial lead; and 114,200 tons in other alloys. New scrap, primarily drosses from scrap smelting, contributed 13 percent of the lead, and old scrap, predominantly battery plates, furnished 87 percent.

TABLE 6.—Refined lead produced at primary refineries in the United States, by source material

(Short tons)

	1954–58 (average)	1959	1960	1961	1962	1963
Refined lead:						
From primary sources:						
Domestic ores and base bullion	321,870	225,270	228,899	288,078	245,645	239,660
Foreign ores and base bullion	180,503	115,661	153,537	161,487	130,418	155,072
Total	502,373	340,931	382,436	449,565	376,063	394,732
From secondary sources	3,763	1,194	4,776	1,569	1,842	3,741
Grand total	506,136	342,125	387,212	451,134	377,905	398,473
Average sales price per pound	$0.141	$0.115	$0.117	$0.103	$0.093	$0.108
Calculated value of primary refined lead (thousands)[1]	$141,669	$78,414	$89,490	$92,610	$69,948	$85,262

[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)	Anitimony content: Short tons	Anitimony content: Percent	Lead content by difference (short tons): From domestic ore	From foreign ore	From scrap	Total
1954–58 (average)	61,755	3,258	5.3	7,132	8,339	43,026	58,497
1959	37,487	1,924	5.1	6,447	5,955	23,161	35,563
1960	30,230	1,575	5.2	1,216	1,169	26,270	28,655
1961	35,080	1,894	5.4	12,988	11,978	8,220	33,186
1962	33,325	2,249	6.7	14,838	12,545	3,693	31,076
1963	41,077	1,890	4.6	16,350	15,165	7,672	39,187

TABLE 8.—Stocks and consumption of new and old lead scrap in the United States in 1963

(Short tons, gross weight)

Class of consumers and type of scrap	Stocks Jan. 1 [1]	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks Dec. 31
Smelters and refiners:						
Soft lead	3,218	53,249		53,499	53,499	2,968
Hard lead	1,265	15,858		15,991	15,991	1,132
Cable lead	1,133	27,313		27,107	27,107	1,339
Battery-lead plates	23,377	419,373		407,494	407,494	35,256
Mixed common babbitt	233	3,312		3,162	3,162	383
Solder and tinny lead	290	9,027		8,915	8,915	402
Type metals	1,069	26,025		25,507	25,507	1,587
Drosses and residues	14,545	92,446	84,507		84,507	22,484
Total	45,130	646,603	84,507	541,675	626,182	65,551
Foundries and other manufacturers:						
Soft lead	122	326	76	242	318	130
Hard lead	295	147		150	150	292
Cable lead	31	26		36	36	21
Battery-lead plates	21	3		3	3	21
Mixed common babbitt	127	13,930		13,945	13,945	112
Solder and tinny lead	41	275	57	224	281	35
Type metals						
Drosses and residues	201					201
Total	838	14,707	133	14,600	14,733	812
Grand total:						
Soft lead	3,340	53,575	76	53,741	53,817	3,098
Hard lead	1,560	16,005		16,141	16,141	1,424
Cable lead	1,164	27,339		27,143	27,143	1,360
Battery-lead plates	23,398	419,376		407,497	407,497	35,277
Mixed common babbitt	360	17,242		17,107	17,107	495
Solder and tinny lead	331	9,302	57	9,139	9,196	437
Type metals	1,069	26,025		25,507	25,507	1,587
Drosses and residues	14,746	92,446	84,507		84,507	22,685
Grand total	45,968	661,310	84,640	556,275	640,915	66,363

[1] Revised figures.

TABLE 9.—Secondary metal recovered[1] from lead and tin scrap in the United States in 1963, by type of products

(Short tons, gross weight)

	Lead	Tin	Antimony	Other	Total
Refined pig lead	108,890				108,890
Remelt lead	25,639				25,639
Total	134,529				134,529
Refined pig tin		3,018			3,018
Remelt tin		410			410
Total		3,428			3,428
Lead and tin alloys:					
Antimonial lead	244,797	353	14,874	223	260,247
Common babbitt	19,792	988	1,752	42	22,574
Genuine babbitt	64	249	25	10	348
Solder	25,661	5,427	392	17	31,497
Type metals	29,554	1,676	3,584	10	34,824
Cable lead	16,602	8	155		16,765
Miscellaneous alloys	1,454	608	21	31	2,114
Total	337,924	9,309	20,803	333	368,369
Tin content of chemical products		803			803
Grand total	472,453	13,540	20,803	333	507,129

[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)

	1954–58 (average)	1959	1960	1961	1962	1963
As metal:						
At primary plants	3,763	1,194	4,776	1,569	1,842	3,741
At other plants	121,106	124,185	143,443	139,100	116,626	130,788
Total	124,869	125,379	148,219	140,669	118,468	134,529
In antimonial lead:						
At primary plants	43,026	23,161	26,270	8,220	3,693	7,672
At other plants	189,420	181,185	179,217	197,349	225,699	237,125
Total	232,446	204,346	205,487	205,569	229,392	244,797
In other alloys	118,834	121,662	116,197	106,554	96,342	114,145
Grand total:						
Quantity	476,149	451,387	469,903	452,792	444,202	493,471
Value (thousands)	$134,889	$103,819	$109,957	$93,275	$82,622	$106,590

TABLE 11.—Lead recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1962	1963	Form of recovery	1962	1963
New scrap:			As soft lead:		
Lead-base	44,803	59,577	At primary plants	1,842	3,741
Copper-base	5,586	6,094	At other plants	116,626	130,788
Tin-base	529	611	Total	118,468	134,529
Total	50,918	66,282	In antimonial lead [1]	229,392	244,797
Old scrap:			In other lead alloys	87,243	92,203
Battery-lead plates	252,593	272,412	In copper-base alloys	9,019	21,878
All other lead-base	124,277	135,844	In tin-base alloys	80	64
Copper-base	16,409	18,928			
Tin-base	5	5	Total	325,734	358,942
Total	393,284	427,189	Grand total	444,202	493,471
Grand total	444,202	493,471			

[1] Includes 3,693 tons of lead recovered in antimonial lead from secondary sources at primary plants in 1962 and 7,672 tons in 1963.

CONSUMPTION AND USES

Lead consumption in the United States advanced sharply in January 1963 compared with December 1962 and except for the month of August was consistently above the corresponding month in 1962. Total consumption of 1,163,400 tons was 5 percent above the previous year and was last exceeded in 1956. Consumption of soft lead was 740,200 tons, a moderate increase. Use of antimonial lead, however, increased substantially with the lead content increasing from 295,800 tons in 1962 to the 314,400 tons registered in 1963. Lead in alloys, copper-base scrap and that used directly in fabricated end products all advanced in relation to 1962 totals. Of the 1,119,000 tons of smelter processed lead consumed in the United States, excluding that used directly in end products, soft lead represented 66 percent; lead in antimonial lead, 28 percent; lead in alloys, 4 percent; and lead in copper-base scrap, 2 percent. Industrial consumption of lead was widespread throughout the United States. Four States—New Jersey, Illinois, California, Indiana—each consuming over 100,000 tons, represented 46 percent of the total.

Metal products accounted for 835,900 tons of lead, a gain of 4 percent. Increased use was shown for all classes, except sheet lead and type metal. The downward trend in cable covering was reversed but type metal continued to decline as a major use. Pigments, after showing a recovery in 1962, again declined to 99,100 tons with a substantial decrease of consumption in white lead and in red lead and litharge. Gasoline antiknock additives registered a major gain and a record for this use at 192,800 tons of lead. The two major end product uses of lead, storage batteries and gasoline additives, combined, represent 54 percent of the total lead consumed.

The Association of Battery Manufacturers, Inc., reported shipments of 31,840,000 units of replacement batteries and total battery shipments of 41,128,400 units, including exports. This is a gain of almost 6 percent and, in relation to replacement batteries, a new high.

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TABLE 12.—Lead consumption in the United States, by products

(Short tons)

Product	1962	1963	Product	1962	1963
Metal products:			Pigments—Continued		
Ammunition	47,779	49,894	Pigment colors	11,660	11,767
Bearing metals	16,472	21,713	Other [1]	3,892	7,813
Brass and bronze	20,607	21,943			
Cable covering	56,676	57,707	Total	102,968	99,075
Calking lead	72,648	76,308			
Casting metals	7,355	7,856	Chemicals:		
Collapsible tubes	11,972	14,832	Gasoline antiknock additives	168,926	192,811
Foil	3,720	3,952	Miscellaneous chemicals	2,715	632
Pipes, traps, and bends	19,819	20,100			
Sheet lead	28,540	26,495	Total	171,641	193,443
Solder	66,873	67,945			
Storage batteries:			Miscellaneous uses:		
Battery grids, posts, etc	217,525	222,286	Annealing	5,306	4,847
Battery oxides	202,381	216,795	Galvanizing	1,146	1,631
Terne metal	1,402	1,983	Lead plating	236	220
Type metal	26,760	26,069	Weights and ballast	10,330	12,207
Total	800,529	835,878	Total	17,018	18,905
			Other, unclassified uses	17,479	16,057
Pigments:					
White lead	11,091	8,846	Grand total [2]	1,109,635	1,163,358
Red lead and litharge	76,325	70,649			

[1] Includes lead content of leaded zinc oxide and other pigments and chemicals.
[2] Includes lead which went directly from scrap to fabricated products.

TABLE 13.—Lead consumption in the United States, by months

(Short tons)

Month	1962	1963	Month	1962	1963
January	98,828	100,789	August	96,393	93,833
February	88,415	96,023	September	91,122	94,587
March	91,040	92,606	October	105,145	111,149
April	86,659	95,340	November	96,293	101,723
May	94,685	98,264	December	91,500	99,372
June	89,988	94,024			
July	79,567	85,648	Total [1]	1,109,635	1,163,358

[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 1963, 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	206,311	86,534	47,368	16,451	356,664
Storage batteries	220,860	218,214	7		439,081
Pigments	94,912	178			95,090
Chemicals	193,443				193,443
Miscellaneous	10,915	7,987	3		18,905
Unclassified	13,719	1,525	565		15,809
Total	740,160	314,438	47,943	16,451	[1] 1,118,992

[1] Excludes 40,381 tons of lead that went directly from scrap to fabricated products and 3,985 tons of lead contained in leaded zinc oxide and other pigments and chemicals.

TABLE 15.—Lead consumption in 1963, by States [1]

(Short tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	81,297	27,227	6,682	1,322	116,528
Colorado	1,500	2,456	183		4,139
Connecticut	12,445	11,039	50	1,033	24,567
District of Columbia	107				107
Florida	4,347	3,519			7,866
Georgia	31,692	11,057	1,883	69	44,701
Illinois	71,485	40,172	8,101	1,842	121,600
Indiana	62,568	43,470	2,554	817	109,409
Kansas	9,710	8,842	7	169	18,728
Kentucky	2,888	3,823	1		6,712
Maryland	5,756	18,740	513		25,009
Massachusetts	5,697	3,799	287	185	9,968
Michigan	16,116	19,111	1,651	945	37,823
Missouri	34,069	5,562	147	1,388	41,166
Nebraska	5,439	907		572	6,918
New Jersey	134,658	19,914	10,556	667	165,795
New York	32,689	3,631	8,525	1,039	45,884
Ohio	12,634	6,203	2,309	1,079	22,225
Pennsylvania	48,483	29,449	851	2,244	81,027
Rhode Island	1,638	367	20		2,025
Tennessee	218	6,839	160	229	7,446
Virginia	2,505	1,617	618	961	5,701
Washington	6,925	944	278		8,147
West Virginia	15,731	7,157			22,888
Wisconsin	767	3,838	85	173	4,863
Alabama and Mississippi	553	715		719	1,987
Arkansas and Oklahoma	4,038	3,266	28		7,332
Hawaii and Oregon	542	2,488	2	239	3,271
Iowa and Minnesota	1,946	6,922	893	165	9,926
Louisiana and Texas	112,605	14,316	1,456	340	128,717
Montana and Idaho	12,375				12,375
New Hampshire, Maine, Delaware	6,393	3,422	103	254	10,172
North and South Carolina	222	3,474			3,696
Utah, Nevada, Arizona	122	152			274
Total	740,160	314,438	47,943	16,451	1,118,992

[1] Excludes 40,381 tons of lead which went directly from scrap to fabricated products and 3,985 tons of lead contained in leaded zinc oxide and other nonspecified pigments.

LEAD PIGMENTS

Production of lead pigments, consumed mainly by the paint, rubber, and battery manufacturers increased 4 percent to 299,400 tons of lead content. All of the white lead, red lead, and litharge as well as 175,000 tons of black oxide (battery oxides) were produced from refined pig lead and, combined, represented 99 percent of the lead used for the manufacture of lead oxides. The remaining 1 percent was the lead content of ore used to produce leaded zinc oxide. Production of basic lead is not published and lead silicate, a derivative of litharge, is included with litharge.

Consumption and Uses, White Lead.—Shipments of white lead again declined, both dry and in oil, with the total of 15,400 tons about 800 tons less than the 1962 shipments. The paint industry, registering most of the consumption decrease, consumed 74 percent and the ceramic industry consumed 1 percent. Other uses include: Chemicals, greases, plasticizers, and stabilizers for plastics.

Basic Lead Sulfate.—Most of the lead sulfate was used in making leaded zinc oxide. Individual production and consumption are withheld to avoid disclosure of company confidential data.

Red Lead.—Production and shipments of red lead were both higher in 1963. Shipments totaled 26,200 tons and the paint industry accounted for 50 percent. The other 50 percent was widely distributed for use in lubricants, petroleum, rubber, and miscellaneous small uses.

Litharge.—Shipments of litharge exceeded production in 1962 by 9,900 tons. The shipments were distributed among various manufacturers. Ceramics, chrome pigments, oil refining, rubber, and varnish accounted for 30 percent of the total. To avoid disclosing company confidential data, a large percentage of litharge shipped has been incorporated into the group classified "Other." Production of leaded litharge, known to the trade as "black oxide," by battery manufactures amounted to 182,900 tons in comparison to the 161,000 tons produced in 1962.

Prices.—The quoted price of white lead was 16.5 cents per pound in carload lots, f.o.b. plants until September 9, when it increased to 17.75 cents per pound. The average value of 1963 shipments of dry white lead was $366 per ton; white lead in oil averaged $467 per ton. Red lead price advanced on January 21 from 13.75 cents to 14.25 cents per pound where it held until June 10 when raised to 14.50 cents per pound. During the last 6 months the price advanced five times to 16.25 cents per pound, quoted on December 2. The average value of shipments, as reported, however, declined from $285 per ton to $282 per ton in 1963. The price of commercial litharge, f.o.b. works in less than carload lots also trended upward during the year advancing from the year opening quotation of 13.25 cents per pound in 7 increments to a yearend price of 15.75 cents per pound reached on December 2. Average value of litharge shipments was $238 per ton.

TABLE 16.—Production and shipments of lead pigments [1] and oxides in the United States

Pigment	1962				1963			
	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	10,161	10,597	$4,240,362	$400	10,239	10,075	$3,688,456	$3.66
In oil [3]	5,410	5,602	2,667,363	476	3,758	5,327	2,485,367	4.67
Total	15,571	16,199	6,907,725	426	13,997	15,402	6,173,823	4.01
Red lead	24,898	25,517	7,279,183	285	25,780	26,245	7,391,928	2.82
Litharge	102,908	103,397	23,860,746	231	93,958	103,834	24,672,270	2.38
Black oxide	161,023				182,934			

[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	1962				1963			
	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	----------	----------	12,457	12,457	----------	----------	11,198	11,198
Red lead	----------	----------	22,570	22,570	----------	----------	23,370	23,370
Litharge	----------	----------	95,704	95,704	----------	----------	87,381	87,381
Black oxide	----------	----------	153,819	153,819	----------	----------	175,005	175,005
Leaded zinc oxide	1,727	760	----------	2,487	1,555	869	----------	2,424
Total	1,727	760	284,550	287,037	1,555	869	296,954	299,378

[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	1954–58 (average)	1959	1960	1961	1962	1963
Paints	19,117	15,148	14,145	12,086	12,054	11,358
Ceramics	508	243	219	141	137	138
Other	4,131	[2] 3,833	[2] 3,578	3,996	4,008	3,906
Total	23,756	19,224	17,942	16,223	16,199	15,402

[1] Excludes basic lead sulfate; figures withheld to avoid disclosing individual company confidential data.
[2] Figures for plasticizers and stabilizers withheld to avoid disclosing individual company confidential data.

TABLE 19.—Distribution of red lead shipments, by industries

(Short tons)

Industry	1954–58 (average)	1959	1960	1961	1962	1963
Paints	14,185	12,098	12,903	12,895	13,716	13,213
Storage batteries	(1)	(1)	(1)	(1)	(1)	(1)
Ceramics	(1)	(1)	328	(1)	637	(1)
Other	12,495	9,807	9,400	9,961	11,164	13,032
Total	26,680	21,905	22,631	22,856	25,517	26,245

[1] Included with "Other."

TABLE 20.—Distribution of litharge shipments, by industries

(Short tons)

Industry	1954-58 (average)	1959	1960	1961	1962	1963
Ceramics	(1)	15,340	15,753	14,393	17,752	17,762
Chrome pigments	4,321	4,682	(1)	(1)	(1)	5,763
Floor covering	(1)	(1)	(1)	(1)	(1)	(1)
Insecticides	(1)	(1)	(1)	(1)	(1)	(1)
Oil refining	3,421	3,096	2,371	2,147	2,404	1,973
Rubber	1,705	1,808	1,373	1,243	1,792	1,702
Storage batteries	(1)	(1)	(1)	(1)	(1)	(1)
Varnish	3,878	4,725	3,471	3,394	4,083	4,240
Other	110,448	76,362	75,672	77,773	77,366	72,394
Total	123,773	106,013	98,640	98,950	103,397	103,834

[1] Included with "Other."

TABLE 21.—U.S. imports for consumption of lead pigments and compounds

Kind	1962		1963	
	Short tons	Value (thousands)	Short tons	Value (thousands)
White lead	2,361	$578	2,434	$549
Red Lead	555	83	1,171	198
Litharge	15,597	2,229	22,440	3,592
Other lead pigments	34	13	12	9
Other lead compounds	439	124	238	52
Total	18,986	3,027	26,295	4,400

Source: Bureau of the Census.

TABLE 22.—U.S. exports of lead pigments and compounds

Kind	1962		1963	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Lead pigments [1]	1,919	$595	1,845	$620
Lead arsenate	711	249	401	135
Total	2,630	844	2,246	755

[1] Includes white lead, red lead, and litharge.

Source: Bureau of the Census.

STOCKS

Stocks of refined lead at primary producing plants declined 87,200 tons during the year to 49,300 tons at yearend, and antimonial lead stocks increased to 7,300 tons. Total yearend stocks representing physical inventories at primary plants, regardless of ownership, but not including material in process or in transit, were 120,800 tons compared with 196,700 tons at the close of 1962.

Stocks reported by the American Bureau of Metal Statistics indicated an additional 20,300 tons of lead in bullion was in process at or in transit to primary plants and about 25,800 tons of lead in ores was in process at smelters. Total stocks of primary lead as metal or in raw materials was thus 166,900 tons, a decrease of 66,100 tons during the year.

Consumer and secondary smelter stocks of lead increased from 93,500 tons at the end of 1962 to 119,900 tons at the end of 1963 and were last exceeded in 1959. The major increase was in refined soft lead with a gain of 20,400 tons and in antimonial lead with a gain of 6,200 tons.

On December 31, the total lead inventory in all Government stockpiles was 1,378,400 tons of which 1,050,000 tons was in the national (strategic) stockpile and 328,000 was in the supplemental stockpile.

TABLE 23.—Stocks of lead at primary smelters and refineries in the United States, Dec. 31

(Short tons)

Stocks	1954-58 (average)	1959	1960	1961	1962	1963
Refined pig lead	76,266	107,683	148,415	195,200	136,544	49,347
Lead in antimonial lead	11,193	11,361	10,483	10,354	5,975	7,323
Lead in base bullion	12,000	12,840	26,025	16,978	10,392	14,947
Lead in ore and matte	40,887	39,195	65,219	39,570	43,750	49,219
Total	140,346	171,079	250,142	262,102	196,661	120,836

TABLE 24.—Consumer stocks of lead in the United States, Dec. 31, by types of material

(Short tons, lead content)

Year	Refined soft lead	Antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
1959	80,277	38,688	6,435	1,096	126,496
1960	49,725	39,230	7,216	1,097	97,268
1961	55,951	33,633	8,298	1,258	99,140
1962	51,121	34,389	6,817	1,169	93,496
1963	71,558	40,606	6,558	1,208	119,930

PRICES

The quoted New York price for common lead at the opening of 1963 was 10.00 cents per pound. On January 14 the price increased to 10.50 cents and then increased in increments of 0.25 cent on June 5, July 23, August 19, September 16, and October 8. On November 21 the price firmed at 12.50 cents for the remainder of 1963. The average New York price quotation for the year was 11.14 cents.

Quotations on the London Metal Exchange ranged from a low of £53.75 per long ton in January (equivalent to 6.73 cents per pound, U.S. currency—computed on the average monthly rate of exchange) to a high of £77.38 (9.66 cents) on December 31. The average for the year was 7.93 cents per pound.

TABLE 25.—Average monthly and yearly quoted prices of lead at St. Louis, New York, and London [1]

(Cents per pound)

Month	1962			1963		
	St. Louis	New York	London [2]	St. Louis	New York	London [2]
January	9.83	10.03	7.42	10.12	10.32	6.79
February	9.38	9.58	7.37	10.30	10.50	6.84
March	9.30	9.50	7.62	10.30	10.50	6.97
April	9.30	9.50	7.60	10.30	10.50	7.24
May	9.30	9.50	7.51	10.30	10.50	7.58
June	9.30	9.50	7.24	10.52	10.72	8.12
July	9.30	9.50	6.74	10.88	11.08	8.14
August	9.30	9.50	6.39	11.16	11.36	8.38
September	9.30	9.50	6.49	11.44	11.64	8.47
October	9.30	9.50	6.62	11.75	11.95	8.70
November	9.79	9.99	6.79	11.96	12.16	8.63
December	9.80	10.00	6.94	12.30	12.50	9.28
Average	9.43	9.63	7.06	10.94	11.14	7.93

[1] St. Louis: Metal Statistics, 1964, p. 447. New York: Metal Statistics, 1964, p. 443. London: E&MJ Metal and Mineral Markets.
[2] Based on monthly rates of exchange by Federal Reserve Board.

FOREIGN TRADE

Imports.—General imports of lead were 389,100 tons, about 3 percent lower than the 402,800 tons reported for 1962. Imports for consumption were 376,400 tons in comparison with 397,400 for 1962. Import quotas were not completely filled except in the first quarter. Lead ore and concentrate imports for consumption were less than the total allowable in each of the last three quarters of the year, and metal imports did not fill the quota for the last quarter of the year. Pigs and bars accounted for 59 percent of imports for consumption; ore and concentrate for 36 percent; bullion for 1 percent; and scrap and other products for the remaining 4 percent.

Peru, Republic of South Africa, Australia, Canada, Bolivia, and Honduras, in descending order of quantity, were the major suppliers of ore and concentrate. Mexico, with 33 percent, was the leading supplier of lead metal followed by Australia, Yugoslavia, Canada, and Peru, the other major suppliers.

Exports.—Total lead exported was 3,500 tons, less than one-half of the 1962 exports. Exports of ore and concentrate were negligible and exports of metal decreased to 1,100 tons. Scrap export of 2,400 tons was approximately the same as in 1962.

Tariff.—A revised system of tariff classification was effective September 1, 1963, which altered duties on certain lead materials and reportings by the Bureau of the Census. Duties on lead metal, bullion, and drosses continued, however, at 1.0625 cents per pound of lead content, and duties on lead ores and concentrates remained at 0.75 cent. Suspension of duty on lead scrap continued throughout the year.

TABLE 26.—U.S. imports [1] of lead, by countries

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
Ore, flue dust, and matte (lead content):						
North America:						
Canada	30,368	32,226	26,473	34,361	27,728	23,634
Guatemala	5,756	153	1,809	9,817	2,135	305
Honduras	2,779	3,639	4,906	5,512	[2] 4,965	6,809
Mexico	2,771	489	1,249	1,166	1,180	1,071
Other	1,089	195	-	-	-	-
Total	42,763	36,702	34,437	50,856	[2] 36,008	31,819
South America:						
Bolivia	15,794	11,221	9,021	11,370	8,242	9,791
Chile	220	113	1,283	610	-	-
Colombia	639	570	705	722	439	9
Peru	52,929	36,777	36,300	28,970	[2] 32,999	43,950
Other	320	53	103	-	-	-
Total	69,902	48,734	47,412	41,672	[2] 41,680	53,750
Europe	246	221	222	300	280	-
Asia:						
Philippines	1,794	310	228	238	57	23
Other	197	25	504	-	181	244
Total	1,991	335	732	238	238	267
Africa:						
Morocco [3]	-	-	5,238	-	-	-
South Africa, Republic of [4]	42,884	27,879	39,352	34,089	33,881	34,273
Other	9	-	-	-	-	-
Total	42,893	27,879	44,590	34,089	33,881	34,273
Oceania: Australia	29,259	24,963	18,299	20,031	26,544	27,633
Total ore, flue dust, and matte	187,054	138,834	145,692	147,186	[2] 138,631	147,742
Base bullion (lead content):						
North America	8	34	254	362	5	851
South America	115	46	39	60	2,080	2,647
Europe	-	-	-	([5])	-	2
Asia	([5])	-	-	-	-	-
Oceania	-	-	-	-	2,514	1,937
Total base bullion	123	80	293	422	4,599	5,437
Pigs and bars (lead content):						
North America:						
Canada	36,019	41,533	26,088	54,717	56,807	29,619
Mexico	92,995	86,827	69,930	81,328	65,892	74,466
Other	4	324	9	3	-	-
Total	129,018	128,684	96,027	136,048	122,699	104,085
South America:						
Peru	31,113	29,311	25,197	26,195	22,115	23,486
Other	349	-	-	-	-	36
Total	31,462	29,311	25,197	26,195	22,115	23,522
Europe:						
Belgium-Luxembourg	1,900	1,503	610	-	2,980	11,235
Germany, West	1,226	2,893	551	842	914	277
Spain	8,057	9,395	4,115	8,529	4,104	7,694
United Kingdom	2,810	988	7	-	335	3,555
Yugoslavia	38,015	32,731	30,027	30,347	31,909	31,063
Other	2,659	4,872	1,388	-	12	-
Total	54,667	52,382	36,698	39,718	40,254	53,824
Asia	13	-	-	-	-	-
Africa: Morocco [3]	[6] 10,068	[7] 5,384	[7] 1,328	-	-	-
Oceania: Australia	73,936	47,655	46,783	54,891	72,133	45,596
Total pigs and bars	299,164	263,416	206,033	256,852	257,201	227,027

See footnotes at end of table.

TABLE 26.—U.S. imports [1] of lead, by countries—Continued

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
Reclaimed, scrap, etc. (lead content):						
North America:						
Canada	4,197	2,251	4,059	1,441	1,279	3,243
Mexico	4,328	1,293	1,054	2,294	688	55
Other	966	245	160	45	186	162
Total	9,491	3,789	5,273	3,780	2,153	3,460
South America:						
Peru	138	(5)				
Venezuela	377					
Other	11	120				
Total	526	120				
Europe:						
Belgium-Luxembourg	140					
Denmark	273					
Germany, West	115	1	1		(5)	1
Netherlands	54				17	12
Other	198		4	2		
Total	780	1	5	2	17	13
Asia:						
Japan (including Nansei and Nanpo Islands)	8	18	5		2	
Other	14					
Total	22	18	5		2	
Oceania: Australia	1,732	4,351	2,355	1,160	149	5,402
Total reclaimed, scrap, etc	12,551	8,279	7,638	4,942	2,321	8,875
Grand total	498,892	410,609	359,656	409,402	[2] 402,752	389,081

[1] Data are general imports; that is, they include lead imported for immediate consumption plus material entering the country under bond.
[2] Revised figure.
[3] French Morocco before Jan. 1, 1957.
[4] Union of South Africa before Jan. 1, 1962.
[5] Less than 1 ton.
[6] Includes material classified by the Bureau of the Census as being from Algeria but believed by Bureau of Mines to be from French Morocco.
[7] Includes 1,052 tons from the Federation of Rhodesia and Nyasaland in 1959 and 224 tons in 1960.

Source: Bureau of the Census.

TABLE 27.—U.S. imports for consumption[1] of lead, by countries

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
Ore, flue dust, and matte (lead content):						
North America:						
Canada	37,692	28,633	27,944	31,439	[2] 29,523	29,937
Guatemala	5,673	157	1,519	5,527	4,691	387
Honduras	2,946	3,649	4,457	4,803	[2] 5,959	8,692
Mexico	3,485	627	943	1,060	1,899	1,850
Other	1,061	8				
Total	50,857	33,074	34,863	42,829	[2] 42,072	40,866
South America:						
Bolivia	16,647	10,822	10,581	10,470	7,479	10,055
Chile	2,738	113	27	401	3	
Colombia	664	370	628	514	480	95
Peru	55,305	38,872	33,571	32,318	[2] 32,327	32,140
Other	472	56	103		3	
Total	75,826	50,233	44,910	43,703	[2] 40,292	42,290
Europe	148	107	(3)		220	
Asia:						
Philippines	1,802	293	187	380	111	31
Other	173	25	427			223
Total	1,975	318	614	380	111	254
Africa:						
Morocco [4]			5,238			
South Africa, Republic of [5]	43,101	28,939	30,784	29,736	29,756	29,740
Other	8	1,821			2	
Total	43,109	30,760	36,022	29,736	29,758	29,740
Oceania:						
Australia	31,259	22,034	20,894	20,132	20,627	21,295
Other	32					
Total	31,291	22,034	20,894	20,132	20,627	21,295
Total ore, flue dust, and matte	203,206	136,526	137,303	136,780	[2] 133,080	134,445
Base bullion (lead content):						
North America	8	34	254	134	5	964
South America	95		39	102	2,078	854
Europe				(3)		3
Asia	(3)					
Oceania						1,937
Total base bullion	103	34	293	236	2,083	3,758
Pigs and bars (lead content):						
North America:						
Canada	36,019	41,478	26,154	54,902	56,807	29,674
Mexico	90,679	82,762	73,748	71,289	68,147	78,254
Other	4	261	29	6		
Total	126,702	124,501	99,931	126,197	124,954	107,928
South America:						
Peru	31,102	29,311	25,197	26,195	22,103	22,224
Other	349					35
Total	31,451	29,311	25,197	26,195	22,103	22,259
Europe:						
Belgium-Luxembourg	1,647	1,569	1,733	41	1,685	4,366
Denmark	2,191	187	88			
Germany, West	1,204	2,613	654	911	614	577
Spain	7,111	11,270	6,056	8,775	3,958	7,713
United Kingdom	2,754	1,035	133	16		1,462
Yugoslavia	38,015	32,376	30,159	30,230	32,240	31,063
Other	432	2,984	1,877		12	
Total	53,354	52,034	40,700	39,973	38,509	45,181
Asia	13					

See footnotes at end of table.

TABLE 27.—U.S. imports for consumption[1] of lead, by countries—Continued

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
Pigs and bars—Continued						
Africa:						
Morocco[4]	[6] 9,912	5,032	1,243	4		
Other	315	703	460	113		
Total	10,227	5,735	1,703	117		
Oceania: Australia	73,040	51,051	45,816	54,945	72,300	45,030
Total pigs and bars	294,787	262,632	213,347	247,427	257,866	220,398
Reclaimed, scrap, etc. (lead content):						
North America:						
Canada	4,169	2,396	4,053	1,441	1,240	3,218
Mexico	4,792	1,350	1,189	2,291	612	55
Other	953	602	220	91	58	288
Total	9,914	4,348	5,462	3,823	1,910	3,561
South America:						
Peru	183	(3)				903
Venezuela	377					
Other	17	120				
Total	577	120				903
Europe:						
Belgium-Luxembourg	140					
Denmark	273					
Germany, West	171	1	1		(3)	(3)
Netherlands	54				17	12
Other	232		15	2		
Total	870	1	16	2	17	12
Asia	22	17	5	1	2	
Oceania:						
Australia	1,170	3,411	115	68	149	10,929
Other	11					
Total	1,181	3,411	115	68	149	10,929
Total reclaimed, scrap, etc	12,564	7,897	5,598	3,894	2,078	15,405
Sheets, pipe and shot:						
North America:						
Canada	210	452	213	114	49	35
Canal Zone	4					
Mexico	2,703			55		
Total	2,917	452	213	169	49	35
Europe	811	3,156	2,641	2,639	2,197	2,389
Asia	(3)	(3)	1	37	30	5
Total sheets, pipe and shot	3,728	3,608	2,855	2,845	2,276	2,429
Grand total	514,388	410,697	359,396	391,182	[2] 397,383	376,435

[1] Excludes imports for manufacture in bond and export, classified as "imports for consumption" by the Bureau of the Census.
[2] Revised figure.
[3] Less than 1 ton.
[4] French Morocco before Jan. 1, 1957.
[5] Union of South Africa before Jan. 1, 1962.
[6] Includes material classified by the Bureau of the Census as being from Algeria but believed by the Bureau of Mines to be from French Morocco.

Source: Bureau of the Census.

TABLE 28.—U.S. imports for consumption of lead, by classes [1] [2]

Year	Lead in ores, flue dust or fume, and mattes, n.s.p.f. (lead content)		Lead in base bullion (lead content)		Pigs and bars (lead content)		Sheets, pipe, and shot		Not otherwise specified value (thousands)	Total value (thousands)
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)		
1954–58 (average)	203,206	[3] $49,957	103	$33	294,787	[3] $75,144	3,728	[3] $931	[3] $261	[3] $129,072
1959	136,526	27,035	34	19	262,632	54,667	3,608	850	586	84,461
1960	137,303	27,816	293	[4] 62	213,347	45,065	2,855	696	710	75,383
1961	136,780	24,332	236	[4] 51	247,427	45,881	2,845	641	807	72,304
1962	[5] 133,080	[5] 21,003	2,083	710	257,866	41,570	2,276	474	978	[5] 65,004
1963	134,445	21,436	3,758	1,792	220,398	40,226	2,429	513	792	66,768

[1] Excludes imports for consumption in bond and export, classified as "imports for consumption" by the Bureau of the Census.
[2] In addition to quantities shown (value included in total value), "reclaimed scrap, etc." imported as follows: 1954–58 (average): 12,564 tons, $2,746,134; 1959: 7,897 tons, $1,304,107; 1960: 5,598 tons, $1,034,141; 1961: 3,894 tons, $591,971; 1962: 2,078 tons, $269,101; 1963: 15,405 tons, $2,008,916.
[3] Data known to be not comparable with other years.
[4] Values for Peru in 1960 and Peru and Mexico in 1961 have been adjusted by the Bureau of Mines to reflect the value of lead.
[5] Revised figure.

Source: 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 [1]			Type metal and antimonial lead		
	Gross weight (short tons)	Lead content (short tons)	Value (thousands)	Gross weight (short tons)	Lead content (short tons)	Value (thousands)
1954–58 (average)	3,289	1,906	[2] $2,993	7,741	6,893	$2,222
1959	11,840	3,751	16,820	5,612	5,020	1,204
1960	9,274	1,512	16,024	4,560	3,915	970
1961	7,930	1,409	14,207	6,430	5,765	1,340
1962	2,438	1,030	3,443	8,576	7,512	1,393
1963	2,535	1,246	3,207	[3] 3,747	[3] 3,196	[3] 621

[1] 1960–62 data known to be not comparable with earlier years.
[2] Data known to be not comparable with other years.
[3] Due to changes in classification, effective Sept. 1, 1963, data no longer separately classified. January–August data tabulated.

Source: Bureau of the Census.

TABLE 30.—U.S. exports of lead, by countries [1]

(Short tons)

Destination	1954–58 (average)	1959	1960	1961	1962	1963
Ore, matte, base bullion (lead content):						
North America:						
Canada	18	3	16	3		
Mexico	827	108	107			
Other						4
Total	845	111	123	3		4
Europe	6			77	7	
Asia	31	113	1,174	4,357	2,891	
Total ore, matte, base bullion	882	224	1,297	4,437	2,898	4
Pigs, bars, anodes:						
North America:						
Canada	71	11	24	80	39	112
Cuba	40	37	10			
Mexico	15	28	60	24	25	23
Other	76	156	149	39	66	95
Total	202	232	243	143	130	230
South America	193	92	18	794	588	188
Europe	541	9	30	3	28	153
Asia:						
Japan	696	5				
Philippines	270	472	34	227	81	26
Taiwan	159	1,916	1,536	874	950	
Other	204	29	103	78	321	478
Total	1,329	2,422	1,673	1,179	1,352	504
Africa	(2)	1	2	12	9	10
Oceania			1	2	1	3
Total pigs, bars, anodes	2,265	2,756	1,967	2,133	2,108	1,088
Scrap:						
North America	77	7	1,220	54	37	14
South America	(2)	(2)	2	2	15	8
Europe:						
Belgium-Luxembourg	175		6	688	328	1,182
Germany, West	329	51	129	253	119	498
Italy	7	95	74	162	289	
Netherlands	280	460	297	251	159	72
United Kingdom	600	513	851	1,167	786	519
Other	150	15			116	41
Total	1,541	1,134	1,357	2,521	1,797	2,312
Asia:						
Japan	565			2,579	593	85
Other	(2)		(2)	7	19	2
Total	565		(2)	2,586	612	87
Total scrap	2,183	1,141	2,579	5,163	2,461	2,421
Grand total	5,330	4,121	5,843	11,733	7,467	3,513

[1] In addition foreign lead was re-exported as follows: Ore, matte, and base bullion 1954–58 (average) 3 tons; 1959–63, None. Pigs, bars, anodes, 1954–58 (average) 93 tons, 1959: 83 tons; 1960: None; 1961: 294 tons; 1962–63: None. Scrap: 1954–58 (average) 24 tons; 1959: 11 tons; 1960–63: None.
[2] Less than 1 ton.

Source: Bureau of the Census.

WORLD REVIEW [3]

The upward trend in world mine production, smelter production, and consumption of lead continued during 1963. World mine production was estimated to be 2.8 million short tons and smelter production slightly lower. According to the American Bureau of Metal Statistics,[4] the free world consumption was 2.23 million tons of primary lead, a gain of some 69,000 tons over that of 1962. Producer stocks, as computed by the International Lead and Zinc Study Group,[5] declined from 289,300 tons at the beginning of the year to 165,600 tons at yearend.

Demand continued strong throughout the free world and prices moved up during the year in all markets. The monthly average price in the United Kingdom rose each month from the January 6.8 cents to 9.3 cents per pound for December. The New York monthly average increased from 10.3 cents per pound in January to 12.5 cents per pound in December.

Japan increased imports of concentrates substantially over those of 1962 as did France and Italy. United Kingdom imports decreased slightly and those of West Germany were significantly reduced. Refined metal exports of Belgium-Luxembourg increased as did those of the U.S.S.R. whereas France, West Germany, Canada, and Australia reduced exports of refined lead.

TABLE 31.—World mine production of lead (content of ore) recoverable where indicated, by countries [1] [2]

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	[3] 195,655	[3] 186,696	[3] 205,650	[4] 182,557	[4] 211,321	[4] 198,988
Cuba	73	----------	----------	----------	----------	----------
Greenland	[5] 7,625	11,633	7,635	10,104	892	----------
Guatemala [3]	7,596	6,381	9,432	9,458	1,067	825
Honduras	2,379	4,604	5,913	6,762	6,522	[6] 10,913
Mexico	212,491	210,188	210,177	199,877	213,074	209,425
United States [3]	324,373	255,586	246,669	261,921	236,956	253,369
Total	750,192	675,088	685,476	670,679	669,832	673,520
South America:						
Argentina	28,770	33,400	29,432	31,306	32,606	28,991
Bolivia (exports)	23,810	24,293	23,610	22,403	20,504	22,226
Brazil [7]	5,400	6,700	12,200	15,300	17,500	17,500
Chile	3,667	2,560	2,694	2,252	1,603	1,074
Colombia (U.S. imports)	639	570	705	722	439	9
Ecuador	119	118	119	122	137	181
Peru	138,716	[3] 127,003	[3] 145,097	[3] 150,353	[3] 141,290	163,468
Total	201,121	194,644	213,857	222,458	214,079	233,449

See footnotes at end of table.

[3] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[4] American Bureau of Statistics. Yearbook 1963, p. 43.
[5] International Lead and Zinc Study Group. Lead and Zinc Statistics. V. 4, No. 6, June 1964, p. 6.

TABLE 31.—World mine production of lead (content of ore) recoverable where indicated, by countries [1] [2]—Continued

(Short tons)

Country	1954-58 (average)	1959	1960	1961	1962	1963
Europe:						
Austria [3]	5,596	5,906	5,758	6,051	5,855	5,504
Bulgaria	63,642	88,673	92,341	88,229	104,058	97,995
Czechoslovakia [7]	5,700	7,000	7,200	7,200	14,900	14,900
Finland	1,561	2,126	1,755	3,439	3,161	1,262
France	12,091	18,335	20,451	20,785	15,735	7,187
Germany:						
East [7]	6,800	7,700	7,700	7,700	8,300	8,300
West	73,260	57,882	54,919	54,453	54,710	57,143
Greece	6,839	11,023	10,141	12,787	14,550	[7] 14,550
Ireland	1,898	1,476	1,480	279	---	---
Italy	56,267	56,655	54,525	52,612	45,463	36,266
Norway	1,157	2,487	2,780	2,524	3,417	3,858
Poland	38,272	39,022	43,211	42,108	36,156	42,659
Portugal	1,485	35	34	28	49	---
Rumania [7] [8]	12,700	13,200	13,200	13,200	13,800	13,800
Spain	69,139	77,271	80,353	87,863	78,262	67,076
Sweden	38,217	53,322	60,963	70,518	74,737	77,051
U.S.S.R. [7]	285,000	[8] 350,000	[8] 360,000	[8] 390,000	[8] 390,000	[8] 390,000
United Kingdom	[3] 8,018	2,632	1,549	1,656	446	276
Yugoslavia	97,326	101,909	100,554	106,572	112,430	111,968
Total [7]	785,000	896,700	918,900	968,000	976,000	949,800
Asia:						
Burma	17,913	21,275	19,070	18,519	22,377	28,788
China [7]	38,600	77,000	88,000	99,000	99,000	110,000
India	3,309	5,292	4,991	4,478	5,065	4,758
Iran [7] [9]	17,900	16,500	16,500	16,500	11,000	11,000
Japan	33,357	39,844	43,577	51,015	58,924	58,115
Korea:						
North [7]	33,000	44,000	55,000	55,000	55,000	55,000
Republic of	960	256	1,012	1,014	1,558	2,113
Philippines	1,849	391	134	111	90	78
Thialand	4,025	1,455	2,028	2,437	2,600	2,496
Turkey	2,226	1,301	1,830	3,538	4,299	2,811
Total [7]	153,100	207,300	232,100	251,600	259,900	275,200
Africa:						
Algeria	11,481	12,173	11,529	10,337	9,964	8,841
Congo, Republic of	3,294	5,448	4,741	965	368	364
Morocco	98,098	101,082	104,444	97,299	39,323	81,000
Nigeria	226	424	223	7	---	---
Rhodesia and Nyasaland, Federation of: Northern Rhodesia [8]	16,659	16,128	16,161	16,999	16,343	21,616
South Africa, Republic of	583	150	121	91	6	16
South-West Africa [10]	87,903	[3] 77,551	71,540	69,997	82,688	80,878
Tanganyika (exports)	4,514	6,401	6,927	387	---	---
Tunisia	27,101	19,997	19,986	19,163	14,936	15,245
Uganda (exports)	110	60	---	---	---	---
United Arab Republic (Egypt)	205	770	88	39	595	550
Total	250,174	240,184	235,760	215,284	224,223	208,510
Oceania: Australia	345,167	354,249	345,143	302,015	414,530	459,026
World total (estimate)	2,484,000	2,570,000	2,630,000	2,630,000	2,760,000	2,800,000

[1] Data derived in part from United Nations Statistical Yearbook, Yearbook of the American Bureau of Metal Statistics, and annual issues of the Statistical Summary of the Mineral Industry (Overseas Geological Survey, London), and Metal Statistics (Metallgesellschaft) Germany.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Recoverable.
[4] Data for 1961, 1962, and 1963 not strictly comparable to previous years.
[5] Average annual production 1956-58.
[6] Exports.
[7] Estimate.
[8] Smelter production.
[9] Year ended March 21 of year following that stated.
[10] Includes lead content of lead-vanadium concentrates.

TABLE 32.—World smelter production of lead by countries [1] [2]
(Short tons)

Country	1954-58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	148,856	140,881	160,079	172,365	152,743	202,398
Guatemala	[3] 55	----------	200	62	68	52
Mexico	223,805	206,134	205,263	194,476	208,447	205,217
United States (refined)[4]	502,149	340,886	382,436	449,486	376,024	394,732
Total	874,865	687,901	747,978	816,389	737,282	802,399
South America:						
Argentina	28,000	34,200	28,300	30,865	27,000	26,500
Boliva (exports)[5]	1,798	250	119	4	138	----------
Brazil	4,882	6,091	10,997	13,809	15,758	[3] 15,400
Chile	185	892	661	529	280	243
Peru	68,985	62,619	81,726	84,253	75,356	91,577
Total	103,850	104,052	121,803	129,460	118,532	133,720
Europe:						
Austria [6]	13,035	13,610	13,717	13,605	13,417	10,783
Belgium [6]	99,664	97,489	102,190	110,110	102,681	108,507
Bulgaria	13,393	36,090	44,540	45,099	48,171	56,584
Czechoslovakia [3]	9,500	10,000	10,000	10,000	15,400	15,400
France	74,257	77,082	81,998	78,052	77,787	85,570
Germany:						
East [3] [6]	27,000	27,500	27,500	27,500	28,700	28,700
West	133,688	164,833	162,772	155,008	163,902	154,032
Greece	3,590	4,122	3,407	3,267	3,300	3,900
Italy	45,388	48,548	45,912	49,769	46,282	46,224
Poland	38,101	42,645	43,762	43,874	44,842	42,895
Portugal	1,157	876	998	1,663	2,227	1,129
Rumania [3]	12,700	13,200	13,200	13,200	13,800	13,800
Spain	69,590	75,497	78,464	85,678	79,666	65,973
Sweden	26,994	40,619	48,010	42,745	42,716	45,000
U.S.S.R.[3]	285,000	350,000	360,000	390,000	390,000	390,000
United Kingdom	6,889	1,580	1,224	1,178	614	297
Yugoslavia	83,971	94,132	98,263	99,650	107,945	114,832
Total [3]	943,900	1,097,800	1,136,000	1,170,400	1,181,500	1,183,600
Asia:						
Burma	19,298	21,768	18,499	17,376	19,164	19,553
China [3]	28,000	66,000	77,000	95,000	95,000	99,000
India	2,919	4,363	4,128	4,039	3,140	3,899
Iran [7]	1,151	[3] 1,000	1,279	1,437	441	[3] 440
Japan	46,343	67,152	76,465	83,476	96,783	104,499
Korea: North [3]	13,000	22,000	33,000	45,000	45,000	45,000
Turkey [3]	[6] 2,070	509	518	698	702	2,073
Total [3]	112,800	182,800	210,900	247,000	260,200	274,500
Africa:						
Morocco	32,158	31,368	33,871	26,993	26,566	20,679
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	16,659	16,128	16,161	16,999	16,343	21,616
Tunisia [5]	27,966	24,039	21,894	20,307	17,447	14,110
Total	76,783	71,535	71,926	64,299	60,356	56,405
Oceania: Australia:						
Refined lead	216,504	208,102	212,603	181,736	212,941	251,558
Pb content of lead bullion (for export)	49,562	56,347	59,050	53,861	81,883	90,341
Total	266,066	264,449	271,653	235,597	294,824	341,899
World total (estimate)	2,380,000	2,410,000	2,560,000	2,665,000	2,655,000	2,795,000

[1] Data derived in part from United Nations Statistical Yearbook, Yearbook of the American Bureau of Metal Statistics, and annual issues of Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London), and Metal Statistics (Metallgesellschaft) Germany.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Figures cover lead refined from domestic and foreign ores; refined lead produced from foreign base bullion not included.
[5] Lead bars only; does not include lead contained in antimonial lead or in solders.
[6] Includes scrap.
[7] Year ended March 21 of year following that stated.

NORTH AMERICA

Canada.—Mine production of lead decreased to 205,900 tons from the 215,300 tons of recoverable lead in 1962. Lead output of Consolidated Mining & Smelting Co. of Canada, Ltd. (Cominco), plant located at Trail, British Columbia, was 155,900 tons. Exports of lead as metal and ores and concentrates were to the United Kingdom, the United States, and Japan, the principal importers in that order.

British Columbia was the largest producer of the various provinces, accounting for almost 78 percent of the total and the three mines operated by Cominco—Sullivan at Kimberley, H. B. at Salmo, and Bluebell at Riondel—produced by far the major part. Other important producers were: Reeves MacDonald Mines, Ltd., Sheep Creek Mines, Ltd., Canadian Exploration, Ltd., and Mastodon-Highland Bell Mines, Ltd. Several small mining operations were active in the various areas during the year.

The only producer in the Yukon Territory was United Keno Hill Mines, Ltd., operating three mines in the Keno Hill area about 120 miles north of Whitehorse. At the Pine Point Mines, Ltd., property south of Great Slave Lake, construction progressed on the townsite, as well as stripping and excavation for mine and mill facilities. The Canadian National Railway Co. progressed with the railway spur from Grimshaw, Alberta, to the mine site and arrangements have been made for construction of a power generating facility. With these services available, mining operations are expected to commence late in 1965.[6]

The Hudson Bay Mining & Smelting Co., Ltd., was the only lead producer in the Manitoba-Saskatchewan area with the Flin Flon mine and Chisel Lake mine the major producers.

Lead output in Ontario was confined to operations of Geco Mines, Ltd., and Willroy Mines, Ltd. Lead recovery improved substantially at the Geco mine to show a small overall increase for the province.

Lead production in Quebec declined in 1963 as a result of a prolonged strike at the Solbec Copper Mines, Ltd. Other companies producing lead concentrates for smelting were: The Coniagas Mines, Ltd., Manitou-Barvue Mines, Ltd., and New Calumet Mines, Ltd.

Newfoundland production of lead in concentrates ranked second to British Columbia with 12 percent of the Canadian total. The Buchans mines, including the new McLean mine, operated by American Smelting and Refining Co., provided all of the output.

Other producers in the Atlantic provinces were: Magnet Cove Barium Corp., Ltd., at Walton, Nova Scotia, and Heath Steele Mines, Ltd., in the Bathurst, New Brunswick area. In November construction was begun on a lead-zinc smelter complex to be built by East Coast Smelting and Chemical Co., at Balladune Point, 25 miles northwest of Bathurst. The smelter will treat concentrates from mines near Bathurst being developed by Brunswick Mining & Smelting Corp., Ltd.

Mexico.—The mines and plants of Compania Minera Asarko, S.A., the wholly owned Mexican subsidiary of American Smelting and Refining Co., operated without interruption during the year. Con-

[6] The Consolidated Mining and Smelting Co. of Canada, Ltd. Annual Report, 1963, p. 4.

tinuing efforts were made to qualify for Mexicanization under the Mining Law of 1961 and application was made under the July 1963 regulations providing for placement of 51 percent of the shares in trust for sale to qualified Mexican investors.[7]

Minera Frisco, S.A., 49 percent owned by San Francisco Mines of Mexico, Ltd., since completion of Mexicanization in 1963, was closed by strike during the last half of June. Ore mined came from the San Francisco mine, 83 percent, and the Clarissa mine and declined from the record high of the previous year. Progress was made in obtaining the tax benefits occurring under Mexicanization and efforts were made to resume a long term development program.[8]

Compania Fresnillo, S.A., with affiliated Mexican companies operated at approximately the same level of ore processed and lead recovered as in 1962. The company acquired full ownership of the Sombrerete Mining Co. and was negotiating to fulfill requirements for nationalization under the Mining Law of 1961. The company operated the Fresnillo Unit and the Sombrerete mine; State of Zacatecas; Naica Unit; State of Chihuahua; and Zimapan Unit, State of Hidalgo. The Plateros mine in the Fresnillo unit was closed and the plant dismantled.[9]

Metalurgica Mexicana Penoles, S.A., 49 percent owned by American Metal Climax, Inc., operated at an increased profit during 1963 because of higher metal prices and improved efficiencies. The tax benefits occurring under "Mexicanization" had not been implemented.[10]

SOUTH AMERICA

Argentina.—About 85 percent of the Argentina output of lead is by Cia. Minera Aguilar, S.A. (99.9 percent owned by St. Joseph Lead Co.) and production declined slightly in 1963. Cia Minera Castano Viejo, S.A., an affiliate of National Lead Co., produced most of the remaining lead from Argentina mines. An accelerated program of development was in progress at Viejo.

Bolivia.—Production of lead by the six nationalized mines operated by Corporatión Minera de Bolivia was on the order of 8,500 tons in ore. The Mining Bank of Bolivia (Banco Minero) continued to act as agent for production of certain individuals and cooperative associations operating mines that export ore.

Brazil.—Cia. Brasileira de Chumbo controlled by Cia. Accumuladores Prest-O-Lite operated two mines—Mineracão Boquira, Ltd., in the State of Bahia and Cia. Plumbum, S.A., in Parana. Soc. Mineracao Furnas, S.A., and Institute de Pesquesas Tecnologicans operated smelters consuming ores and secondary materials.

Peru.—Cia. Minerales Santander, Inc., a wholly owned subsidiary of St. Joseph Lead Co., produced 8,700 tons of lead concentrates from open-pit operations. During the year stripping operations were at an abnormally high rate as was underground exploration to delineate the ore body in depth. About half of the concentrate is smelted in Peru and the other half is exported to the United States and West Germany.

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[7] American Smelting and Refining Co. Annual Report. 1963, p. 13.
[8] San Francisco Mines of Mexico, Ltd. Annual Report. 1963, p. 2.
[9] The Fresnillo Company. Annual Report. 1963, p. 13.
[10] American Metal Climax, Inc. Annual Report. 1963, p.26.

Cerro de Pasco Corp. produced 89,000 tons of lead, a new record and an increase of 22 percent above the 1962 output, which was restricted because of labor troubles. The Paragsha concentrator located at the Cerro de Pasco mine was altered to treat both underground ore and ore from the McCune pit. The capacity of the La Oroya lead refinery was increased, principally by improved operating techniques, from 84,000 tons to 100,000 tons annually. The company's mines produced 54 percent of the lead in 1963 in comparison to 41 percent in 1962 with the remainder purchased in the Central District of Peru.

EUROPE

Austria.—The Austrian nationalized firm, Bleiberger Bergwerks-Union, the only company mining lead-zinc ores in Austria developed a new lead smelting process at the Gailitz, Carenthia, smelter. The process involving pelletization and reduction to metal in a modified Schlippenbach rotating ore hearth was expected to be in use in early 1963. Current lead refining capacity is about 12,100 tons per year of which Austrian ores contribute 50 percent.

Bulgaria.—The first pig lead was produced in Bulgaria by the Plovdiv Non-ferrous Metals Combine on October 25. The output is expected to total 7,200 tons of pig lead in 1963 and to reach 49,000 tons in 1964. The Combine will process 450 tons of concentrate daily at full capacity and the concentrate will be obtained from the Rhodope mining area.

Finland.—The Vihante mine, operating on a predominately zinc ore, was reported to have produced 1,800 tons of lead concentrates containing 69.6 percent lead.

Germany, West.—Lead and zinc mines operated under a Federal subsidy program which limited each of the three companies to a specified production tonnage on which it may claim subsidy payments. The annual production of lead is about 55,000 tons and the production quotas assigned as applicable to recovery of losses was about 36,000 tons.

Ireland.—Discovery of a substantial reserve of lead and zinc ore at the Silvermines Lead and Zinc, Ltd., property in County Tipperary through exploration conducted by Consolidated Mogul Mines, Ltd., of Canada, has spurred exploration in several areas. The Irish Base Metals Co., Ltd., a subsidiary of Northgate Explorations, Ltd., Canada, completed a pilot plant to test the recently discovered deposits in the Tynagh area of eastern County Galway and necessary financing arrangements were made for construction of a 2,000-ton-per-day plant with initial production expected in 1965.

Italy.—Società Monteponi-Montevecchio has undertaken a major program of construction and mining research in Sardinia. Investment of $30 million is proposed for development of 2 mines and construction of a flotation plant.

Sweden.—The Boliden Mining Company, the major producer of nonferrous ores and metals from their own mines in north and central Sweden and also, the publicly owned mines of the Adak area, is constructing a slag-fuming plant at its Ronnskär works in North Sweden. The project, when completed in mid-1964, will produce

7,000 tons of leached lead dust per year along with the 25,000 tons of zinc clinker.

Yugoslavia.—The reactivated Sasi mine in southwest Serbia has exceeded expectations and was reported to be approaching an annual rate of 220,000 tons of ore. Allocation of $3.4 million for a new flotation plant to treat lead-zinc ores from Ajalija, Kisnica, and Novo Brdo mines has been announced. The plant to be built near Pristina, South Serbia, will process 600,000 tons of ore per year in its first phase of operation and more than 1 million tons when completed. Reconstruction of the smelting works at the Trepca mine, to be completed within 3 years, is expected to raise the Yugoslav output of lead by 35 percent.

ASIA

India.—The Metal Corporation of India has been licensed to expand its lead smelter in Tundoo, Bihar, for refining of ores mined by the corporation from its mines in Zawar. The lead deposits recently discovered in the Bunyar area of western Kashmir may prove to be of significant size.

Iran.—In November 1962, a U.S. survey team under contract with the U.S. Agency for International Development (AID) began a 6-month assistance program at the Bama lead and zinc mine near Isfahan. Until recent years the mine exported most of the 16,000-ton-per-year output to the U.S.S.R. but now ships to Europe. The program will incorporate exploration and modernization assistance.

Korea, Republic of.—Production of lead ores from several small mines was on the order of 3,000 tons, principally for export to Japan. A project sponsored by the U.S. Agency for International Development includes the construction of a 30-ton-per-day lead smelter facility at Changhang scheduled for completion in early 1964.

Thailand.—A field survey has found indications of iron, zinc, and lead deposits, stated to be large, in Loey Province in northeast Thailand near the Laotian border. The Government is currently surveying the area as part of a program to develop the Mekong River basin.

AFRICA

Algeria.—Output of the mines at El Abed (Société Algerienne du Zinc) and Oued Zounder (Société Nouvelle des Mines d'Ain-Arko) both near the Moroccan frontier, was reported to be substantially reduced in the first half of 1963.

Morocco.—Activities of the Boubeker mine near Oujda operated by Société des Mines de Zellidja were curtailed early in the year for 3 months by a labor strike. Société Nord-Africaine du Plomb was the other principal producer. The Oued-el Heimer smelter owned jointly by Société des Mines de Zellidja and Société Minère et Métallurgique de Penarroya was the only producer of refined lead.

Rhodesia and Nyasaland, Federation of.—The Rhodesian Broken Hill Development Co., Ltd., was the only lead producer. A 5-week strike began on February 15, which disrupted production but an increase in output for the year was achieved mainly in the last 7 months after modification of equipment and improved operating procedures for the Imperial, associated with the Imperial Smelting Furnace, were completed in the first quarter.

South-West Africa.—Tsumeb Corp., Ltd., mined and milled 658,700 tons of ore at Tsumeb and 201,700 tons at Kombat during the fiscal year ending June 30, 1963, and sold 90,900 tons of lead in comparison to 64,700 tons in fiscal 1962. The reserves of proven and probable ore were increased to a combined total of 13.47 million tons. The new lead smelter was placed in production in November.[11]

OCEANIA

Australia.—Australia is the largest lead producer in the free world with 1963 production of ore about 24 percent above the 1962 level and lead content of concentrate about 14 percent above the indicated output in 1962. Broken Hill, New South Wales and Mount Isa, Queensland, are the predominant lead producing areas.

North Broken Hill, Ltd., Broken Hill South, Ltd., New Broken Hill Consolidated, Ltd., and The Zinc Corp., Ltd. comprising the Broken Hill Group, all increased the tonnage of ore milled and lead recovered in concentrates. Major developments in the area were initiation of ore hoisting at the No. 3 shaft of North Broken Hill in February, and completion, in April, of a 6,200-foot handlage tunnel connecting the No. 7 shaft and Junction Shaft areas of Broken Hill South.

The Broken Hill Associated Smelters Pty., Ltd., lead smelter at Port Pirie, South Australia, operated without restriction throughout 1963 and produced 255,600 tons of refined lead in comparison to 221,000 tons in 1962. A new lead blast furnace with an estimated annual capacity of 245,000 tons is under construction and expected to come into operation in 1964.[12]

Mount Isa Mines, Ltd., 53.7 percent owned by American Smelting & Refining Co., notably increased production over 1962 when operations were interrupted by an 8-week strike. Production of ore amounted to 3,709,000 tons from which 58,900 tons of refined lead and 6,900 tons of antimonial lead were recovered. The expansion program to provide facilities for treating 16,000 tons of ore per day were continued with a new production shaft and a 6,000-ton-per-day lead-zinc concentrator remaining to be completed. Exploration and development added new ore reserves in excess of the tonnage milled.[13]

E. Z. Industries, Ltd., produced 321,900 tons of ore from the Rosebery Mines and the Hercules mine in Tasmania during the fiscal year ending June 30 in comparison to 297,400 tons in the like period of 1962.

At Cockle Creek, New South Wales, the new Imperial Smelting Furnace of the Sulphide Corp., Pty., Ltd., was in full production and produced 23,400 tons of lead bullion and 49,300 tons of slab zinc.

[11] Newmont Mining Corp. Annual Report, 1963, p. 11.
[12] The Rio Tinto-Zinc Corp. Annual Report. 1963, p. 24.
[13] American Smelting & Refining Co. Annual Report. 1963, p. 17.

TECHNOLOGY

The program of research and investigation initiated by the Lead Industries Association and the American Zinc Institute continued to bring forth expanded knowledge of the basic characteristics of lead and the application of lead metal and its alloys.[14] The wide geographic scope of industry participation is indicated by the redesignation of the program in May 1963 to the International Lead-Zinc Research Organization (ILZRO).

A significant development in industrial practice was the DM process for continuous casting of lead sheet devised by Broken Hill Associated Smelters and made public through the ILZRO.[15] The application of lead in sound-proofing, vibration dampening, and nuclear shielding were investigated, and the technique and results were presented in abstracts available from the Lead Industries Association. Work in the field of fibre reinforcement has shown promising applications,[16] the importance of lead in glass was discussed,[17] and articles were presented on removal of copper in the refining of lead.[18]

The Bureau of Mines issued an information circular on mining methods and costs at a small underground mine[19] and reports on investigation relative to recovery of lead and zinc from slimes,[20] synthesis of lead and barium disilic fluoromicas,[21] and determination of heat of formation of vanadates.[22]

U.S. patents were issued relating to commercial techniques for producing a purified metal from the sulfide by heating with lead in a reducing atmosphere,[23] for preparing lead azide by reacting solutions of lead nitrate and a alkali metal azide,[24] for producing battery paste using a foam stabilizing agent,[25] and for a high-temperature treatment of lead-antimony alloy prior to extrusion to improve the extrusion properties.[26]

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25 Sabatino, Anthony, and Ernest J. Jackson (assigned to Globe-Union Inc., Milwaukee, Wis.). Active Material for Storage Batteries and Method of Making Same. U.S. Pat. 3,100,162, Aug. 6, 1963.

26 Larsen, Elmer J. (assigned to Western Electric Co., Inc., New York). Methods of Improving Extrusion Properties of Lead-Antimony Alloys. U.S. Pat. 3,113,020, Dec. 3, 1963.

Lime

By Perry G. Cotter [1]

LIME production by 208 plants totaled 14.5 million tons in 1963, an increase of 6 percent over that of 1962. Tonnage of open-market lime increased 9 percent and accounted for 61 percent of total production. Output of captive lime was relatively unchanged. Average value increased $0.15 per ton.

TABLE 1.—Salient lime statistics in the United States

(Thousand short tons and thousand dollars)

	1954–58 (average)	1959	1960	1961	1962	1963
Active plants	150	154	157	220	215	208
Sold or used by producers:						
Quicklime	5,738	7,746	8,271	8,998	9,509	10,128
Hydrated lime	2,100	2,766	2,715	2,269	2,386	2,444
Dead-burned dolomite	1,997	1,988	1,949	1,982	1,858	1,949
Total	9,835	12,500	12,935	13,249	13,753	14,521
Value [1]	$124,222	$163,909	$172,733	$177,463	$186,754	$199,389
Average value per ton	$12.63	$13.11	$13.35	$13.39	$13.58	$13.73
Open-market	8,204	8,396	8,189	8,072	8,145	8,889
Captive [2]	1,631	4,103	4,746	5,177	5,608	5,632
Imports for consumption	39	35	32	37	78	101
Exports	70	53	61	30	20	17

[1] Selling value, f.o.b. plant, exluding cost of containers.
[2] Incomplete figures; before 1961 the coverage of captive plants was only partial.

DOMESTIC PRODUCTION

In October, construction began at Lucerne Valley, Calif., on the calcining and hydrating plant of C. K. Williams & Co. Div., Chas. Pfizer & Co., Inc., New York, N.Y. Small size limestone, quarried in Furnace Canyon, San Bernardino Mountains, Calif. would be calcined in a fluidized solids kiln. This lime plant, scheduled to be completed in the fall of 1964, would establish Chas. Pfizer & Co. as a major west coast producer of chemical lime.[2]

[1] Commodity specialist, Division of Minerals.
[2] Chas. Pfizer & Co., Inc. Condensed Interim Earnings Statement for the Nine Months Ended Sept. 29, 1963. Pp. 3, 5.
Pfizer News. Chas. Pfizer To Construct Chemical Lime Plant in Southern Calif. Sept. 27, 1963, pp. 1–3.
Skillings' Mining Review. Unique Kiln for Limestone Plant at Lucerne Valley, Calif. V. 52, No. 46, Nov. 16, 1963, p. 10.

TABLE 2.—Lime sold or used by producers in the United States [1]

State	1962			1963		
	Active plants	Short tons	Value	Active plants	Short tons	Value
Alabama	7	521,636	$6,298,390	6	596,001	$6,974,244
Arizona	6	174,375	2,913,800	6	180,860	3,048,217
Arkansas	5	349,807	4,541,539	5	166,795	2,236,837
California	17	469,673	8,453,722	16	487,480	8,931,689
Colorado	15	92,511	1,518,464	15	127,643	2,103,817
Connecticut	1	35,180	634,730	1	35,262	666,313
Florida	3	(1)	(1)	3	126,430	1,995,878
Hawaii	2	15,243	385,724	2	12,056	427,882
Idaho	5	67,560	801,232	4	60,207	873,931
Illinois	5	(1)	(1)	5	(1)	(1)
Iowa	2	(1)	(1)	2	(1)	(1)
Kansas	1	4,775	59,449			
Louisiana	5	624,121	6,518,862	5	656,952	6,861,552
Maryland	3	(1)	(1)	3	(1)	(1)
Massachusetts	3	148,401	2,337,027	3	144,889	2,425,699
Michigan	10	1,152,620	15,371,402	10	1,370,965	18,431,373
Minnesota	5	(1)	(1)	5	(1)	(1)
Mississippi	1	(1)	(1)	1	(1)	(1)
Missouri	6	1,176,222	13,702,925	5	1,239,859	14,385,950
Montana	6	104,110	1,048,962	6	114,158	1,289,650
Nebraska	5	(1)	(1)	5	(1)	(1)
Nevada	3	(1)	(1)	3	(1)	(1)
New Jersey	1	(1)	(1)	1	(1)	(1)
New Mexico	1	28,969	402,669	1	27,125	377,038
New York	4	(1)	(1)	3	(1)	(1)
Ohio	22	3,102,148	43,791,540	22	3,206,924	45,957,280
Oklahoma	1	(1)	(1)	1	(1)	(1)
Oregon	3	77,680	1,514,090	3	86,681	1,835,228
Pennsylvania	18	1,103,556	16,646,902	18	1,188,217	17,547,940
South Dakota	2	(1)	(1)	2	(1)	(1)
Tennessee	3	(1)	(1)	3	(1)	(1)
Texas	11	1,046,256	[2] 11,998,799	11	1,131,205	13,025,809
Utah	7	163,359	2,759,143	7	156,264	2,667,804
Vermont	2	(1)	(1)	2	(1)	(1)
Virginia	10	614,513	7,668,303	9	638,800	8,058,415
Washington	2	(1)	(1)	3	(1)	(1)
West Virginia	3	(1)	(1)	3	(1)	(1)
Wisconsin	6	(1)	(1)	5	(1)	(1)
Wyoming	3	(1)	(1)	3	(1)	(1)
Undistributed		2,677,090	37,383,706		2,767,484	39,265,981
Total [3]	215	13,753,000	186,754,000	208	14,521,000	199,388,000
Puerto Rico	1	568	14,463	2	4,101	102,779

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Revised figure.
[3] Data may not add to totals shown because of rounding.

The Colorado Fuel and Iron Corp., Pueblo, Colo., planned to install a third kiln in its new $2.5 million captive lime plant. The metallurgical quicklime was used in basic-oxygen-process steelmaking. Limestone for the kilns was hauled 120 miles by rail from the Monarch quarry.

A 100-foot-high storage pile of hydrated lime collapsed at Air Reduction Co., Louisville, Ky., in February and caused over $1 million damage. The carbide lime, which was a byproduct of acetylene manufacture, engulfed buildings, buried 60 automobiles, toppled utility poles, and pushed over storage tanks, railroad cars, and tank trucks. Byproduct carbide lime was regularly calcined to quicklime at this plant in a 330-ton-per-day rotary kiln for reuse in manufacturing calcium carbide and acetylene. Some byproduct lime was sold.

The 10- by 275-foot fuel-oil-fired rotary limekiln at Oxford Paper Co., Rumford, Maine, had a capacity of 190 tons of pebble quicklime per day but normally produced 125 to 150 tons per day from calcium

TABLE 3.—Lime sold or used by producers in the United States, by types and major uses

(Short tons)

Type and use	1962			1963		
	Sold	Used	Total	Sold	Used	Total
By types:						
Quicklime	6,066,740	5,298,508	11,365,248	6,752,016	5,325,641	12,077,657
Hydrated lime	2,076,839	307,718	2,384,557	2,138,046	306,554	2,444,600
Total [1]	8,145,000	5,608,000	13,753,000	8,889,000	5,632,000	14,521,000
By use:						
Agricultural:						
Quicklime	74,249		74,249	66,283		66,283
Hydrated lime	117,388		117,388	110,276	(2)	110,276
Total [1]	192,000		192,000	176,000	(2)	176,000
Construction:						
Quicklime	103,714	4,925	108,639	101,522	5,322	106,844
Hydrated lime	1,112,277	69,313	1,181,590	1,254,661	73,664	1,328,325
Total [1]	1,216,000	74,000	1,290,000	1,356,000	79,000	1,435,000
Chemical and other industrial:						
Quicklime	4,102,140	5,222,782	9,324,922	4,704,354	5,251,223	9,955,577
Hydrated lime	847,174	238,405	1,085,579	773,109	232,890	1,005,999
Total [1]	4,949,000	5,461,000	10,411,000	5,477,000	5,484,000	10,961,000
Refractory (dead-burned dolomite)	1,787,000	71,000	1,858,000	1,880,000	69,000	1,949,000

[1] Data may not add to totals shown because of rounding.
[2] Included with hydrated lime sold to avoid disclosing confidential data.

TABLE 4.—Regenerated lime produced in the United States [1]

State	Quicklime		Hydrated lime		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1962:						
Alabama	316,943	$4,735,155			316,943	$4,735,155
Arkansas	93,076	1,822,011			93,076	1,822,011
Florida	443,787	5,907,445			443,787	5,907,445
Georgia	263,101	4,886,505			263,101	4,886,505
North Carolina	306,194	4,435,700	650	$9,200	306,844	4,444,900
Oregon	123,303	3,069,700			123,303	3,069,700
South Carolina	262,465	2,686,649			262,465	2,686,649
Undistributed [2]	1,443,131	24,175,835	435,045	3,572,526	1,877,481	27,748,635
Total	3,252,000	51,719,000	436,000	3,582,000	3,687,000	55,301,000
1963:						
Alabama	323,416	4,860,917			323,416	4,860,917
Arkansas	105,273	1,408,487			105,273	1,408,487
Florida	401,766	5,502,708			401,766	5,502,708
Georgia	315,291	5,865,317			315,291	5,865,317
Maine	32,277	459,947			32,277	459,947
North Carolina	293,297	4,250,300	619	8,760	293,916	4,259,060
Ohio	89,082	1,066,979			89,082	1,066,979
Oregon	127,325	3,174,750			127,325	3,174,750
Pennsylvania	21,705	361,388			21,705	361,388
South Carolina	289,152	2,906,590			289,152	2,906,590
Wisconsin	26,000	453,700			26,000	453,700
Undistributed [2]	1,385,260	23,716,381	382,625	3,174,738	1,767,885	26,891,119
Total	3,410,000	54,027,000	383,000	3,184,000	3,793,000	57,211,000

[1] Produced mainly at pulpmills and to a lesser extent at calcium carbide and municipal water treatment plants.
[2] A number of States are shown as "Undistributed" to avoid disclosing individual company confidential data.

carbonate sludge. About 8 million B.t.u.'s were required to produce a ton of quicklime.[3]

Martin Marietta Corp., Baltimore, Md., was ordered by the Federal Trade Commission in March to sell two of its lime plants, Standard Lime & Cement Division, Kimballton, Va., and Standard Lime & Cement Division, Knoxville, Tenn. The corporation was ordered not to acquire any more lime plants east of the Mississippi River during the next 10 years. Foote Mineral Co., Exton, Pa., signed an agreement to purchase the two lime plants, subject to the approval of the Federal Trade Commission.

New England Lime Co., Division of Chas. Pfizer & Co., Inc., began constructing another fluidized-bed limekiln at its Adams, Mass., plant. This third kiln at the Adams, Mass., plant was expected to be completed late in 1964. A new hydrated lime for residential construction was announced for marketing in 1964.

Ash Grove Lime & Portland Cement Co., Kansas City, Mo., stopped producing lime at its Springfield, Mo., lime plant early in 1963. Production continued at its Galloway, Mo., lime plant.

Basic, Inc., Cleveland, Ohio, closed its subsidiary lime producer, Kelley Island-New York Corp., at Buffalo, N.Y. For 40 years this plant had manufactured chemical and metallurgical lime.

The second rotary kiln began operating at Grand River Lime Co., Grand River, Ohio, raising the plant capacity from 180 to 400 tons of quicklime per day. The kilns were fired by a mixture of bituminous coal and gas.[4]

Ash Grove Lime & Portland Cement Co. began operating its 250-ton-per-day lime plant at Portland, Oreg. Both quicklime and hydrated lime were produced.

The Rapid City Lime Co., Rapid City, S. Dak., began producing quicklime in a 8.5- by 162-foot rotary kiln. Part of the output was hydrated. Annual production of quicklime and hydrated lime was expected to be 50,000 tons.

United States Gypsum Co. plant at New Braunfels, Tex., was being enlarged. The expansion program was to be completed by April 1964. Another United States Gypsum Co. plant was to be built at Galena Park, Tex., to produce additional hydrated lime for the increasing road stabilization market in Texas.

Open-market lime production was resumed in the State of Washington when Pacific Lime Co., Ltd., began operating its grate-kiln lime plant at Tacoma.

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[3] Lowrey, F. Thomas. Lime Recovery at Oxford Paper Co. Minerals Processing, v. 4, No. 3, March 1963, pp. 19–21.

[4] Herod, Buren C. Ohio Lime Producer Aims at Premium Market. Pit and Quarry, v. 55, No. 11, May 1963, pp. 148–152, 154.

TABLE 5.—Number and production of domestic lime plants, by size of operation [1]

Annual production (short tons)	1962			1963		
	Plants	Production		Plants	Production	
		Short tons	Percent of total		Short tons	Percent of total
Less than 10,000	80	325,318	3	67	298,238	2
10,000 to less than 25,000	35	561,001	4	37	610,918	4
25,000 to less than 50,000	36	1,276,371	9	39	1,423,364	10
50,000 to less than 100,000	25	1,821,084	13	25	1,828,411	13
100,000 to less than 200,000	22	3,484,189	25	21	3,211,690	22
200,000 and over	17	6,281,842	46	19	7,149,636	49
Total [2]	215	13,753,000	100	208	14,521,000	100

[1] Includes captive tonnage.
[2] Data may not add to totals shown because of rounding.

CONSUMPTION AND USES

Chemical and industrial uses absorbed 75 percent of the U.S. primary lime production; construction, 10 percent; and refractory lime or dead-burned dolomite, 13 percent. Use of lime in agriculture again declined slightly, but the average price increased $0.54 per ton. Production of open-market lime for steel fluxing increased 17 percent; production of captive lime for the same use declined 4 percent. Both open-market and captive lime sold or used in the paper and pulp industry increased, and this industry used 90 percent of the 3.5 million tons of regenerated lime produced.

TABLE 6.—Lime sold or used by producers in the United States, by major uses

Use	1962			1963		
	Short tons	Value [1]		Short tons	Value [1]	
		Total	Average per ton		Total	Average per ton
Agricultural	191,637	$2,636,844	$13.76	176,559	$2,582,169	$14.30
Construction	1,290,229	21,980,560	17.04	1,435,169	23,519,221	16.39
Chemical and industrial uses	10,410,501	131,074,683	12.59	10,961,576	140,229,607	12.79
Refractory (dead-burned dolomite)	1,857,438	31,059,293	16.72	1,948,953	33,057,530	16.96
Total [2]	13,753,000	186,754,000	13.58	14,521,000	199,389,000	13.73

[1] Selling value, f.o.b. plant, excluding cost of container.
[2] Data may not add to totals shown because of rounding.

TABLE 7.—Lime sold or used by producers in the United States, by uses

(Short tons)

Use	1962			1963		
	Open market	Captive	Total	Open market	Captive	Total
Agriculture	192,000		192,000	176,000	(1)	176,000
Construction:						
Finishing lime	446,204		446,204	463,838		463,838
Mason's lime	469,746	74,165	543,911	457,376		457,376
Soil stabilization	275,914	73	275,987	395,577	83	395,660
Other	24,127		24,127	39,392	78,903	118,295
Total [2]	1,216,000	74,000	1,290,000	1,356,000	79,000	1,435,000
Chemical and other industrial:						
Alkalies (ammonium, potassium, and sodium compounds)	26,693	3,068,236	3,094,929	11,064	3,129,125	3,140,189
Brick, sand-lime, slag, and silica	25,457		25,457	32,267		32,267
Calcium carbide	565,375	361,339	926,714	583,869	368,147	952,016
Glass	255,861		255,861	243,717		243,717
Other chemical uses [3]	728,756	530,165	1,258,921	632,131	838,327	1,470,458
Metallurgical uses:						
Aluminum	50,164	280,253	330,417	91,559	90,284	181,843
Copper smelting	106,503	199,689	306,192	107,574	178,457	286,031
Magnesium	26,802	336,770	363,572	17,814	93,539	111,353
Other nonferrous	3,814	35,957	39,771	4,720		4,720
Ore concentration [4]	52,856	2,427	55,283	62,226	2,840	65,066
Steel flux	1,574,867	74,536	1,649,403	1,842,789	71,643	1,914,432
Miscellaneous steel processing (wire drawing, etc.)[5]	32,283	35	32,318	19,190	41,664	60,854
Paper and pulp	610,429	33,944	644,373	747,896	40,212	788,108
Sewage and trade-wastes treatment	117,709	15,698	133,407	202,478	43,798	246,276
Sugar	30,152	515,008	545,160	25,497	585,735	611,232
Water softening and treatment	741,593	7,130	748,723	852,672	342	853,014
Total [5]	4,949,000	5,461,000	10,411,000	5,477,000	5,484,000	10,961,000
Refractory lime (dead-burned dolomite)	1,787,000	71,000	1,858,000	1,880,000	69,000	1,949,000
Grand total [2]	8,145,000	5,608,000	13,753,000	8,889,000	5,632,000	14,521,000

[1] Included with open-market agricultural lime to avoid disclosing confidential data.
[2] Data may not add to totals shown because of rounding.
[3] 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, and unspecified uses.
[4] Includes flotation, cyanidation, bauxite purification, and magnesia manufacture.
[5] Includes wire drawing and various metallurgical uses.

TABLE 8.—Regenerated lime sold or used by producers in the United States, by uses

(Short tons)

Use	1962			1963		
	Open market	Captive	Total	Open market	Captive	Total
Paper and pulp		3,138,884	3,138,884		3,143,394	3,143,394
Water softening and purification	8,163	72,364	80,527	3,084	79,883	82,967
Other [1]	292,664	175,324	467,988	289,298	277,429	566,727
Total [2]	301,000	3,387,000	3,687,000	292,000	3,501,000	3,793,000

[1] "Other" includes regenerated lime for agriculture, calcium carbide, construction, petrochemicals, sewage treatment, and steel.
[2] Data may not add to totals shown because of rounding.

TABLE 9.—Apparent consumption of lime (primary and regenerated) sold and used in the United States, by States

(Short tons)

State	1962			1963		
	Quicklime	Hydrated lime	Total	Quicklime	Hydrated lime	Total
Alabama	541,458	80,689	622,147	575,622	78,508	654,130
Alaska		250	250		575	575
Arizona	155,083	17,348	172,431	159,041	15,108	174,149
Arkansas	140,029	295,825	435,854	234,518	10,790	245,308
California	533,038	76,874	609,912	581,851	110,781	692,632
Colorado	117,524	21,446	138,970	150,417	16,991	167,408
Connecticut	44,358	24,565	68,923	34,457	23,881	58,338
Delaware	37,914	11,782	49,696	35,304	10,919	46,223
District of Columbia	20	7,321	7,341	10	9,328	9,338
Florida	610,876	57,742	668,618	598,185	60,707	658,892
Georgia	323,377	23,525	346,902	391,460	19,145	410,605
Hawaii		15,245	15,245		12,056	12,056
Idaho	66,530	13,398	79,928	71,606	4,230	75,836
Illinois	411,382	126,862	538,244	466,234	136,111	602,345
Indiana	555,796	39,988	595,784	630,909	48,929	679,838
Iowa	89,986	24,491	114,477	77,772	20,533	98,305
Kansas	44,746	18,512	63,258	42,568	17,220	59,788
Kentucky	560,022	40,798	600,820	587,200	19,367	606,567
Louisiana	854,400	98,146	952,546	924,636	101,889	1,026,525
Maine	71,529	11,518	83,047	81,070	10,474	91,544
Maryland	210,520	27,215	237,735	195,657	67,847	263,504
Massachusetts	32,552	46,491	79,043	36,503	48,221	84,724
Michigan	1,095,980	304,688	1,400,668	1,554,471	105,318	1,659,789
Minnesota	106,610	18,363	124,973	145,682	21,900	167,582
Mississippi	289,691	17,446	307,137	295,701	41,555	337,256
Missouri	113,978	53,861	167,839	123,711	56,427	180,138
Montana	106,077	4,079	110,156	113,943	8,624	122,567
Nebraska	29,729	9,899	39,628	50,683	8,566	59,249
Nevada	33,278	3,911	37,189	27,346	3,245	30,591
New Hampshire	5,573	3,932	9,505	5,172	2,448	7,620
New Jersey	52,888	99,721	152,609	40,765	94,505	135,270
New Mexico	31,113	22,379	53,492	154,557	37,967	192,524
New York	1,030,887	138,264	1,169,151	894,843	114,300	1,009,143
North Carolina	336,428	32,683	369,111	233,998	24,320	258,318
North Dakota	9,878	1,721	11,599	26,825	11,128	37,953
Ohio	2,026,622	135,367	2,161,989	2,101,998	142,056	2,244,054
Oklahoma	44,674	13,552	58,226	45,818	20,321	66,139
Oregon	207,460	13,144	220,604	169,804	63,391	233,195
Pennsylvania	966,261	254,068	1,220,329	1,084,709	177,590	1,262,299
Rhode Island	7,989	6,409	14,398	7,814	7,781	15,595
South Carolina	273,326	7,738	281,064	307,918	6,914	314,832
South Dakota	15,772	3,400	19,172	18,716	8,418	27,134
Tennessee	156,923	58,867	215,790	160,985	73,049	234,034
Texas	717,809	475,882	1,193,691	772,794	537,727	1,310,521
Utah	99,268	16,298	115,566	100,915	13,784	114,699
Vermont	294	2,705	2,999	94	1,692	1,786
Virginia	310,379	43,624	354,003	390,002	42,298	432,300
Washington	346,869	127,172	474,041	392,769	16,234	409,003
West Virginia	183,359	233,508	416,867	142,767	203,383	346,150
Wisconsin	111,367	56,231	167,598	175,676	61,081	236,757
Wyoming	16,826	4,030	20,856	24,401	4,276	28,677
Total [1]	14,128,000	3,243,000	17,371,000	15,440,000	2,754,000	18,194,000

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

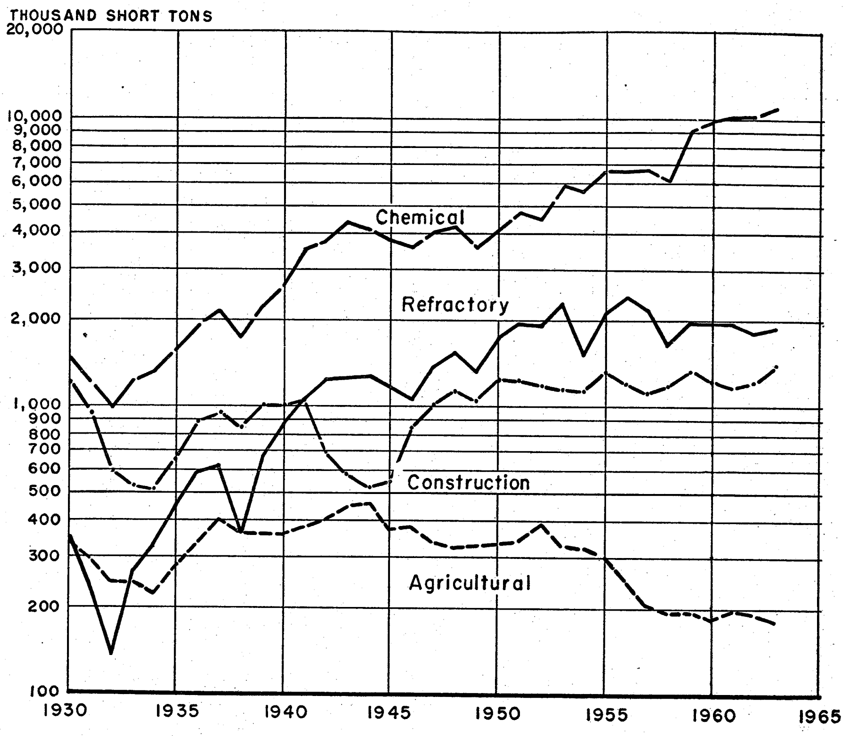

FIGURE 1.—Trends in major uses of lime, 1930–63.

PRICES

The average price of open-market and captive quicklime and hydrated lime, f.o.b. plant, excluding the cost of containers, increased from $13.58 per ton in 1962 to $13.73 per ton in 1963. Lime prices reported by Oil, Paint and Drug Reporter [5] did not change during the year. Bulk chemical quicklime was $14.25 per ton, bagged chemical hydrated lime was $17.25 per ton, and bagged hydrated spray lime was $18.25 per ton. These prices, which had not changed since April 21, 1958, were for 25-ton carlots from eastern lime plants near New York City. Wholesale prices delivered in New York City were $6.29 per ton higher when the freight charge from nearby producing plants was added. On November 25, Oil, Paint and Drug Reporter began quoting National Formulary purified lime in 100-pound fiber drums at $0.18 per pound.

Quotations for delivered hydrated finishing lime in November ranged from $25.80 per ton in the Baltimore area to $52 per ton at Seattle, less customary discounts. For the same period pulverized lime prices ranged from $26.33 per ton in Birmingham to $49.20 in Minneapolis.[6]

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[5] Oil, Paint and Drug Reporter. V. 183, Nos. 1–25, v. 184, Nos. 1–27, Jan. 7–Dec. 30, 1963.

[6] Engineering News Record. V. 171, No. 22, Nov. 28, 1963, p. 50.

FOREIGN TRADE

Imports.—The combined tonnage of dead-burned refractory material, hydrated lime, and quicklime, imported from Canada accounted for 98 percent of total imports. Small amounts of magnesia were imported from West Germany and Yugoslavia.

TABLE 10.—U.S. imports for consumption of lime

Year	Hydrated lime		Other lime		Dead-burned dolomite [1]		Total	
	Short tons [2]	Value	Short tons [2]	Value	Short tons [2]	Value	Short tons [2]	Value
1954-58 (average)	924	$14,574	30,121	$530,420	7,511	$490,220	38,556	$1,035,214
1959	530	9,346	26,374	442,330	8,468	495,952	35,372	947,628
1960	676	14,597	18,445	369,051	12,932	550,365	32,053	934,013
1961	950	21,710	31,418	491,352	4,256	233,271	36,624	746,333
1962	1,141	18,755	71,970	939,226	4,456	244,788	77,567	1,202,769
1963	692	12,226	90,676	1,004,920	9,389	454,721	100,757	1,471,867

[1] Dead-burned basic refractory material consisting chiefly of magnesia and lime.
[2] Includes weight of immediate container.

Source: Bureau of the Census.

Exports.—The 11,137 tons of lime exported to Canada accounted for 64 percent of U.S. exports. Mexico imported 2,942 tons from the United States.

TABLE 11.—U.S. exports of lime

Year	Short tons	Value	Year	Short tons	Value
1954-58 (average)	69,897	$1,337,146	1961	29,969	$920,668
1959	52,780	1,000,337	1962	19,512	660,408
1960	61,056	991,769	1963	17,463	565,299

Source: Bureau of the Census.

WORLD REVIEW [7]

Table 12, reports world lime production, in short tons, during 1959–63. In 1963, as in preceding years, the U.S.S.R., United States, and West Germany were the leading producers.

NORTH AMERICA

Puerto Rico.—Puerto Rican Cement Co., Inc., Ponce Division, Ponce, began producing lime about 2 years ago.

SOUTH AMERICA

Brazil.—The Government announced a program to build more limekilns to produce additional agricultural lime for treating acid soils.[8]

[7] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[8] Chemical Age (London). Brazilian "Crash" Programme for Fertilisers. V. 90, No. 2298, July 27, 1963, p. 143.

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EUROPE

Germany, West.—The Federation of the German Lime Industry (Bundesverbond der Deutschen Kalkindustrie), Cologne, held a technical conference at Bad Kissingen on October 17 and 18.[9]

Hungary.—A $6 million, 80,000 ton-per-year lime plant with semiautomatic kilns began operating at Tatabanya Cement and Lime Works, Northwest Hungary, on June 6.[10] Construction of a 100,000-ton-per-year lime plant began at Hejocsaba. British oil-burning equipment was considered for the limekilns of Danube Cement and Lime works at Vac.[11]

Ireland.—Irish Sugar Co., Ltd., operated the two largest limestone quarries in Ireland to supply feed for the vertical limekilns at its beet-sugar factories. One quarry was at Ballybeg north of the sugar factory at Mallow, and the other at Killough near the sugar factory at Thurles. Besides providing its own lime needs, Irish Sugar Co., Ltd. sold ground agricultural limestone and lime sludge that was the byproduct of sugar manufacture.[12]

Italy.—A lime plant was erected at Lecco by cooperating Austrian and Hungarian companies. The battery of three large vertical kilns was automatically operated and could be fired with coke, natural gas, or oil, or by combinations of these fuels.[13]

Norway.—Two large, mixed-feed, coke-fired, vertical limekilns at a chemical plant were converted to fuel oil- and carbide-furnace-gas firing.[14]

Poland.—As the result of an expansion, 150,000 tons more lime was expected to be produced at Gorazdze in 1964 than in 1963. Five automated limekilns and an automated hydrator were under construction.[15]

United Kingdom.—Limekilns were manufactured by Industrial Plant (Combustion) Ltd., Sheffield; The Power-Gas Corp. Ltd., Stockton-on-Tees; Riley (I.C.) Products Ltd., London; Vickers-Armstrong (Engineers) Ltd., London; and West's Gas Improvement Co., Ltd., Manchester.[16]

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[9] Cement, Lime and Gravel (London). German Lime Federation. V. 38, No. 9, September 1963, p. 306.
[10] Cement, Lime and Gravel (London). V. 38, No. 9, September 1963, p. 306.
[11] Cement, Lime and Gravel (London). Hungary's Biggest Cement Works Goes Into Production. V. 38, No. 4, April 1963, pp. 133–134.
[12] Cement Lime and Gravel. Agricultural Lime in Eire. V. 38, No. 4, April 1963, pp. 107–111.
[13] Madaras, J. G. Experience With Modern Lime-Burning Systems. Cement, Lime and Gravel (London), v. 38, No. 2, February 1963, pp. 37–41.
[14] Azbe, Victor J. Oil-Gas Takes Over Kiln Firing. Rock Products, v. 66, No. 7, July 1963, pp. 71–73, 78.
[15] Cement, Lime and Gravel (London). Polish Lime Modernization. V. 38, No. 8, August 1963, p. 275.
[16] Cement, Lime and Gravel (London). Kilns and Kiln Equipment. V. 38, No. 4, April 1963, p. 49a.

TABLE 12.—World production of quicklime, hydrated lime, and dead-burned dolomite, sold or used

(Thousand short tons)

Country [1]	1959	1960	1961	1962	1963
North America:					
Canada	1,686	1,530	1,415	1,424	1,440
Costa Rica [2]	3	4	4	4	6
Honduras	14	12	11	(3)	(3)
Nicaragua	27	27	28	29	[2] 31
Puerto Rico	10	1	1	1	4
United States (sold or used by producers)	12,456	12,934	13,249	13,752	14,521
West Indies:					
Bahamas	4	3	3	2	3
Barbados	(3)	11	(3)	(3)	(3)
Dominican Republic	[2] 16	8	[2] 8	7	(3)
Haiti [2]	180	180	180	180	180
South America:					
Argentina	[2] 1,100	[2] 1,100	[2] 1,100	(3)	(3)
Brazil	1,224	1,179	1,410	1,308	(3)
Columbia	83	88	90	94	107
Paraguay	11	15	15	16	14
Peru	74	85	77	88	94
Uruguay [2]	36	36	36	36	33
Venezuela	50	43	38	49	53
Europe:					
Austria	696	747	784	740	759
Belgium	1,955	2,125	2,120	2,245	2,222
Bulgaria	399	474	698	766	(3)
Czechoslovakia	2,263	2,543	2,598	2,611	(3)
Denmark	134	146	162	162	[2] 160
Finland	217	236	245	243	234
France	2,856	3,224	3,248	3,078	5,790
Germany:					
East	3,343	3,363	3,116	3,686	(3)
West	9,620	[4] 10,702	10,939	10,690	10,775
Hungary	590	643	676	690	685
Ireland	33	32	32	(3)	39
Luxembourg	47	39	13	---	---
Malta	(3)	44	45	39	(3)
Poland	2,025	2,048	2,071	2,186	2,667
Rumania	634	658	724	746	(3)
Spain	72	126	286	203	(3)
Sweden	900	1,033	(3)	(3)	(3)
Switzerland	147	185	205	212	203
U.S.S.R.	16,784	17,790	18,955	18,237	[2] 18,700
United Kingdom	2,240	(3)	(3)	(3)	(3)
Yugoslavia	681	767	800	847	947
Asia:					
Indonesia	93	119	(3)	(3)	(3)
Japan	(3)	(3)	(3)	1,291	1,511
Lebanon	(3)	[2] 8	8	[2] 10	39
Philippines	51	21	28	47	(3)
Ryukyu Islands	2	1	3	1	(3)
Saudi Arabia	(3)	(3)	(3)	(3)	7
Syrian Arab Republic	[2] 12	(3)	(3)	(3)	(3)
Taiwan	47	49	84	83	88
Africa:					
Algeria	9	18	(3)	(3)	(3)
Cape Verde Islands	3	1	2	(5)	(3)
Ethiopia [6]	3	3	5	8	5
Libya [2]	15	17	18	19	(3)
Mozambique	(3)	12	(3)	(3)	(3)
South Africa, Republic of (sales)	849	852	758	726	(3)
South-West Africa	4	3	4	3	3
Tanganyika	4	4	4	3	1
Tunisia	99	139	133	142	158
Uganda	11	17	16	18	(3)
Oceania:					
Australia [7]	130	125	124	(3)	(3)
Fiji Islands	5	3	4	3	6

[1] Lime is also produced in Chile, China, Republic of the Congo, Ecuador, Greece, Guatemala, India, Iran, Israel, Italy, Republic of Korea, Mexico, Morocco, New Zealand, Pakistan, Federation of Rhodesia and Nyasaland, Ruanda-Urundi, and Viet-Nam, but production data are not available. In addition, Bermuda, El Salvador, Guadeloupe, Netherlands Antilles, Sarawak and St. Thomas and Principe Islands produce less than 1000 tons.

[2] Estimate.

[3] Data not available.

[4] Including Saar, beginning 1960.

[5] Negligible.

[6] Year ended September 10 of year stated.

[7] Year ended June 30 of year stated.

ASIA

India.—Plans for the installation of a 5-compartment fluidized-bed limekiln at Mettur Chemical and Industrial Corp., Sondkaridrug, Madras, were announced by Dorr-Oliver (India) Ltd. The principal components of the lime plant would be manufactured in the United States by Dorr-Oliver, Inc., Stamford, Conn., and the construction would be conducted by its subsidiary in India. The oil-fired kiln was to be 60 feet high, 14 feet in diameter, and have a daily capacity of 50 tons of quicklime. This would be the fourth Dorr-Oliver fluidized-bed calcining system for lime and the first outside the United States.[17]

Japan.—A completely automated lime plant on the Azuma River began production late in 1963.[18]

Turkey.—Lime was manufactured from suitable limestone that occurs in almost every district.[19]

OCEANIA

Australia.—Quicklime for anticipated basic oxygen steel processing at Newcastle, New South Wales, would be manufactured in vertical kilns at Newcastle. Quicklime and hydrated lime were produced in South Australia. Many old-fashioned, rectangular flare kilns were operated intermittently in limestone localities on the Yorke Peninsula, along the coast from Coobowie to Kulpara, and at Tailem Bend, Murray Bridge, Port Lincoln, Strathalbyn, and Gawler. The introduction of rotary kilns and fluidized-bed kilns was considered for calcining the soft limestones of Mount Gambier and the calcareous sands of Coffin Bay. Hydrated lime was sold by Hydrated Lime Ltd., Adelaide, South Australia, for stabilizing a haulage road in clay.[20]

TECHNOLOGY

Manufacturing rights to the Knibbs lime-hydrating system were obtained by Fluostatic Ltd., Borough Green, England. Knibbs hydrators were to be manufactured for use in conjunction with the fluidized-bed kilns being manufactured by the company.[21]

A road-base material sold by Poz-O-Products, Inc., Cincinnati, Ohio, consisted of lime, fly ash, aggregate, and water.[22]

Southern Research Institute, Birmingham, Ala., conducted research under the auspices of the National Lime Association, Washington, D.C., to compare the effectiveness of hard-burned lime and soft-burned lime in removing the impurities from pig iron in the basic oxygen process. Both types of quicklime yielded quality steel in short heats,

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[17] Minerals Processing. Lime Calcining Kiln. V. 4, No. 7, July 1963, p. 6.
Pit and Quarry. Lime Calcining Kiln Ordered for Indian Operation. V. 55, No. 12, June 1963, p. 120.

[18] Cement, Lime and Gravel (London). V. 38, No. 9, September 1963, p. 282.

[19] Cement, Lime and Gravel (London). Cement, Lime and Gravel in Turkey. V. 38, No. 7, July 1963, pp. 221–222.

[20] Johns, R. K. Limestone, Dolomite and Magnesite Resources of South Australia. South Australia Dept. of Mines, Geological Survey of South Australia (Adelaide), Bull. 38, 1963, pp. 9–13.
National Lime Association. Lime Helps Australian Contractor Speed Foundation Project. Limeographs, v. 30, December 1963, p. 31.

[21] Cement, Lime and Gravel (London). The Knibbs Hydrating System. V. 38, No. 4, April 1963, p. 137.

[22] Rock Products. New Road Base Producer. V. 66, No. 3, March 1963, p. 128.

according to preliminary results. Although the degree of calcination did not seem to affect the quicklime used in the basic oxygen process, one steel company representative stated that the lime supplied should be a product of consistent calcination and contain very little fines. As the basic oxygen process was used more widely through the United States, consideration was given to establishing captive lime plants at steel mills, but open-market lime companies prepared to retain this expanding market.[23]

Further research on use of metallurgical lime, also sponsored by the National Lime Association, was initiated at the University of Michigan to determine the solution rate of solid lime in molten slag. Later experiments are to be conducted in an oxygen converter pilot plant.[24]

A refractory lime brick for lining the high-temperature zones of rotary kilns was introduced by Mississippi Lime Co., Alton, Ill. The service life of the new refractory brick is as long as 18 months. High-calcium lime was mixed with additives and dead-burned. The brick withstood temperatures above 3,500° F, had minimum porosity, low thermal conductivity, resistance to spalling, little shrinkage, and low cost.[25]

The five basic construction steps in soil stabilization with lime were scarification, lime spreading, mixing and watering, compaction, and curing. Lime was spread dry using bulk or bagged lime or was spread wet as a slurry to avoid creating dust. Time recommended for curing the stabilized layer was 4 to 7 days. For heavy clays, it was recommended that the lime-soil mixture be cured for 1 to 2 days and then be remixed to insure adequate pulverization before compaction. The cost of lime stabilization for 6 inches of compacted depth using 2 to 5 percent hydrated lime was $0.25 to $0.50 per square yard.[26]

Use of lime along Interstatae Highway 90 in South Dakota reduced the plasticity index from 25.8 to 10.9 and the volume change from 41 to 3.6 percent, thus reducing the expansive properties of the Pierre Shale, which is the dominant soil type in this area.[27]

Lime improved clayey soils for construction by reducing the plasticity index and shrinkage, forming agglomerates, increasing friability, drying, increasing compressive and bearing strength, forming water-resistant layers, creating firm subgrades, and permitting flexible schedules through slow setting and easy reworking.[28]

Bulk hydrated lime from the Union Carbide Olefins Co. plant, Woodstock, Tenn., was delivered 30 miles by tank trucks to stabilize the subbase of a cloverleaf interchange of Interstate Highway 40 near West Memphis, Ark. Dry hydrated lime was loaded into tank trailers by gravity from an overhead storage tank; as much as 23.5 tons of lime was loaded by one man in less than a half hour. At the construc-

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[23] Rock Products. Research to the Rescue for the Lime Industry. V. 66, No. 6, June 1963, pp. 95–96.
[24] Blast Furnace & Steel Plant. Research on Lime in Basic Oxidizing Slags. V. 51, No. 10, October 1963, p. 918.
[25] Minerals Processing. Mississippi Lime Co. Develops and Tests High-Temperature Refractory Lime Brick. V. 4, No. 2, February 1963, p. 33.
[26] National Lime Association. Lime Stabilization. 1963, 4 pp.
[27] Berg, Richard O., and Charles A. Piper. Lime Stabilizes Shale Subgrade. Civil Eng., v. 33, No. 9, September 1963, pp. 35–36.
[28] National Lime Association. Lime Stabilization. 1963, 4 pp.

tion site, a pneumatic system unloaded the tank trucks directly into dump trucks for spreading.[29]

The South District Filtration Plant of the Chicago waterworks system, using 3 million pounds of lime per year, found that self-unloading bulk trailers could deliver the 60,000 pounds of lime required each week within 24 hours after the order was placed, compared with 5 to 7 days required by railroad transportation. Labor costs were reduced by $50 per week.[30]

The first lime stabilization project in Illinois was completed by the Chicago Bureau of Engineering in 1962. A soft glacial clay containing 30 to 50 percent water was converted into a subgrade for a 0.5-mile, eight-lane section of the Dan Ryan Superhighway. Hydrated lime dried the clay and changed it into a firm layer on which the granular subbase and concrete pavement were built. Lime stabilization saved 6 weeks of construction time on this job, which was started in the spring when the clay was considered a quagmire. The subgrade was stabilized over a width of 144 feet at a rate of 25 pounds per square yard to a 6-inch depth. Hydrated lime constituted 5 percent by weight of the lime-clay mixture; about 600 tons of hydrated lime was used.[31]

The thermal decomposition of calcium carbonate was studied kinetically in an airstream at 750° to 900° C. Pellets pressed from powdered material acted as solid masses, even though void space was present. At any specified temperature, the decrease in rate of decomposition with increasing back pressure of carbon dioxide was directly proportional to the difference between the back pressure and the equilibrium pressure. The reaction appeared to be controlled by the rate of diffusion of carbon dioxide through a layer of active calcium oxide of constant thickness.[32]

At the Colorado Fuel and Iron Corporation's $2.5 million lime-calcining plant at Pueblo, automatic controls and newly designed equipment produced 300 tons per day of lime for basic oxygen and openhearth furnaces.[33]

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[29] Roads and Streets. Dry Bulk Carriers Feed Lime Spreaders. V. 106, No. 2, February 1963, p. 122.
[30] Water Works Engineering. Delivery Time, Inventory, and Costs Cut With Self-Unloading Bulk Trailers. V. 116, No. 12, December 1963, p. 962.
[31] Berman, Sidney. Lime Tames Wet Clay for Early Spring Start. Roads and Streets, v. 106, No. 1, January 1963, pp. 32–35, 44.
[32] Ingraham, T. R., and P. Marier. Kinetic Studies on the Thermal Decomposition of Calcium Carbonate. Dept. of Mines and Tech. Surveys (Ottawa, Canada), Mines Branch Res. Rept. R118, August 1963, 4 pp. (reprinted from the Canadian Journal of Chemical Engineering, August 1963).
[33] Taeler, David H. Automated Lime Production Cuts Costs at CF&I's Pueblo Plant. Minerals Processing, v. 4, No. 12, December 1963, pp. 15–17.

Lithium

By Donald E. Eilertsen[1]

DOMESTIC output of lithium mineral source materials, which were produced in three States, was larger in 1963 than in 1962. Imports were all from Africa and were much smaller than in 1962.

DOMESTIC PRODUCTION

Production of lithium mineral source materials was approximately 10 percent larger than in 1962. More spodumene flotation concentrate and select amblygonite were produced, but output of crude dilithium-sodium phosphate from brines declined.

Foote Mineral Co. mined spodumene ore from pegmatite and produced spodumene flotation concentrate at Kings Mountain, N.C.; American Potash & Chemical Corp. recovered crude dilithium-sodium phosphate from Searles Lake brines at Trona, Calif.; and Hough and Judson produced substantial amounts of amblygonite from the Hugo Lode mine, Keystone, S. Dak., for export. Production and shipment figures are not disclosed as they are company confidential.

The principal consumers of lithium source materials and producers of lithium primary products were Foote Mineral Co., at Sunbright, Va., and Exton, Pa.; Lithium Corporation of America, at Bessemer City, N.C.; American Potash & Chemical Corp., at Trona, Calif.; and Maywood Chemical Works, Division of Stepan Chemical Co., at Maywood, N.J. No production figures were available for publication.

Lithium Corporation of America, Inc., obtained a long-term option on 23,000 acres of land near Promontory Point on the north shore of Great Salt Lake, Utah, for future use in producing a number of products including lithium chloride.

CONSUMPTION AND USES

Domestically-produced and imported lithium mineral concentrates were used to produce lithium metal, alloys, and compounds, especially the latter. Other applications for lithium minerals were in certain ceramics and glass.

Lithium chemicals were used in multipurpose greases, nuclear energy, air conditioning, storage and dry cell batteries, welding and brazing, ceramics, glass, bleaches, and catalysis and preparing hydrogen. No major new use was developed for lithium chemicals, but many developments and potential applications were investigated which eventually may increase the markets for lithium products.

[1] Commodity specialist, Division of Minerals.

There was increased interest in lithium hydride for emergency buoyancy devices, as lithium hydride reacts with water to yield hydrogen which can be used for inflating rafts or other devices.

Lithium metal had applications in the refining of various metals and in alloying and catalysis.

PRICES

Lithium metal, 99.5-percent pure, was quoted at $9 to $11 per pound throughout 1963.[2] Prices for various lithium compounds are shown in table 1.

TABLE 1.—Range of prices on selected lithium compounds, in 1963

(Per pound)

Compound	January	December
Lithium bromide, natural formulary, granular, bags, works, freight equalized [1]	$2.60	
Lithium carbonate, drums, ton lots [2]	.58	$0.61
Technical, drums, ton lots [2]	.50	.55
Lithium chloride, chemically pure, anhydrous, drums, ton lots	1.235	1.235
Technical, anhydrous, drums, carlots, truckloads, delivered or works, freight allowed	.87	.87
Drums, less than carlots, freight allowed	.88-.92	.88-.92
Lithium hydride, powder, drums, 500-pound lots or more, works	9.50	9.50
Lithium hydroxide, monohydrate, drums, carlots, truckloads, freight allowed	.54	.54
Drums, less than carlots, freight allowed	.58	.58
Lithium nitrate, technical, drums, 100-pound lots	1.15-1.25	1.15-1.25
Lithium stearate, drums, carlots, works	.475	.475
Drums, ton lots, works	.485	.485
Drums, less than ton lots, works	.535	.535

[1] Quotation not given after Mar. 25.
[2] Price changed Oct. 7.

Source: Oil, Paint, and Drug Reporter.

FOREIGN TRADE

Imports.—Imports of lithium minerals in 1962–63 are shown in table 2. No lithium metal was imported during 1963. Lithium compounds, separately classified from other materials since September 1, were: 282,000 pounds, valued at $121,260, from Canada; 3 pounds, valued at $587, from West Germany, and 10 pounds valued, at $1,625, from United Kingdom.

Export figures for lithium metal and compounds were not available.

WORLD REVIEW

Free-world production of lithium minerals during 1959 to1963 and exports of lithium mineral concentrate in 1962–63 from Federation of Rhodesia and Nyasaland and also from South-West Africa are shown in tables 3, 4, and 5, respectively.

Germany, West.—A report describing the 50-year development of the Hans-Heinrich-Hüttle (smelter) at Langelsheim, the first producer of lithium metal and compounds in West Germany (1925), was published. The publication also contains a summary of the miner-

[2] E&MJ Metal & Mineral Markets. V. 34, Nos. 1–52, January–December 1963.

TABLE 2.—U.S. imports for consumption of lithium minerals by countries and U.S. customs district

Country and U.S. customs district	1962		1963	
	Short tons	Value	Short tons	Value
North America: Canada: Michigan	330	$16,500	---	---
Africa:				
British East Africa: South Carolina	---	---	1,127	$31,014
Mozambique:				
Maryland	2,196	59,643	---	---
Philadelphia	1,149	43,769	---	---
South Carolina	2,316	55,928	2,248	62,049
Total	5,661	159,340	2,248	62,049
Rhodesia and Nyasaland, Federation of:				
Maryland	23,603	752,268	17,967	539,997
South Carolina	---	---	1,121	30,831
Total	23,603	752,268	19,088	570,828
South Africa, Republic of: New York	1,115	77,929	---	---
Total Africa	30,379	989,537	22,463	663,891
Grand total	30,709	1,006,037	22,463	663,891

Source: Bureau of the Census.

alogy and geology of lithium deposits and describes applications of the metal and its compounds. [3]

TABLE 3.—Free world production of lithium minerals, by countries

(Short tons)

Country	Mineral produced	1959	1960	1961	1962	1963
North America:						
Canada [1]	Spodumene	1,378	102	268	250	332
United States	Lithium minerals	(2)	(2)	(2)	(2)	(2)
South America:						
Argentina	Lithium minerals	187	153	443	496	(3)
Brazil	Spodumene (exports)	468	---	---	165	(3)
	Amblygonite (exports)	590	55	---	---	---
Surinam	Amblygonite (exports)	---	---	475	827	(3)
Europe: Spain	Amblygonite	---	28	19	---	---
Africa:						
Mozambique	Lepidolite	99	---	170	302	115
Rhodesia and Nyasaland, Federation of: Southern Rhodesia.	Eucryptite	[4] 57,901	1,334	1,879	866	1,164
	Amblygonite		---	86	35	52
	Lepidolite		15,485	24,037	21,243	16,157
	Petalite		63,336	27,698	21,705	29,947
	Spodumene		7,690	1,627	1,496	2,236
Ruanda-Urundi	Amblygonite	2,965	2,569	1,854	359	(3)
South Africa, Republic of	Lithium minerals	10	173	260	1,263	[5] 510
South-West Africa	Amblygonite	242	161	136	141	[5] 165
	Lepidolite	2,168	972	1,418	1,781	[5] 115
	Petalite	2,787	3,909	2,540	1,007	[5] 395
Uganda	Amblygonite	---	---	26	22	(3)
Oceania: Australia	Petalite	28	1	108	94	[5] 275
	Amblygonite	---	17	27	31	
	Spodumene	---	---	6	27	

[1] Tons of lithia in spodumene concentrates.
[2] U.S. figure withheld to avoid disclosing individual company confidential data. No estimates included in total.
[3] Data not available.
[4] Exports.
[5] Estimate.

[3] Thieler, Erich. Special Jubilee Issue 50th Anniversary of the Foundation of the Hans-Heinrich-Hütte Metal Gesell. A.G., Frankfurt am Main, West Germany, Review of Activities, new series, No. 6, 1963, 31 pp.

TABLE 4.—Federation of Rhodesia and Nyasaland: Exports of lithium mineral concentrates, by countries

Destination	1962		1963	
	Short tons	Value [1]	Short tons	Value [1]
Belgium	1,555	$24,425	4,304	$76,180
Germany, West	226	3,173	51	2,856
Italy	23	388	714	4,665
Japan	3,338	90,790	3,499	98,140
Netherlands	3,486	69,187	3,403	78,954
South Africa, Republic of	186	2,926	189	2,965
United Kingdom	2,619	44,054	3,827	56,784
United States	21,274	481,358	24,256	507,366
Total	32,707	716,301	40,243	827,910

[1] Converted to U.S. currency at the rate of £1 equals US$2.8078 (1962) and US$2.8000 (1963).

TABLE 5.—South-West Africa: Exports of lithium mineral concentrates, by countries

Year and destination	Amblygonite		Lepidolite		Petalite	
	Short tons	Value [1]	Short tons	Value [1]	Short tons	Value [1]
1962:						
Germany, West	146	$8,092	148	$1,399		
Japan			1,253	27,297		
Netherlands			75	2,594	233	$5,483
United Kingdom					114	2,518
Total	146	8,092	1,476	31,290	347	8,001
1963: [2]						
Germany, West	145	8,285	315	7,134	5	120
Japan					62	1,381
United Kingdom					586	12,832
Total	145	8,285	315	7,134	653	14,333

[1] Converted to U.S. currency at the rate of one rand equals US$1.3987 (1962) and US$1.3948 (1963).
[2] January to September, inclusive.

Korea Republic of.—A report concerning lithium mineral occurrences in Korea revealed that the Japanese eagerly sought lithium in this country in the early 1940's. More than 20 occurrences were known in North Korea, and 10, in the Republic of Korea. In the north, Munich'on (Bunsen) mine near ch'onggye-ri (Seikei-ri) produced about 40 tons of lepidolite. In the south, the Ulchin (Uruchin) mine near Tongsugok shipped 650 to 900 tons of hand-sorted lepidolite, and the Tanyang (Tanyo) operations, near Tanyang, produced approximately 400 tons of milled lithium-bearing mica.[4]

Surinam.—Representatives of the Dutch-owned mining firm, N.V. Billiton Maatschappij along with Government mining service geologists reported that Billiton's small amblygonite deposit on the Jorkakreek in eastern Surinam had been depleted and that no other commercial deposits of this mineral are known in this country. The last shipment of amblygonite was expected to be made in mid-September.[5]

[4] Gallagher, David. Lithium. Mineral Resources of Korea. Min. Branch, Ind. and Min. Division USOM/Korea in cooperation with Geol. Survey of Korea, v. 4-B, 1963, pp. 85-91.
[5] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, p. 25.

TECHNOLOGY

Bureau of Mines research on lithium consisted principally of developing fluorescent X-ray spectrographic analysis methods for lithium fluoride, thermodynamic studies on lithium oxalate, and studies on recovering spodumene in connection with recovering beryl from North Carolina spodumene mill tailing.

The Atomic Energy Commission investigated lithium as a potential coolant for reactors. This included studies on the physical and thermodynamic properties and corrosion behavior in potential cladding materials.

A comprehensive report, translated from Russian on the mineral, chemical, and metallurgical technology of lithium and a brief description of uses was published.[6] Another report describes fields of application for lithium.[7]

Numerous patents were issued on lithium disclosing new extraction and recovery methods,[8] new procedures in preparing lithium-compounds,[9] and the development of numerous new uses.[10]

The nuclear and electronic properties of lithium were presented.[11]

The growing, cleaving, and applications of superpure lithium fluoride crystals were described.[12]

A procedure for manufacturing foamed refractories based on beta spodumene or petalite was discussed.[13]

Fe_3O_4, $LiFe_5O_8$ and two forms of $LiFeO_2$ solid corrosion products were observed in the reaction of lithium hydroxide with steel at 316° C.[14]

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[6] Ostroushko, Yu. I., and Others. Lithium, Its Chemistry and Technology. U.S. Atomic Energy Commission AEC-tr-4940 Chemistry, Translated from Litii, Ego Khimiya i Tekhnologiya, Moscow, 1960); U.S. Department of Commerce, OTS 62-11792, July 1962, 276 pp.

[7] Kogan, Boris Iosifovich. Lithium, Fields of Known and Possible Application. U.S. Army Missile Command, Redstone Scient. Inf. Center, RSIC-71; Redstone, Ala., U.S. Department of Commerce, OTS N63-23351, Oct. 1, 1963, 155 pp.

[8] Archambault, Maurice, and Others (assigned to Department of Natural Resources, Quebec, Canada). Sodium-Ammonium Compounds Process for Extracting Lithium From Spodumene. U.S. Pat. 3,112,170, Nov. 26, 1963.

Archambault, Maurice (assigned to Department of Natural Resources, Quebec, Canada). Lithium Carbonate Production. U.S. Pat. 3,112,171, Nov. 26, 1963.

Chubb, Philip A. Treatment of Lithium Ores. U.S. Pat. 3,073,673, Jan. 15, 1963.

Saito, Eiichi (assigned to Commissariat a l'Énergie Atomique, Paris, France). Separation of the Isotopes of Lithium. U.S. Pat. 3,105,737, Oct. 1, 1963.

Whaley, Thomas H. (assigned to Texaco Development Corp., New York). Recovery of Metal Values from Lithium Ores. U.S. Pat. 3,087,782, Apr. 30, 1963.

[9] Coons, William R., William R. Hencke, and Gordon S. Bright (assigned to Texaco, Inc., Delaware). Rheopectic Lithium Soap Grease and Method of Preparation Therefor. U.S. Pat. 3,079,341, Feb. 26, 1963.

Cretzmeyer, John W. (assigned to Lithium Corporation of America, Inc., Minneapolis, Minn.). Process for Producing Anhydrous Lithium Perchlorate. U.S. Pat. 3,075,827, Jan. 29, 1963.

Hedrick, Ross M., and Edward H. Mottus (assigned to Monsanto Chemical Co., St. Louis, Mo.). Homogneous Propellant Compositions of Lithium Perchlorate and Polylactum. U.S. Pat. 3,107,185, Oct 15, 1963.

Hedrick, Ross M., and Edward H. Mottus (assigned to Monsanto Chemical Co., St. Louis, Mo.). Solid Composite Propellants Containing Lithium Perchlorate and Polyamide Polymers. U.S. Pat. 3,094,444, June 18, 1963.

Wood, Judson A. (assigned to Olin Mathieson Chemical Corp., Virginia). Purification of Lithium Chloride. U.S. Pat. 3,114,602, Dec. 17, 1963.

[10] Cope, L. H. (assigned to United Kingdom Atomic Energy Authority, London). Powders for Extinguishing Fires (use of lithium fluoride). U.S. Pat. 3,095,372, June 25, 1963.

Grego, P., and R. G. Howell (assigned to Corning Glass Works, Corning, N.Y.). Glass Staining Method and Material (use of lithium nitrate). U.S. Pat. 3,079,264, Feb. 26, 1963.

Currie, Thomas E. (assigned to Foote Mineral Co., Berwyn, Pa.). Single Coat Porcelain Enamel. U.S. Pat. 3,114,646, Dec. 17, 1963.

Mets, Edwin J. (assigned to General Electric Co., New York). Method of Protecting Metal From Corrosion. U.S. Pat. 3,073,720, Jan. 15, 1963.

Miller, Mary L. (assigned to American Cyanamid Co., New York). Method of Making Crystallizable Polymer With Lithium as Catalyst. U.S. Pat. 3,088,939, May 7, 1963.

[11] Gilman, Henry, and John J. Eisch. Lithium. Sci. Am., v. 208, No. 1, January 1963, pp. 88–102.

[12] Chemical & Engineering News. Harshaw Grows Ultrahigh-Purity LiF Crystals. V. 41, No. 16, Apr. 22, 1963, pp. 48–49.

[13] Fishwick, J.H. Manufacture of Foamed Ceramics Based on Petalite and Beta Spodumene. Am. Ceram. Soc. Bull., v. 42, No. 3, March 1963, pp. 110–113.

[14] Bloom, M. C., M. Krulfeld, and W. A. Fraser. Some Effects of Alkalis on the Corrosion of Mild Steel in Steam Generating Systems. Pres. at 19th Annual Conference of the Nat. Assoc. of Corrosion Eng., Mar. 11-15, 1963, 13 pp.

Magnesium

By Lloyd R. Williams [1] and John W. Stamper [1]

PRODUCTION of primary magnesium in the United States increased by 7,000 short tons, accounting for most of the 6 percent increase in world production during the year. Magnesium was an asset for the United States in the balance of foreign trade.

Increased domestic consumption of magnesium was reported for all distributive or sacrificial purposes except zinc alloys and scavenger and deoxidizer uses which decreased. A decrease was reported for all structural products except die and permanent mold castings. Consumption of these increased.

A comprehensive Bureau of Mines report reviewed the magnesium industry's history, geology, sources, production, and uses as well as methods for recovering and processing the element and it's many valuable compounds.[2]

TABLE 1.—Salient magnesium statistics

(Short tons)

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Production:						
Primary magnesium	62,114	31,033	40,070	40,745	68,955	75,845
Secondary magnesium	9,678	10,090	10,348	8,125	9,610	14,553
Imports for consumption	945	593	401	1,005	2,359	1,982
Exports	3,228	1,601	4,467	6,160	6,426	3,268
Consumption	43,817	41,551	37,100	45,533	[1] 47,320	51,240
Price per pound cents	32.18	35.25	35.25	35.25	35.25	35.25
World: Primary production	106,200	82,300	102,500	116,400	145,900	154,800

[1] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

On August 31, 1963, the duty on metallic magnesium and scrap was decreased from 45 to 40 percent ad valorem. Duty on magnesium alloys (metallic magnesium content) was decreased from 18 cents per pound plus 9 percent ad valorem to 16 cents per pound plus 8 percent ad valorem. For wrought magnesium powder, ribbon, sheets, tubing, manufactures, and so forth, the duty decreased from 15.5 cents per pound plus 7.5 percent ad valorem to 13.5 cents per pound plus 7 percent ad valorem. Suspension of duty on metallic scrap continued to June 30, 1964.

[1] Commodity specialist, Division of Minerals.
[2] Comstock, H. B. Magnesium and Magnesium Compounds. A Materials Survey. BuMines Inf. Circ. 8201, 1963, 128 pp.

Magnesium was listed as a strategic and critical material. In the period 1960–63, there were no acquisitions for the stockpile.

Releases from Government stockpiles in short tons gross weight were as follows:

	1960	1961	1962	1963
Ingot			210	3,475
Scrap	423	1,076	1,223	
Total	423	1,076	1,433	3,475

DOMESTIC PRODUCTION

Primary.—Production of 75,845 tons of primary magnesium was 10 percent above the 1962 output and was about 74 percent of the total capacity of the three operating producers. The Dow Chemical Co. operated plants at Freeport and Velasco, Tex.; Alabama Metallurgical Corp. operated a plant at Selma, Ala.; and Chas. Pfizer & Co., Inc. operated the Government-owned plant at Canaan, Conn. This list of producers does not include the production or capacity of the Titanium Metals Corp. of America primary magnesium plant at Henderson, Nev., because all of that plant's recovered magnesium was recycled for titanium production.

Harvey Aluminum, Inc., and Standard Magnesium and Chemical Co. announced plans to build primary magnesium plants in the Pacific Northwest—a 20,000-ton-per-year plant and a 10,000-ton-per-year plant, respectively.[3]

Secondary.—Recovery of magnesium from new magnesium-base scrap was 10,539 short tons, the highest since 1944.

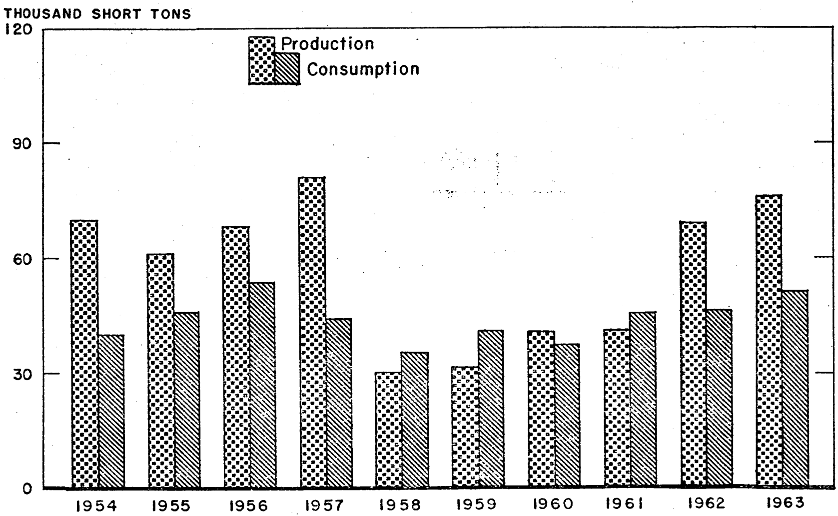

FIGURE 1.—Domestic production and consumption of primary magnesium, 1954–63.

[3] Chemical & Engineering News. New Magnesium Makers May Change Market. V. 41, No. 48, Dec. 2, 1963, pp. 21–22.

TABLE 2.—Production and shipments of primary magnesium in the United States, by months

(Short tons)

Month	1954–58 (average)		1959		1960	
	Production	Shipments	Production	Shipments	Production	Shipments
January	6,107	5,489	1,877	2,976	3,355	3,775
February	5,311	4,796	1,725	3,671	3,180	3,675
March	5,690	4,567	1,925	3,681	3,600	5,625
April	4,827	4,551	1,808	4,176	3,290	4,105
May	5,358	4,018	2,668	3,995	3,240	4,465
June	5,110	4,564	2,778	4,271	3,075	4,335
July	4,175	3,600	2,850	4,559	3,120	2,435
August	4,793	4,349	2,967	4,367	3,200	5,310
September	5,130	4,648	2,846	3,026	3,290	4,785
October	5,313	4,228	3,018	3,556	3,535	4,925
November	5,140	5,248	3,042	4,718	3,200	4,470
December	5,160	3,670	3,529	4,536	3,985	6,445
Total	62,114	53,728	31,033	47,532	40,070	54,350
	1961		1962		1963	
	Production	Shipments	Production	Shipments	Production	Shipments
January	3,255	4,090	4,825	5,315	6,140	6,150
February	3,265	4,880	4,570	5,180	5,640	5,745
March	3,470	4,395	5,555	5,395	6,210	6,905
April	3,435	3,560	5,930	5,360	5,890	6,975
May	3,490	4,655	6,160	6,285	6,580	6,955
June	3,440	4,145	5,810	5,020	6,120	2,290
July	3,675	2,270	6,150	5,310	6,335	5,900
August	3,930	4,870	6,035	5,250	6,230	6,630
September	1,525	5,190	5,695	5,300	6,360	5,580
October	3,505	5,165	6,010	6,820	6,820	5,975
November	3,900	7,165	6,125	6,795	6,655	5,640
December	3,855	5,130	6,090	7,380	6,865	7,510
Total	40,745	55,515	68,955	69,410	75,845	72,255

TABLE 3.—Magnesium recovered from scrap processed in the United States, by kinds of scrap and forms of recovery

(Short tons)

	1954–58 (average)	1959	1960	1961	1962	1963
Kind of scrap:						
New scrap:						
Magnesium-base	3,151	3,073	3,179	1,905	4,700	10,539
Aluminum-base	1,927	2,105	2,825	1,500	1,770	1,912
Total	5,078	5,178	6,004	3,405	6,470	12,451
Old scrap:						
Magnesium-base	3,955	4,133	3,560	4,260	2,620	1,540
Aluminum-base	645	779	784	460	520	562
Total	4,600	4,912	4,344	4,720	3,140	2,102
Grand total	9,678	10,090	10,348	8,125	9,610	14,553
Form of recovery:						
Magnesium alloy ingot [1]	3,634	3,881	3,828	1,090	1,110	1,746
Magnesium alloy castings (gross weight)	181	219	103	360	650	1,019
Magnesium alloy shapes	3	2	3	350	195	291
Aluminum alloys	2,970	3,507	3,208	1,910	1,850	2,765
Zinc and other alloys	39	21	54	1,095	560	873
Chemical and other dissipative uses	19	600	255	1,350	260	437
Cathodic protection	2,832	1,860	2,897	1,970	4,985	7,422
Total	9,678	10,090	10,348	8,125	9,610	14,553

[1] Figures include secondary magnesium content of both secondary and primary magnesium alloy ingot.

TABLE 4.—Stocks and consumption of new and old magnesium scrap in the United States in 1963

(Short tons, gross weight)

Scrap item	Stocks, Jan. 1[1]	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Cast scrap	445	1,695	480	1,250	1,730	410
Solid wrought scrap	570	2,910	3,165	----------	3,165	315
Borings, turnings, drosses, etc	240	8,570	8,640	----------	8,640	170
Total	1,255	13,175	12,285	1,250	13,535	895

[1] Revised figures.

CONSUMPTION AND USES

Consumption of primary magnesium in 1963 increased about 8 percent. A 7 percent decrease in structural products was more than offset by an increase of 21 percent for distributive or sacrificial purposes.

Magnesium was used to produce large containers suitable in size and shape for transporting liquids by freight car or truck. The containers were considered part of the car and moved without freight charge in both directions. It was reported that more than 50 percent of the castings used in the aircraft field were made from magnesium. Extrusions and deep drawn sheet were used for the manufacture of luggage.[4] A magnesium die cast fan was scheduled to replace a steel fan on the 1964 Corvair engine.[5] A 1,170-pound magnesium casting was produced for use on the Apollo manned aircraft.[6] Cast magnesium was used as shells of bowling pins filled with plastic foam and coated with plastic.[7] More than 300 pounds of alloy ZK60A–T5 extrusions were used as flooring in each HC–IB helicopter built by Boeing Co. for the U.S. Army.[8] Kenworth Motor Truck Co. delivered 19 truck-cab units with magnesium sheet used for external cab areas.[9]

STOCKS

On December 31, 1963, producer and consumer stocks were 11,190 short tons of primary magnesium and 7,3b0 short tons of primary magnesium alloy ingot—increases of 4,120 tons of primary magnesium and 4,280 tons of primary magnesium alloy ingot above stocks at the beginning of the year. In the national strategic stockpile there were 176,203 short tons of specification grade and 943 tons of subspecification grade magnesium ingot.

[4] American Metal Market. Container, Castings Gains Seen, World Magnesium Conference. V. 70, No. 201, Oct. 17, 1963, pp. 1, 10.

[5] Metal Working News. Say Corvair Will Feature Magnesium Cast Fan. V. 4, No. 153, Aug. 12, 1963, p. 23.

[6] Modern Metals. Huge Magnesium Castings for Moon Landing Program. V. 19, No. 6, July 1963, p. 72.

[7] Modern Metals. Profile Machining Magnesium Bowling Pins. V. 19, No. 6, July 1963, p. 82.

[8] Modern Metals. Extruded Magnesium Floor for Heavy Cargo Service. V. 19, No. 3, April 1963, p. 74.

[9] American Metal Market. Magnesium Used to Reduce Weight in Tractor Unit. V. 70, No. 85, May 3, 1963, p. 8.

TABLE 5.—Domestic consumption of primary magnesium (ingot equivalent and magnesium content of magnesium-base alloys), by uses

(Short tons)

Use	1954–58 (average)	1959	1960	1961	1962	1963
For structural products:						
Castings:						
Sand	6,934	4,770	2,561	2,408	3,464	3,280
Die [1]	1,888	[1] 1,772	[1] 1,528	[1] 1,328	[2] 3,660	5,580
Permanent mold	831	981	745	464	901	1,400
Wrought products:						
Sheet and plate	4,786	6,128	4,112	4,434	6,352	5,650
Extrusions (structural shapes, tubing)	4,099	3,074	2,580	3,990	6,240	3,370
Forgings	207	1,913	893	767	415	220
Total	18,745	18,638	12,419	13,391	[2] 21,032	19,500
For distributive or sacrificial purposes:						
Powder	584	456	430	244	465	1,175
Aluminum alloys	10,894	14,780	12,511	19,754	[2] 18,405	21,780
Zinc alloys	(3)	(3)	(3)	27	100	70
Other alloys	320	840	421	1,017	896	1,420
Scavenger and deoxidizer	635	292	788	344	1,120	150
Chemical	145	351	276	297	[2] 430	470
Cathodic protection (anodes)	3,496	3,005	3,264	2,406	2,024	2,985
Reducing agent for titanium, zirconium, hafnium, uranium, and beryllium	8,678	3,175	6,978	7,950	[2] 2,843	3,070
Other [4]	320	14	13	103	5	620
Total	25,072	22,913	24,681	32,142	[2] 26,288	31,740
Grand total	43,817	41,551	37,100	45,533	[2] 47,320	51,240

[1] Includes primary metal to produce small quantities of investment castings.
[2] Revised figure.
[3] Before 1961, included with "Other alloys".
[4] Includes primary metal for experimental purposes, debismuthizing lead, and producing nodular iron and secondary magnesoum alloys.

PRICES

The base price of primary magnesium ingot in standard 42-pound pig form remained at 35.25 cents per pound, f.o.b. U.S. plants. World market prices were lower. The Dow Metal Products Co. increased prices on selected items of alloys HK31A and HM21A from 1 to 15 percent and decreased prices on selected items of alloy AZ31B from 2 to 8 percent.[10]

FOREIGN TRADE

Imports.—Total magnesium imports in 1963 dropped 3 percent below those of 1962 but were more than twice the quantity imported in 1961. Most of the 16-percent drop in metallic magnesium and scrap in 1963 was offset by increased imports of magnesium alloys (metallic magnesium content). Metallic magnesium and scrap accounted for about 83 percent of the 2,374-ton total. These imports came from 21 countries: 1,295 tons from Canada; 193 tons from Japan; 167 tons from West Germany; 143 tons from the Netherlands; 104 tons from Belgium-Luxembourg; 128 tons from Pakistan; 83 tons from the United Kingdom; 69 tons from Norway; 44 tons from Sweden; 33 tons from the Philippines; 13 to 23 tons each from Spain, Italy, Taiwan, Greece,

[10] Materials in Design Engineering. The Materials Age. Prices and Supply. V. 58, No. 3, September 1963, p. 13.

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and the Republic of South Africa; and less than 10 each from Morocco, Singapore, Federation of Malaya, Nicaragua, El Salvador, and Honduras. Canada replaced Japan as the principal source of imported magnesium.

Exports.—Exports of 4,000 tons of magnesium were about half of the quantity exported in 1962. However, industry reports indicate that actual exports were several times that shown by the Bureau of the Census. West Germany and Canada were the principal recipients.

TABLE 6.—U.S. imports for consumption and exports of magnesium

Year	Imports					
	Metallic and scrap		Alloys (magnesium content)		Powder, sheets, tubing, ribbons, wire and other forms (magnesium content)	
	Short tons	Value	Short tons	Value	Short tons	Value
1954–58 (average)	945	$487,154	17	$121,178	7	[1] $32,309
1959	593	303,307	26	154,775	26	120,630
1960	401	202,087	28	287,916	4	60,623
1961	1,005	482,907	31	170,304	5	80,419
1962	2,359	1,079,819	53	106,242	35	83,399
1963	1,982	825,107	374	602,570	18	112,146
	Exports					
	Metal and alloys in crude form and scrap		Semifabricated forms, n.e.c.		Powder	
	Short tons	Value	Short tons	Value	Short tons	Value
1954–58 (average)	[2] 3,228	[2] $1,982,028	[2] 415	[2] $768,732	27	$46,553
1959	[2] 1,601	[2] 881,514	[2] 776	[2] 1,146,180	12	31,536
1960	[2] 4,467	[2] 2,658,480	[2] 658	[2] 1,037,325	7	23,048
1961	[2] 6,160	[2] 3,639,669	[2] 488	[2] 878,815	33	78,297
1962	[2] 6,426	[2] 3,656,316	[2] 594	[2] 1,002,977	21	52,980
1963	[2] 3,268	[2] 1,830,175	[2] 690	[2] 1,187,912	33	87,075

[1] Owing to changes in tabulating procedures by the Bureau of the Census, data known to be not comparable with other years.
[2] Effective Jan. 1, 1958, some material formerly included with "Metals and alloys in crude form, and scrap" included with "Semifabricated forms, not elsewhere classified."

Source: Bureau of the Census.

WORLD REVIEW

World production of primary magnesium increased 6 percent to 155,000 tons. The United States continued to be the largest producing country and accounted for 49 percent of the world total. At the World Magnesium Congress in Montreal, Canada, it was generally noted that the price of magnesium should be on a competitive basis with the price of aluminum.

Canada.—Production of magnesium decreased slightly in 1963. The United Kingdom continued to be the principal market. A newly installed magnesium plant in the United Kingdom was expected to cause a decrease in that market. Another reported detriment to future competitive markets was a graduated 1963–66 tax on materials

TABLE 7.—U.S. exports of magnesium, by classes and countries

(Short tons)

Destination	1962			1963		
	Primary metal, alloys, and scrap	Semifabricated forms, n.e.c.	Powder	Primary metal, alloys, and scrap	Semifabricated forms, n.e.c.	Powder
North America:						
Canada	1,508	158	6	597	207	2
Mexico	517	24	----------	343	68	(1)
Other	----------	5	----------	----------	5	----------
Total	1,925	187	6	940	280	2
South America:						
Brazil	259	133	----------	93	1	----------
Colombia	(1)	14	----------	----------	16	----------
Venezuela	4	49	----------	4	36	1
Other	17	11	----------	22	11	----------
Total	280	207	----------	119	64	1
Europe:						
Belgium-Luxembourg	----------	26	7	7	21	2
France	249	11	----------	177	6	(1)
Germany, West	2,505	53	----------	993	50	----------
Italy	47	5	(1)	72	13	(1)
Netherlands	255	18	1	54	9	----------
Spain	46	----------	1	144	(1)	2
Sweden	11	8	3	1	3	1
Switzerland	----------	9	----------	----------	3	(1)
United Kingdom	620	15	2	269	11	(1)
Other	145	----------	----------	131	12	6
Total	3,878	145	14	1,848	128	11
Asia:						
India	52	----------	----------	7	7	16
Israel	4	9	1	9	5	2
Japan	----------	27	----------	113	167	----------
Other	49	16	----------	1	9	1
Total	105	52	1	130	188	19
Africa	44	2	----------	11	30	----------
Oceania	194	1	----------	220	(1)	----------
Grand total	6,426	594	21	3,268	690	33

[1] Less than 1 ton.

Source: Bureau of the Census.

used by Dominion Magnesium Ltd.[11] The Canadian export market was also adversely affected by low production costs in Norway and surplus supplies elsewhere.

Germany, West.—More than 98 percent of the estimated 1963 consumption of 38,000 tons was imported. Of the total an estimated 28,000 tons was used in the manufacture of Volkswagen parts.[12]

Japan.—Production of magnesium increased 9 percent in 1963. Furukawa Magnesium Co. Ltd., the only producer with 19 furnaces of 16 retorts each used the thermal process with dolomite as a raw material. The plant, situated about 50 miles north of Tokyo, received raw material from a dolomite resource about 20 miles away. The

[11] Northern Miner (Toronto). Dominion Magnesium Predicts New Tax Could Close Plant. No. 37, Dec. 5, 1963, pp. 1–2.

[12] Herbert Steinjan. Magnesium in Germany. Light Metals Age, v. 21, Nos. 9 and 10, October 1963, pp. 16–18.

TABLE 8.—World production of primary magnesium, by countries [1]
(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
Canada	[2] 7,800	6,102	7,289	7,635	8,816	8,695
China [3]	(4)	1,000	1,000	1,000	1,000	1,000
France	1,656	1,938	2,359	2,282	2,392	1,970
Germany West	290	550	[2] 330	[2] 440	[2] 550	[2] 550
Italy	3,578	4,960	6,003	6,192	6,288	[2] 6,300
Japan	367	[5] 1,724	[5] 2,363	[5] 2,477	[5] 2,301	[2] 2,500
Norway	8,088	10,567	11,373	16,018	16,400	[2] 18,700
U.S.S.R. [2]	17,300	22,000	27,600	34,000	35,000	35,000
United Kingdom [6]	4,435	2,387	4,119	5,600	[2] 4,200	[2] 4,200
United States	62,114	31,033	40,070	40,745	68,955	75,845
World total (estimate) [1]	106,200	82,300	102,500	116,400	145,900	154,800

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Conjectural, denoting an order of magnitude.
[4] Data not available; estimates by senior author included in the world total.
[5] In addition, the following amounts of secondary magnesium were produced: 1959, 2,694 short tons; 1960, 3,327 short tons; 1961, 3,060 short tons; and 1962, 2,130 short tons.
[6] Primary metal and remelt alloys.

company plans to expand production to 5,000 tons under full-scale operation.[13]

U.S.S.R.—Estimated production of magnesium was the same as in 1962. Magnesium in the form of panels, sheet, pressed shapes, tubes, rods, wire, forgings and die castings are used extensively in aircraft, automobile, textile and other industries.[14]

United Kingdom.—A 5,000-ton capacity thermal reduction magnesium plant was erected at Hopton and was in operation. The metal was shipped 50 miles to Clifton Junction for alloying and fabricating. The high cost of electricity forced closure of the Clifton Junction electrolytic extraction units.[15]

TECHNOLOGY

Although development of new and improved magnesium alloys continued, industry representatives expressed a need for research to develop alloys more resistant to corrosion. Development of improved casting design and techniques progressed under technology research.

The technologies of mining, processing, and fabricating magnesium were described in a Bureau of Mines publication.[16]

The Bureau of Mines evaluated the technologic and economic aspect of producing magnesium by metalothermic methods using ferrosilicon and carbon as the reductants.[17]

Technological research for the production of high-strength, premium quality magnesium castings led to the development of alloy

[13] Oyana, Masaya. Magnesium in Japan. Light Metal Age, v. 21, Nos. 9 and 10, October 1963, pp. 22–23.
Rannels, Karl. Japan Rebuilds Industry Slowly—Aims at Meeting Rising Needs. Am. Metal Market, v. 70, No. 207, Oct. 25, 1963, p. 11.
[14] Gurgev, L. I. Magnesium in the U.S.S.R. Light Metal Age, v. 21, Nos. 9 and 10, October 1963, pp. 19–21.
[15] Ball, Major Charles. Magnesium in England. Light Metal Age, v. 21, Nos. 9 and 10, October 1963, pp. 15–16.
[16] Work cited in footnote 2.
[17] Dean, K. C., D. A. Elkins, and B. H. Clemmons. Evaluations of Thermic Production Methods for Magnesium. Oral presentation at Annual Meeting of the AIME, Feb. 16–20, 1964, New York, N.Y., 27 pp.

systems and improved casting design and techniques. Alloys in the magnesium-aluminum-zinc system were useful for temperatures up to 350° F; those in the magnesium-rare earth-zirconium system were useful for temperatures up to 550° F, and those in the magnesium-thorium-zirconium system were useful for temperatures up to 650° F. In the magnesium-zinc-zirconium system, zircon was added as a grain refiner. In the presence of zinc, the zircon also increased the strength of the alloy.[18]

The importance of good foundry techniques, such as exact control of alloying elements, a tapered sprue, a sprue basin, and a screen for filtering the metal was illustrated. Tests showed that chilled castings had greater tensile and yield strength than unchilled castings.[19]

Although hot chamber machines have a theoretical advantage over cold chamber machines, the majority of magnesium die cast parts are made in cold chamber machines.[20]

Experimental work in the Soviet Union indicated that dense magnesium-base castings can be produced by subjecting the castings to pressures of 45 to 75 pounds per square inch immediately after pouring at temperatures of 1,455 to 1,470° F.[21]

Feeding magnesium into a cold chamber die-casting machine was simplified by a newly designed metering system in the molten magnesium, equalizing the heat distribution and eliminating atmospheric oxidation.[22]

Additional information on a lithium-magnesium alloy (LA141X) containing 13 to 15 percent lithium and 1 to 1.5 percent aluminum was published.[23] The alloy with a specific gravity of 1.35 and about 25 percent lighter than standard magnesium alloys was described as suitable for aero-space structures. It was a modification of LA142X with a reduction of aluminum content which improved the weldability but did not significantly decrease the mechanical properties. Tables were included giving the composition and the mechanical and physical properties of LA141X weight comparisons with a magnesium-aluminum-zinc alloy (AZ31B). The two highest strength magnesium alloys, AZ80 and ZK60, used in the aircraft industry required stringent quality control to avoid chemical segregation.[24]

Leaner alloys such as AZ31, AZ61, and ZK21 requiring less stringent control were developed for general industrial use. One publication contained charts showing the strength of various magnesium alloys at different temperatures.[25]

Experimental tests showed a much higher fatigue limit for magnesium at room temperature than at 250° C. Fine grain size increased the fatigue limit particularly at room temperature and at higher stress

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[18] Nelson, K. E. New Specifications for High-Strength Magnesium Castings. Foundry, v. 91, No. 12, December 1963, pp. 58–61.

[19] Flemings, M. C., and E. J. Poirier. Premium Quality Magnesium Castings. Foundry, v. 19, No. 10, October 1963, pp. 71–75.

[20] Tinetti, A. R., E. F. Schultz, Jr., and L. C. Mangett, Jr. Fabricating and Finishing of Magnesium Die Castings. Metal Prog., v. 83, No. 2, February 1963, pp. 66–73.

[21] Foundry. Pressurized Castings. V. 91, No. 2, February 1963, p. 117.

[22] Light Metals. Meter for Molten Magnesium. V. 26, No. 296,, January 1963, p. 43.

[23] Rose, Dr. Stuart T., and J. C. Webster. Magnesium-Lithium Alloys; The Newest Aerospace Material. Metalscope, November 1963, pp. 1–5.

[24] Jablonskiv, S. M. Research Program Opens New Hope for Magnesium Forgings. Modern Metals, v. 19, No. 3, April 1963, pp. 62, 66, 68–70.

[25] McDonald, J. C. Ultrahigh Strength Magnesium and Beryllium Alloys. J. Metals, v. 15, No. 2, February 1963, pp. 136–140.

levels. Mode of fatigue showed a trend from transgranular (within the grain) at room temperature to intergranular (grain boundary region) at elevated temperature. Specimens with large grain size were effected by transgranular fatigue. Intergranular fatigue occurred in those with the small grain size. However, in the case of magnesium alloys containing zinc or aluminum all fractures were transgranular.[26]

A nonelectrolytic process for a paint base on magnesium alloys, particularly spot welds of HK31A alloy, containing thorium, was developed.[27] The solution was based on a soluble chromate and completely soluble sulfate catalyst. The pH was maintained at 1.6 to 1.9 with chromic acid.

Methods of pickling magnesium articles in sulfuric acid containing other compounds to improve corrosion resistance, to impart a bright lustrous finish, and to remove contaminating tarnish and scale were patented.[28]

A fuel was prepared experimentally by suspending 200-mesh magnesium powder in JP-4, a hydrocarbon fuel containing a wetting agent.[29] Detailed data on the use of numerous surfactants in relation to viscosity and settling rate to establish stability in storage and fluidity for pumping were given.

Thin metal strips, 80 millimeters wide and ranging from 0.03 to 0.2 millimeter in thickness, were cut by peeling from cylinders of magnesium and magnesium alloys heated to 200° C.[30]

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[26] May, M. J., and R. W. K. Honeycombe. The Effect of Temperature on the Fatigue Behavior of Magnesium and Some Magnesium Alloys. Inst. of Metals (London), v. 92, pt. 2, October 1963, pp. 41–49.

[27] Groshart, E. C., and J. B. Mohler. Conversion Coating Magnesium. Metal Finishing, v. 61, No. 4, April 1963, pp. 56–58.

[28] Levy, J. D. (assigned to The Dow Chemical Co.). Pickling of Magnesium–Base Alloy Articles. U.S. Pat. 3,100,169, Aug. 6, 1963.

[28] Levy, J. D. (assigned to The Dow Chemical Co.). Pickling of Magnesium-Base Alloy Pat. 3,100,170, Aug. 6, 1963.

[29] Fochtman, E. G., F. J. Bitten, and Sidney Katz. Preparation of a Magnesium JP–4 Slurry Fuel. Product Research and Development, v. 2, No. 3, September 1963, pp. z12, z16.

[30] New Scientist. Turning Magnesium Ribbon. No. 337, v. 18, May 1963, p. 263.

Magnesium Compounds

By Lloyd R. Williams [1] and John W. Stamper [1]

WORLD production of magnesite reached a new high exceeding the previous record in 1962 by 450,000 tons. U.S.S.R. continued as principal producer—32 percent of the total. United States accounted for 6 percent of the world total. U.S. exports of dead-burned magnesite and magnesia increased 8 percent but were 37 percent below that of 1961.

TABLE 1.—Salient magnesium compounds statistics

(Thousand short tons and thousand dollars)

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Crude magnesite: Production:						
Quantity	526	594	499	604	492	528
Value [1]	$2,455	$2,401	$2,051	$3,129	$2,287	$1,779
Caustic-calcined magnesia:						
Sold or used by producers:						
Quantity	42	54	66	80	87	135
Value [2]	$2,526	$3,533	$4,292	$5,004	$5,417	$7,865
Imports for consumption:						
Value	$193	$264	$213	$226	$395	$500
Exports: Value	[3] $1,297	$667	$686	$535	$427	$678
Refractory magnesia:						
Sold or used by producers:						
Quantity	404	518	506	599	576	713
Value	$21,303	$31,458	$30,863	$35,408	$35,186	$44,378
Imports: Value	$5,222	$9,606	$7,576	$3,611	$5,520	$4,593
Exports: Value	[3] $1,308	$5,160	$5,988	$7,988	$5,363	$5,620
Dead-burned dolomite:						
Sold or used by producers:						
Quantity	1,997	1,988	1,949	1,983	1,857	1,949
Value	$30,876	$33,069	$32,468	$32,513	$31,059	$33,058
Imports: Value	$490	$496	$550	$233	$245	$455
World: Crude magnesite: Production:						
Quantity	5,150	6,100	6,850	8,300	8,600	9,050

[1] Partly estimated: Most of the crude is processed by mining companies, and very little enters the open market.
[2] Includes specialty magnesia of high unit value.
[3] Four year average. 1954 data not available.

DOMESTIC PRODUCTION

Nevada and Washington supplied all of the crude magnesite produced in 1963. Production was 528,000 tons, 7 percent more than in 1962 or 13 percent less than in 1961. Refractory magnesia pro-

[1] Commodity specialist, Division of Minerals.

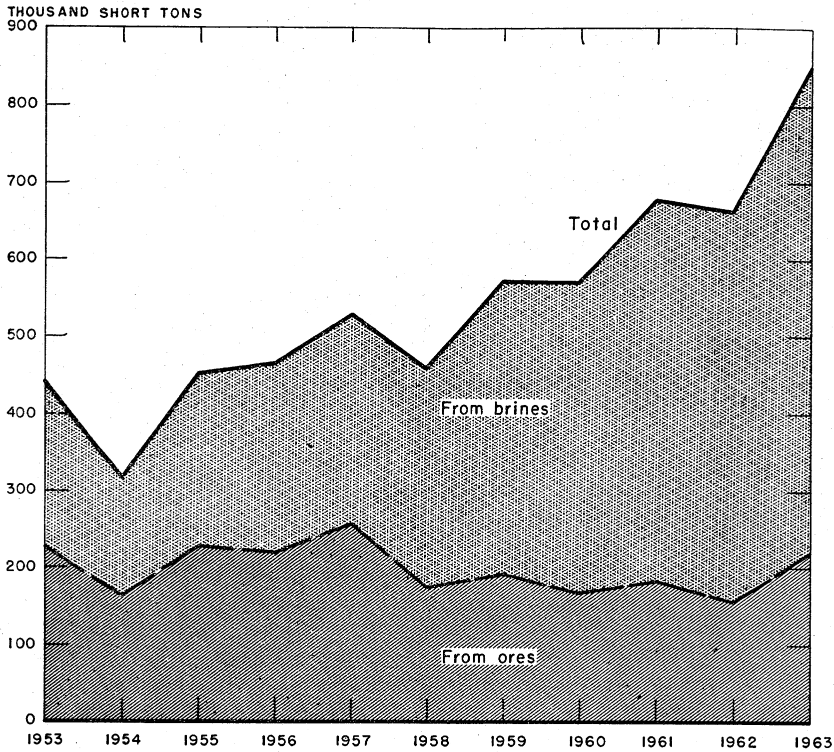

FIGURE 1.—Domestic production of magnesia from ores and brines, 1953–63.

duced from ore increased 10 percent over 1962 and represented 21 percent of the total refractory oxide sold or used by the producers. The remaining 79 percent came from well brines and seawater. Refractory magnesia from the latter source was 24 percent more than in 1962. Michigan led in production and was followed by California, New Jersey, Texas, Florida, and Mississippi. No brucite was reported as mined in 1963.

Approximately 85 percent of the dead-burned dolomite was produced in Ohio, Illinois, and Pennsylvania. Washington and North Carolina accounted for the production of crude olivine, which was less than half of the 1962 output. Pacific Olivine Co., Seattle, Wash.; Scheel Stone Co., Seattle, Wash.; and Olivine Corporation, Bellingham, Wash., started production of olivine in 1963. Omega Mining Inc. at Sedro-Woolley, Wash., discontinued mining olivine.

Output of magnesium trisilicate decreased 31 percent below that of 1961 and production of magnesium sulfate (hydrous) increased 3 percent.

CONSUMPTION AND USES

Consumption of crude magnesite decreased 37 percent, consumption of olivine increased 14 percent and consumption of brucite was 34 percent more than in 1962.

Consumption of caustic calcined magnesia obtained from sea water and brines remained the same as in 1962 and that from ores increased threefold resulting in an average increase of 55 percent from both sources. Consumption of refractory magnesia increased 24 percent, dead-burned dolomite 4 percent, magnesium chlorides 9 percent, and magnesium hydroxide 21 percent.

There was little change in the consumption of magnesium sulfate. Consumption of specified magnesias was less than one-third of the amount in 1962. Consumption of magnesium trisilicate decreased 26 percent and consumption of precipitated magnesium carbonate was 13 percent less than in 1962. A fuel additive (containing magnesium oxide) was used as an inhibitor in residual fuel oils to reduce tube corrosion in boilers. The additive also was reported to increase the fusion temperature of ash, stop slag deposits, neutralize sulfuric acid, and reduce stack emission.[2]

TABLE 2.—Magnesia sold or used by producers in the United States, by kinds and sources

Year and kind	From magnesite, brucite, and dolomite		From well brines, raw sea water, and sea-water bitterns [1]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1962:						
Caustic-calcined	21,440	$1,001	65,369	$4,416	86,809	$5,417
Refractory	135,156	6,783	440,567	28,403	575,723	35,186
Total	156,596	7,784	505,936	32,819	662,532	40,603
1963:						
Caustic-calcined	69,760	3,258	65,117	4,607	134,877	7,865
Refractory	149,113	7,118	563,621	37,260	712,734	44,378
Total	218,873	10,376	628,738	41,867	847,611	52,243

[1] Magnesia made from a combination of dolomite and sea water is included with that from sea water.

TABLE 3.—Dead-burned dolomite sold in and imported into the United States

Year	Sales of domestic product		Imports [1]	
	Short tons	Value (thousands)	Short tons [2]	Value (thousands)
1954–58 (average)	1,996,867	$30,876	7,511	$490
1959	1,987,767	33,069	8,468	496
1960	1,949,260	32,468	12,932	550
1961	1,982,759	32,513	4,256	233
1962	1,857,438	31,059	4,456	245
1963	1,948,953	33,058	8,890	455

[1] Dead-burned basic refractory material comprising chiefly magnesium and lime.
[2] Includes weight of immediate container.

[2] Chemical Engineering. Fuel Additive—Oil Dispersion of Magnesium Oxide Inhibits Tube Corrosion. V. 70, No. 10, May 13, 1963, p. 110.

TABLE 4.—Specified magnesium compounds produced, sold, and used by producers in the United States

Year and product [1]	Plants	Produced (short tons)	Sold		Used (short tons)
			Short tons	Value (thousands)	
1962:					
Specified magnesias (basis, 100 percent MgO), U.S.P. and technical:					
Extra-light and light	4	2,440	2,593	$1,542	----------
Heavy	2	17,409	17,500	2,670	----------
Total	[2] 4	19,849	20,093	4,212	----------
Precipitated magnesium carbonate	5	13,809	5,218	1,161	8,552
Magnesium hydroxide, U.S.P. and technical (basis, 100 percent $Mg(OH)_2$)	6	357,597	197,386	5,589	157,259
Magnesium chloride	7	261,445	12,921	883	[3] 253,000
1963:					
Specified magnesias (basis, 100 percent MgO), U.S.P. and technical:					
Extra-light and light	3	3,290	2,006	1,306	----------
Heavy	2	3,782	3,661	1,527	----------
Total	[2] 4	7,072	5,667	2,833	----------
Precipitated magnesium carbonate	5	11,941	4,336	936	7,649
Magnesium hydroxide, U.S.P. and technical (basis, 100 percent $Mg(OH)_2$)	7	430,830	277,287	7,425	152,427
Magnesium chloride	7	290,759	13,608	945	[3] 275,735

[1] In addition, magnesium phosphate, nitrate, sulfate, trisilicate and acetate were produced.
[2] A plant producing more than 1 grade is counted only once in total.
[3] Greater part used for magnesium metal.

TABLE 5.—Domestic consumption of caustic-calcined magnesia by uses

(Percent)

Use	1959	1960	1961	1962 [1]	1963
Oxychloride and oxysulfate cement	49	47	33	25	16
Rayon	2	3	3	2	8
Fertilizer	(2)	1	(3)	(3)	1
85-percent MgO insulation	4	3	8	2	1
Rubber	1	4	3	4	6
Fluxes	(2)	(2)	(3)	(3)	(3)
Refractories	1	9	27	28	45
Chemical processing	2	3	1	1	3
Uranium processing	9	7	5	4	2
Pulp and paper	(4)	(4)	(4)	(4)	12
Miscellaneous (including chemicals)	32	23	20	34	6
Total	100	100	100	100	100

[1] Revised figures.
[2] Less than 1 percent.
[3] Less than 0.5 percent.
[4] Included with miscellaneous.

TABLE 6.—Domestic consumption of U.S.P. and technical-grade magnesias by uses

(Percent)

Use	1959	1960	1961	1962	1963
Rayon	17	21	17	25	----------
Rubber (filler and catalyst)	11	9	8	27	70
Refractories	14	14	22	22	----------
Medicinal	([1])	([1])	([2])	2	14
Uranium processing	1	([1])	([2])	1	----------
Fertilizer	1	1	1	4	----------
Electrical	14	16	17	----------	----------
Neoprene compounds	----------	----------	----------	----------	----------
Oxychloride and oxysulfate cement	7	2	2	----------	----------
Miscellaneous (including chemicals industry)	35	37	33	19	16
Total	100	100	100	100	100

[1] Less than 1 percent.
[2] Less than 0.5 percent.

PRICES

In April a new price schedule for carlots, f.o.b. Lumming, Nev., was initiated for technical-grade calcined magnesia, as follows; 90 percent—$49.50; 93 percent—$52.50; and 95 percent—$57.50. This compares with the previous schedule of 85 percent—$39.50; 91 percent—$49.40; and 95 percent—$59. U.S.P. grades of magnesia advanced 2 to 3 cents to 39.5 cents per pound for light and 40 cents per pound for heavy. During the year the price of magnesium bromide advanced from $1.15 to $1.60 per pound and magnesium lauryl sulfate dropped from 21 to 19 cents per pound.

FOREIGN TRADE

Imports.—No imports of crude magnesite were reported. Imports of caustic-calcined magnesia increased 28 percent above those of 1962. India furnished 73 percent of the material and accounted for 91 percent of the increase. For the first time a small quantity was reported from British East Africa. Although imports of refractory magnesia from Austria, the principal foreign source, continued to increase, total imports decreased 11 percent.

Exports.—Exports of dead-burned magnesite and magnesia to Japan and West Germany dropped by more than half; however, total exports increased 8 percent. Deliveries to Australia, the principal recipient, increased substantially. Australia, Mexico, Canada, and Japan received 83 percent of the exported dead-burned material. Total value of exported magnesite and magnesia of all classifications increased 9 percent above that of 1962.

Tariff.—Effective August 31, the duty on oxide or calcined magnesia was reduced from 2.25 cents to 2 cents per pound; magnesium carbonate, precipitated, from 0.425 cent to 0.35 cent per pound; magnesium salts and compounds, from 9.5 percent to 8.5 percent ad valorem; and refractory magnesite, including dead-burned and fused magnesite and dead-burned dolomite containing more than 4 percent lime, from 13.5 percent to 12 percent ad valorem. The duty remained the same as in 1962 for other compounds and for all compounds from Communist countries. Some changes resulted from adjustments in pricing units.

TABLE 7.—U.S. imports for consumption of crude and processed magnesite by countries

Country	1962		1963	
	Short tons	Value	Short tons	Value
Crude magnesite:				
South America: Brazil	55	$1,067		
Asia: India	6	267		
Oceania: Australia	1,611	22,528		
Total	1,672	23,862		
Lump or ground caustic-calcined magnesia:				
Europe:				
Austria	1,073	40,327	746	$27,791
Greece	27	1,388	28	1,648
Netherlands	1,064	59,559	1,445	86,628
Switzerland			1	119
United Kingdom	35	2,354		
Yugoslavia	226	7,942	441	15,646
Total	2,425	111,570	2,661	131,832
Asia:				
India	5,261	279,972	7,256	367,303
Pakistan	54	3,301		
Total	5,315	283,273	7,256	367,303
Africa: British East Africa			15	804
Grand total	7,740	394,843	9,932	499,939
Dead-burned and grain magnesia and periclase:				
North America: Canada			82	19,052
Europe:				
Austria	54,816	3,115,572	56,162	2,868,242
Greece	18,783	1,198,514	11,035	707,184
Spain			5	265
Yugoslavia	24,158	1,205,880	19,346	998,077
Total	97,757	5,519,966	86,548	4,573,768
Grand total	97,757	5,519,966	86,630	4,592,820

Source: Bureau of the Census.

TABLE 8.—U.S. imports for consumption of magnesium compounds

Year	Oxide or calcined magnesia		Magnesium carbonate (precipitated)		Magnesium chloride (anhydrous and n.s.p.f.[1])		Magnesium sulfate (epsom salt)		Magnesium salts and compounds n.s.p.f.[1] [2]		Manufactures of carbonate of magnesia	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1954–58 (average)	216	[3] $75,770	276	[3] $61,696	388	$12,664	10,559	[3] $246,121	738	[3] $44,914	10	$2,259
1959	273	71,498	351	93,721	949	28,141	12,350	302,036	1,925	66,096	1	830
1960	266	65,973	346	83,737	1,174	53,920	10,121	240,661	3,036	94,267	28	6,896
1961	248	61,208	342	73,602	1,012	31,375	10,031	231,022	3,796	117,393	6	3,155
1962	182	47,766	398	94,421	1,474	127,090	9,297	209,787	3,505	106,729	4	2,823
1963	93	39,436	623	118,895	668	22,611	8,543	186,997	3,625	128,111		

[1] Not specifically provided for.
[2] Includes magnesium silicofluoride or fluosilicate and calcined magnesia.
[3] Data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 9.—U.S. exports of magnesite and magnesia by countries

Destination	Magnesite and magnesia, dead-burned				Magnesite and magnesia (except dead-burned) and manufactures, n.e.c.[1]	
	1962		1963		1962	1963
	Short tons	Value	Short tons	Value	Value	Value
North America:						
Canada	14.361	$1,181,090	15,275	$1,266,086	$175,577	$167,229
Mexico	16,182	1,050,127	18,405	1,214,674	35,702	24,750
Trinidad and Tobago	—	—	—	—	—	12,750
Other	5	650	4	512	6,550	15,279
Total	30,548	2,231,867	33,684	2,481,272	217,829	220,008
South America:						
Argentina	516	39,859	114	13,449	512	1,046
Brazil	7	4,155	4	2,285	6,807	23,575
Chile	261	18,530	298	23,430	13,704	12,456
Colombia	63	8,650	153	22,855	570	4,108
Peru	1,400	73,950	1,101	69,078	27,304	6,603
Venezuela	11	1,514	—	—	11,546	15,310
Other	1	270	—	—	3,095	—
Total	2,259	146,928	1,670	131,097	63,538	63,098
Europe:						
Belgium-Luxembourg	5	3,051	8	3,221	5,348	15,132
Denmark	255	67,197	14	9,874	—	6,808
France	364	87,592	363	107,525	—	1,964
Germany, West	8,018	655,267	3,046	329,181	370	9,122
Italy	128	43,961	171	35,028	2,237	1,320
Netherlands	1,199	92,458	24	8,120	587	4,984
Portugal	—	—	130	16,466	—	354
Spain	—	—	14	6,026	81,191	65,710
Sweden	67	31,783	82	45,051	16,852	24,733
Switzerland	24	12,499	34	14,516	4,426	4,364
United Kingdom	367	185,251	5,990	521,341	9,309	64,970
Other	17	7,954	31	15,738	1,502	2,160
Total	10,444	1,187,013	9,907	1,112,087	121,822	201,621
Asia:						
Japan	27,816	1,582,926	12,203	701,004	450	26,952
Korea, Republic of	—	—	1,484	77,438	—	—
Kuwait	160	14,742	—	—	730	—
Philippines	34	3,479	88	12,683	6,872	25,447
Other	52	4,430	4	2,715	8,027	81,075
Total	28,062	1,605,577	13,779	793,840	16,079	133,474
Africa:						
Liberia	—	—	—	—	7,370	—
South Africa, Republic of	281	48,321	132	35,629	266	8,163
Other	5	712	2	774	—	2,168
Total	286	49,033	134	36,403	7,636	10,331
Oceania:						
Australia	235	120,460	18,430	1,047,688	250	35,683
New Zealand	32	22,047	25	17,544	—	13,403
Total	267	142,507	18,455	1,065,232	250	49,086
Grand total	71,866	5,362,925	77,629	5,619,931	427,154	677,618

[1] Not elsewhere classified.

Source: Bureau of the Census.

WORLD REVIEW

World production of magnesite increased 5 percent. The U.S.S.R., the leading producer, increased its output 4 percent. Austria, the second largest producer, accounted for the largest drop, 325,000 short tons, or 18 percent. This was offset by an increase of 60 percent, or 330,000 tons, in North Korea. China, the third largest producer, and Greece also contributed major portions to the world's increased production.

NORTH AMERICA

Canada.—Canadian Magnesite Mines was drafting plans to produce dead-burned magnesite from ores in the Timmins area of Ontario.[3]

The company also was considering plans for a flexible pilot plant for research on material from a magnesite deposit in Deloro and Adams Townships.[4]

EUROPE

Austria.—The Lassing magnesite mine in Styria was closed owing to insufficient demand for the product.

Czechoslovania.—A new magnesite quarry was opened at Podrecany in Slovakia to supply the magnesite works at Lovinobana and Kosice.

Italy.—The electrical equipment was ordered for the Sarda Mag magnesite plant at Sant Antioco designed by George Wimpey & Co. Ltd. to produce 50,000 tons per year.

ASIA

India.—The Government of Madras approved construction of a pilot plant to develop a method for producing magnesium from magnesite.[5]

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[3] Mining Journal (London). Canadian Magnesite Project. V. 261, No. 6682, Sept. 13, 1963, p. 241.
[4] Northern Miner (Toronto, Canada). Canadian Magnesite Continues Research. No. 34, Nov. 14, 1963, pp. 13, 18.
[5] Chemical Trade Journal and Chemical Engineer (London). India. Madras Soda Ash and Magnesium Plans. V. 153, No. 3980, Sept. 20, 1963, pp. 434, 436.

TABLE 10.—World production of magnesite by countries [1] [2]
(Short tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
North America: United States	525,629	594,307	498,528	603,656	492,471	527,655
Total [1] [3]	830,000	890,000	810,000	900,000	820,000	830,000
South America:						
Brazil	19,441	53,378	69,793	84,549	103,348	[3] 105,000
Colombia	[4] 22			110	110	[3] 110
Total	19,463	53,378	69,793	84,659	103,458	[3] 105,110
Europe:						
Austria	1,170,276	1,324,106	1,791,701	1,982,704	1,771,863	1,447,099
Czechoslovakia [3]	(5)	440,000	470,000	550,000	580,000	580,000
Greece	79,975	123,566	206,451	163,573	162,921	[3] 275,000
Italy	5,667	7,562	6,584	7,478	9,275	7,512
Norway	583					
Poland	22,084	18,200	23,900	29,900	37,600	[3] 37,600
Spain	33,631	44,569	53,239	91,702	78,691	[3] 78,000
U.S.S.R.[3]	(5)	(5)	(5)	2,750,000	2,750,000	2,870,000
Yugoslavia	195,392	269,851	277,613	301,002	411,561	454,107
Total [1] [3]	3,425,000	3,900,000	4,500,000	5,900,000	5,800,000	5,750,000
Asia:						
China [3]	(5)	880,000	1,100,000	770,000	880,000	990,000
India	92,109	174,129	172,325	231,203	239,201	258,564
Korea, North	(5)	[3] 55,000	[3] 55,000	[3] 220,000	[3] 550,000	880,000
Pakistan	[6] 12	443	486	180	1,036	[3] 1,100
Turkey	853		17	2,414	10,736	19,750
Total [1] [3]	750,000	1,110,000	1,330,000	1,220,000	1,680,000	2,150,000
Africa:						
Kenya	133	3,145	33	1,930		288
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	6,185		8,031	13,880	11,619	12,068
South Africa, Republic of	39,145	58,883	66,793	67,732	102,352	108,309
Tanganyika (exports)	270	118	126	46		94
Total	45,733	62,146	74,983	83,588	113,971	120,759
Oceania:						
Australia	71,316	67,856	69,626	110,651	69,654	[3] 70,000
New Zealand	816		891	650	711	875
Total	72,132	67,856	70,517	111,301	70,365	[3] 70,875
World total (estimate) [1] [2]	5,150,000	6,100,000	6,850,000	8,300,000	8,600,000	9,050,000

[1] Quantities in this table represent crude magnesite mined. Magnesite is also produced in Bulgaria and Canada, but data on tonnage of output are not available; estimates by author of chapter included in total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Data for the year 1958 only.
[5] Data not available; estimate by author of chapter included in total.
[6] Average annual production 1957–58.

TABLE 11.—Austria: Exports of magnesia and magnesite brick by countries[1]

(Short tons)

Destination	Magnesia				Magnesite brick	
	Caustic-calcined		Refractory			
	1962	1963	1962	1963	1962	1963
North America: United States	1,032	749	54,113	50,548	8	207
South America:						
Argentina	44	----------	2,958	1,652	4,697	2,727
Brazil	45	44	33	26	949	1,030
Chile	----------	----------	456	617	821	981
Colombia	6	12	16	55	224	875
Europe:						
Belgium-Luxembourg	197	285	1,833	1,499	7,252	4,960
Bulgaria	----------	11	119	96	1,649	932
Czechoslovakia	3,614	3,833	1	50	1,219	258
Denmark	263	1,081	252	679	4,280	4,514
Finland	----------	----------	440	531	2,461	1,858
France	1,563	1,105	12,460	12,413	25,027	18,967
Germany, West	88,407	85,043	83,812	75,876	24,762	18,937
Greece	----------	----------	270	328	2,256	1,514
Hungary	2,441	2,880	10,389	13,032	----------	----------
Italy	4,408	4,441	22,493	10,758	12,829	11,059
Netherlands	164	354	111	416	1,059	1,212
Norway	22	11	576	452	3,867	4,738
Poland	----------	----------	13	----------	2,965	791
Portugal	19	11	360	481	2,990	1,180
Rumania	----------	----------	198	123	4,396	1,636
Spain	8	44	334	592	2,710	2,222
Sweden	754	933	1,657	1,278	10,054	9,287
Switzerland	3,385	3,266	716	450	2,156	2,055
United Kingdom	10	12	12,153	3,758	4,724	11,564
Yugoslavia	23	44	3	117	----------	1,205
Asia:						
India	----------	----------	217	436	1,146	335
Israel	----------	1	682	711	794	170
Turkey	----------	----------	62	26	1,019	244
Africa:						
Rhodesia and Nyasaland, Federation of	----------	----------	187	----------	4,796	2,773
South Africa, Republic of	----------	----------	5	73	1,147	1,519
United Arab Republic (Egypt)	----------	----------	223	881	736	665
Oceania: Australia	----------	----------	97	2,510	2,595	1,468
Other countries	78	90	1,079	638	3,569	6,171
Total	106,483	104,250	208,318	181,102	139,157	118,054

[1] This table incorporates some revisions.

TABLE 12.—Greece: Exports of magnesite and calcined magnesia, by countries

(Short tons)

Destination	Crude magnesite		Calcined magnesia	
	1962	1963	1962	1963
Canada	----------	----------	2,205	1,102
France	5,451	2,938	5,209	3,570
Germany, West	508	260	13,649	22,875
Italy	14,248	12,983	----------	----------
Netherlands	2,146	2,784	30,928	28,354
Poland	331	606	----------	----------
United Kingdom	3,147	2,872	6,559	8,325
United States	----------	----------	25,172	29,359
Other countries	2	2	5,471	7,494
Total	25,833	22,445	89,193	101,079

TABLE 13.—Netherlands: Exports of refractory magnesia, by countries [1]
(Short tons)

Destination	1962	1963
Belgium-Luxembourg	1,184	1,139
France	644	831
Germany, West	9,439	8,400
Italy	124	144
Other countries	22,321	28,948
Total	33,712	39,462

[1] This table incorporates some revisions.

OCEANIA

Australia.—A comprehensive report published by the South Australia Department of Mines reviewed the production, usage, distribution, and geology of limestone, dolomite, and magnesite in South Australia.[6]

Plans to construct a refractory specialties plant at Port Kembla were announced by Kaiser Refractories, Pty. Ltd.[7]

TECHNOLOGY

Research on physical properties of refractories related to the chemistry of the components aided development of higher grade products.

The heat content of magnesium oxide (periclase) was measured by the dropping method to obtain improved values of the heat and free energy of formation between 298° and 2,000° K. Periclase was considered a better substance for checking high-temperature measuring apparatus than corundum, which is commonly used.[8]

It was reported that by cold working or cyclic strain hardening of magnesium oxide (a technique of alternating stretching and compressing) the yield strength of the ceramics was increased from 12,000 pounds per square inch to 110,000 pounds per square inch at room temperature without loss of ductility.[9]

To evaluate the variance in published data on linear thermal expansion of magnesium oxide, the Bureau of Mines sent portions of a single sample of high-purity magnesium oxide to 21 laboratories for evaluation.[10] Five different methods were used. Three of the laboratories applied more than one method. The Bureau adjusted the values obtained from the laboratories and the previously published values to a single reference temperature of 25° C. The results were tabulated and plotted with procedural descriptions.

An article described technological innovations in open-hearth design required for higher temperatures and use of oxygen to meet

[6] Johns, R. K. Limestone, Dolomite and Magnesite Resources of South Australia. Geol. Survey of South Australia, Bull. 38, 1963, 100 pp.
[7] American Ceramic Society Bulletin. Out of the Kiln. Australian Plant. V. 42, No. 8, August 1963, p. 20a.
[8] Pankratz, L. B., and K. K. Kelley. Thermodynamic Data for Magnesium Oxide (Periclase). BuMines Rept. of Inv. 6295, 1963, 5 pp.
[9] American Metal Market. Strain Hardening Technique Improves Ceramics Strength. V. 70, No. 41, Mar. 1, 1963, p. 11.
[10] Campbell, William J. Thermal Expansion of Magnesium Oxide: An Interlaboratory Study. BuMines Rept. of Inv. 6115, 1962, 50 pp.

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demand for increased production.[11] Advantages in the use of high-purity (95 percent MgO) periclase brick were indicated.

The strength of a refractory was found to depend on the melting point of the bond.[12] Forsterite ($2MgO \cdot SiO_2$) with a melting point of 3,370° F made a satisfactory bond, but in the presence of a slag high in lime the forsterite was converted to monticellite ($MgO \cdot CaO \cdot SiO_2$) with a melting point of 2,700° F, and degraded the refractory. Since dicalcium silicate ($2CaO \cdot SiO_2$) melts at 3,860° F, the melting point of magnesium refractories was affected by the lime-to-silica ratio. The temperature of failure was lowest when the ratio approached one. As the ratio increased either way, the temperature of failure increased. High-purity magnesite, either alone or in combination with other high-purity minerals, produced better grade refractories than less pure magnesite. Tests of burned magnesite, magnesite-chrome, and chrome-magnesite refractories showed that the temperature of failure rose as the percentages of impurities decreased. Temperature of failure was further raised by adding a second oxide such as alumina (Al_2O_3) to form a solid-solution bond of spinel.

Calcined dolomite as a slag addition extended the life of basic linings in converters and other types of furnaces without changing the metal chemistry or increasing the difficulties in handling slag.[13] The magnesia in the slag retarded the slag in absorbing magnesia from the refractory.

By selective open-pit mining of a magnesite and associated brucite deposit, at Gabbs, Nev., a uniform grade of ore was maintained for the preparation of refractories. Selective mining was controlled by staking mining areas based on data obtained from a topographic map with overlays of isograms of lime and silica content.[14]

A 150,000-ton pillar of magnesite ore between 2 empty stopes was fragmented within one-half second by blasting 1,636 loaded long drill holes in 10 relays using millisecond delay detonators.[15]

A corrosive-resistant ceramic material of magnesium oxide was developed. Although an electric insulator it conducted heat. Crucibles of the material had little tendency to contaminate molten metal.[16]

Two continuous processes for producing magnesium hydroxide and calcium chloride brine from dolomite quicklime and magnesium chloride brine by heating and filtering were patented.[17]

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[11] Miller, C. H., and R. N. Ames. Refractories for Open Hearth Furnaces. Iron and Steel Eng., v. 40 No. 4, April 1963, pp. 140-151.

[12] Davies, Ben. High Purity Basic Refractories. Pres. at annual meeting of AIME, Dallas, Tex., Feb. 24, 1963, 21 pp.

[13] Steel. Magnesia Added to Slag for Longer Furnace Life. V. 153, No. 17, Oct. 21, 1963, pp. 115-117.

[14] Willard, H. P., and R. W. Gates. Selective Open Pit Mining Featured at Gabbs. Min. Eng., v. 15, No. 10, October 1963, pp. 44-46.

[15] Northern Miner (Toronto, Canada). Largest Underground Blast in History in Kilzmar. V. 36, No. 10, October 1963, p. 20.

[16] Steel. Insulating Ceramic Conducts Heat. V. 153, No. 17, Oct. 21, 1963, p. 115.

[17] Patton, Richard A., and Charles Baugh (assigned to Morton Salt Co.). Process for Producing Magnesium Hydroxide. U.S. Pat. 3,111,376, Nov. 19, 1963.

Patton, Richard A., Charles Baugh, and Jack F. Suriano (assigned to Morton Salt Co.). Production of Magnesium Hydroxide. U.S. Pat. 3,111,385, Nov. 19, 1963.

Manganese

By Gilbert L. DeHuff [1]

PRICES for manganese ore, alloy, and metal declined during 1963, and domestic production of manganese ore—ores, concentrates, and nodules, containing 35 percent or more manganese—continued its downward trend. Only 11,000 short tons was shipped in 1963. U.S. consumption of ore, on the other hand, was virtually the same as in 1962 and imports increased somewhat. Contracts were signed for the barter of surplus U.S. agricultural products for large quantities of manganese from India and Brazil.

LEGISLATION AND GOVERNMENT PROGRAMS

Financial assistance by the Office of Minerals Exploration remained available for the exploration of domestic manganese deposits to the extent of 50 percent of approved exploration costs.

Barter agreements for the procurement of manganese ore, alloy, and metal, in exchange for surplus U.S. agricultural products were a feature of the year. Details will be found in the World Review section under the countries involved—Brazil and India.

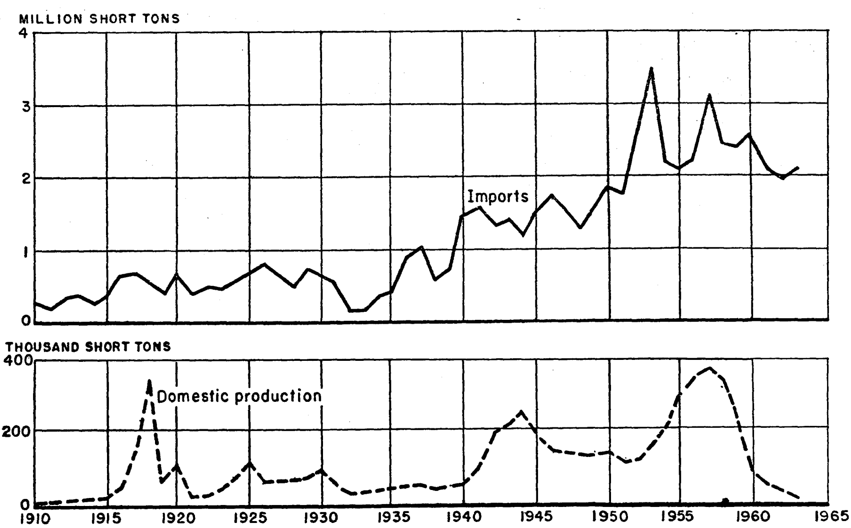

FIGURE 1.—General imports and domestic production (shipments) of manganese ore, 1910–63.

[1] Commodity specialist, Division of Minerals.

TABLE 1.—Salient manganese statistics in the United States

	1954–58 (average)	1959	1960	1961	1962	1963
Manganese ore (35 percent or more Mn):						
Production (shipments):[1]						
Metallurgical____short tons__	299,949	223,164	70,905	39,246	19,007	7,402
Battery________do____	[2] 6,391	6,011	9,116	6,832	5,729	3,220
Miscellaneous________do____	12	24	----------	10	22	----------
Total[1]________do____	306,352	229,199	80,021	46,088	24,758	10,622
Value________thousands__	$23,363	$17,904	$5,352	[3] $3,224	(4)	(4)
Imports, general_____short tons__	2,408,043	2,397,804	2,543,841	2,098,438	[3] 1,970,152	2,093,473
Consumption________do____	1,994,693	1,605,507	1,946,389	[3] 1,701,756	[3] 1,865,272	1,841,725
Manganiferous ore (5 to 35 percent Mn):						
Production (shipments)[1] short tons__	707,269	470,600	658,455	225,004	338,501	543,125
Value________thousands__	$4,227	$3,153	$4,466	$1,480	(4)	(4)
Ferromanganese:						
Production________short tons__	822,452	629,307	842,818	732,813	781,112	751,198
Imports for consumption__do____	136,821	90,062	120,222	221,936	[3] 126,716	148,630
Exports________do____	2,914	947	751	469	4,114	678
Consumption________do____	841,358	755,229	800,430	778,003	805,441	892,884

[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.
[2] Battery ore included in metallurgical in 1958.
[3] Revised figure.
[4] Combined value for total manganese ore and total manganiferous ores equals $4,268,000 in 1962, and $4,054,000 in 1963.

DOMESTIC PRODUCTION

Manganese ore—ores, concentrates, and nodules, containing 35 percent or more manganese—was produced only in New Mexico and Montana in 1963, the former being the leading producer by a small margin. Taylor-Knapp Co. at Philipsburg, Mont., continued to be the country's only producer of natural battery-grade ore; metallurgical (oxide) nodules continued to be shipped from stocks made from previously mined Montana carbonate ore.

Low-grade manganese ores containing 10 to 35 percent manganese were shipped from Minnesota, Montana, and New Mexico. All the Minnesota ore came from the Cuyuna range. Shipments of manganiferous iron ore, containing 5 to 10 percent manganese, were made only from Michigan.

TABLE 2.—Metallurgical manganese ore,[1] ferruginous manganese ore,[2] and manganiferous iron ore,[3] shipped in the United States, by States

(Short tons)

State	1962			1963		
	Metallurgical manganese ore	Ferruginous manganese ore	Manganiferous iron ore	Metallurgical manganese ore	Ferruginous manganese ore	Manganiferous iron ore
California	(4 5)					
Georgia		(4 6)				
Michigan						152,957
Minnesota		147,203	145,576		347,336	
Montana	19,007	2,264		2,040	1,688	
New Mexico	(4 5)	(4)		5,362	41,144	
Undistributed		5 43,458				
Total	19,007	192,925	145,576	7,402	390,168	152,957

1 Containing 35 percent or more manganese (natural).
2 Containing 10 to 35 percent manganese (natural).
3 Containing 5 to 10 percent manganese (natural).
4 Figure withheld to avoid disclosing individual company confidential data; included with "Undistributed."
5 A relatively small quantity of metallurgical ore produced in California and in New Mexico is included in ferruginous manganese ore, undistributed.
6 All miscellaneous.

TABLE 3.—Manganese and manganiferous ore shipped[1] in the United States in 1963, by States

Type and State	Short tons		Value (thousands)
	Gross weight	Manganese content	
Manganese ore:[2]			
Montana	5,260	2,517	(3)
New Mexico	5,362	2,548	$137
Total	10,622	5,065	(4)
Manganiferous ore:			
Ferruginous manganese ore:[5]			
Minnesota	347,336	42,307	(3)
Montana	1,688	548	(3)
New Mexico	41,144	4,814	$242
Total	390,168	47,669	(3)
Manganiferous iron ore:[6] Michigan	152,957	9,223	(3)
Total manganiferous ore	543,125	56,892	(4)

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, concentrates and nodules made from domestic ores.
2 Containing 35 percent or more manganese (natural). All metallurgical except 3,220 short tons of battery ore (concentrate), containing 1,304 tons of manganese, shipped from Montana.
3 Included in total.
4 Combined value for total manganese ore and manganiferous ores equals $4,053,961.
5 Containing 10 to 35 percent manganese (natural).
6 Containing 5 to 10 percent manganese (natural).

CONSUMPTION, USES, AND STOCKS

Domestic consumption of manganese ore decreased 1 percent from that of 1962, with domestic sources supplying less than 1 percent of the total. Industrial ore stocks decreased 3 percent from the beginning of the year to 1.7 million short tons at yearend.

In the production of steel ingots, 13.9 pounds of manganese was consumed as ferroalloys, metal, and direct-charged ore per short ton of open-hearth, bessemer, basic oxygen process, and electric steel produced. In 1962, 13.7 pounds per ton was consumed. Of the 13.9 pounds, 12.0 pounds was ferromanganese; 1.5 pounds, silicomanganese; 0.1 pound, spiegeleisen; and 0.3 pound, manganese metal.

As of September 1, 1963, the name of Union Carbide Metals Co. was changed to Union Carbide Corp., Metals Division.

Electrolytic Manganese and Manganese Metal.—Consumtion of manganese metal totaled 19,000 tons, compared with 15,000 tons in 1962. American Potash & Chemical Corp., Aberdeen, Miss.; Foote Mineral Co., Knoxville, Tenn.; and Union Carbide Corp., Metals Division, Marietta, Ohio, were the only producers of manganese metal, all of which was electrolytic. In addition to the conventional cathode chips, electrolytic manganese metal was marketed as powder and in massive lump form. The powdered metal found particular uses in powder metallurgy and in metallizing ceramics.

Ferromanganese.—Ferromanganese was produced in 17 plants of 11 companies, as follows: Bethlehem Steel Co., Johnstown, Pa.; E. J. Lavino & Co., Sheridan, Pa.; Manganese Chemicals Corp., Kingwood, W. Va.; Montana Ferro-Alloys Co., Inc., Woodstock, Tenn.; Ohio Ferroalloys Corp., Philo, Ohio; Pittsburgh Metallurgical Co., Calvert City, Ky., and Niagara Falls, N.Y.; Tennessee Products & Chemical Corp., Rockwood, Tenn.; Tenn-Tex Alloy & Chemical Corp., Houston, Tex.; Union Carbide Corp., Metals Division, Alloy, W. Va., Ashtabula, Ohio, Marietta, Ohio, Portland, Oreg., and Sheffield, Ala.; United States Steel Corp., Duquesne, Pa., and Birmingham (Ensley-Fairfield), Ala.; and Vanadium Corporation of America, Graham, W. Va. Manganese Chemicals Corp. made low-carbon ferromanganese by fused salt electrolysis at Kingwood, W. Va. The quantity of ferromanganese made in blast furnaces was approximately twice that made in electric furnaces. Shipments of ferromanganese totaled 802,000 tons valued at $125 million, compared with 728,000 tons valued at $134 million in 1962.

Silicomanganese.—Production of silicomanganese in the United States was 152,000 short tons, compared with 136,000 tons in 1962. Shipments from furnaces totaled 155,000 tons ($24.9 million), compared with 130,000 tons ($25.4 million) in 1962. Production was by 8 companies in 13 plants, showing no change from 1962. Consumption of silicomanganese was 16.1 percent that of ferromanganese, compared with 15.2 percent in 1962 and 14.4 percent in 1961.

Spiegeleisen.—The New Jersey Zinc Co., Palmerton, Pa., and Union Carbide Corp., Metals Division, Marietta, Ohio, continued to be the only producers of spiegeleisen. The New Jersey Zinc Co. completed conversion of its production from blast furnaces to electric

TABLE 4.—Consumption and stocks of manganese ore [1] in the United States

(Short tons)

Use and ore source	Consumption 1962	Consumption 1963	Stocks Dec. 31, 1963 [2] (including bonded warehouses)
Manganese alloys and manganese metal:			
Domestic ore	17,510		289
Foreign ore	1,720,184	1,683,450	1,633,601
Total	1,737,694	1,683,450	1,633,890
Steel ingots:			
Domestic ore			
Foreign ore	804	793	768
Total	804	793	768
Steel castings:			
Domestic ore			
Foreign ore	151	67	183
Total	151	67	183
Pig iron:			
Domestic ore			
Foreign ore	14,882	34,830	23,198
Total	14,882	34,830	23,198
Dry cells:			
Domestic ore	3,691	3,907	545
Foreign ore	29,934	23,963	11,847
Total	33,625	27,870	12,392
Chemicals and miscellaneous:			
Domestic ore	3,469	3,228	628
Foreign ore	[3] 74,647	91,487	42,063
Total	[3] 78,116	94,715	42,691
Grand total:			
Domestic ore	24,670	7,135	1,462
Foreign ore	[3] 1,840,602	1,834,590	1,711,660
Total	[3] 1,865,272	1,841,725	[4] 1,713,122

[1] Containing 35 percent or more manganese (natural).
[2] Excluding Government stocks.
[3] Revised.
[4] Excludes small tonnages of dealers' stocks.

furnace and started construction of a second electric furnace, to be completed in the spring of 1964.

Manganiferous Pig Iron.—In producing pig iron, furnaces used 568,000 short tons of manganese-bearing ores containing over 5 percent manganese (natural). Domestic sources supplied 455,000 tons and foreign sources, supplied 113,000 tons. The domestic ore included 310,000 tons of manganiferous iron ore containing 5 to 10 percent manganese (natural) and 145,000 tons of ferruginous manganese ore containing 10 to 35 percent manganese. The foreign ore consisted of 73,000 tons containing 5 to 10 percent manganese (natural), 5,000 tons containing 10 to 35 percent manganese, and 35,000 tons containing 35 percent or more manganese. Egypt supplied all the foreign ferruginous manganese ore, while Canada supplied all the foreign manganiferous iron ore.

TABLE 5.—Consumption, by end uses, and stocks of manganese ferroalloys and metal in the United States in 1963

(Short tons)

Use	Ferromanganese: High carbon	Ferromanganese: Medium and low carbon	Silicomanganese	Spiegeleisen	Manganese metal [1]	Briquets
Steel ingots:						
Stainless steel	663	2,515	5,705	16	7,865	
Other alloy steel	116,012	14,035	33,358	7,693	1,225	4
Carbon steel	664,308	54,231	83,614	14,567	4,975	
Other	391	130	360		41	
Total	781,374	70,911	123,037	22,276	14,106	4
Steel castings:						
Stainless steel	110	225	571		76	
Other alloy steel	8,740	1,362	4,959	296	49	25
Carbon steel	7,322	1,351	9,633	951	14	190
Other	2,997	173	645	121	6	
Total	19,169	3,111	15,808	1,368	145	215
Steel mill rolls	1,120	194	684	575		8
Gray and malleable castings	7,018	778	3,677	9,636		11,742
Alloys (includes welding rods)	7,711	859	882	53	4,738	3
Other	528	111			194	
Grand total	816,920	75,964	144,088	33,908	19,183	11,972
Stocks, Dec. 31: [2]						
Consumer	127,602	7,423	12,398	3,955	1,736	1,170
Producer	(3)	(3)	(3)	4,884	(3)	

[1] Virtually all electrolytic.
[2] Including bonded warehouses. Excluding Government stocks.
[3] Producer stocks of ferromanganese, silicomanganese, and manganese metal totaled 165,505 short tons.

TABLE 6.—Manganese materials in Government inventories as of December 31, 1963

(Thousand short tons, dry equivalent)

Type of material	Total	National (strategic) stockpile	DPA inventory	CCC and supplemental stockpile
Stockpile grade:				
Battery:				
Natural ore	282	144		138
Synthetic dioxide	25	21	4	
Chemical:				
Type A ore	147	29		118
Type B ore	101	2		99
Metallurgical ore	10,243	5,230	1,351	3,662
(Ferromanganese, standard high carbon) [1]	(847)	(143)		(704)
(Manganese metal, electrolytic) [1]	(11.0)	(1.7)	(5.3)	(4.0)
Nonstockpile grade: Metallurgical ore	2,334	621	1,706	7

[1] Gross weight of upgraded forms of manganese. Equivalent ore quantities are included in the stockpile-grade metallurgical ore figures.

Source: Office of Emergency Planning. Statistical Supplement, Stockpile Report to the Congress. OEP-4, July–December 1963, pp. 15–17, 31.

Battery and Miscellaneous Industries.—Manufacturers of dry-cell batteries used 28,000 tons of manganese ore containing more than 35 percent manganese (natural), of which 4,000 tons was of domestic origin.

Chemicals and miscellaneous industries used 95,000 tons of manganese ore containing 35 percent or more manganese, of which 3,000

TABLE 7.—Ferromanganese produced in the United States and metalliferous materials [1] consumed in its manufacture

Year	Ferromanganese produced			Materials consumed			Manganese ore used per ton of ferromanganese made (short tons)
	Gross weight (short tons)	Manganese content		Manganese ore (35 percent or more Mn natural) (short tons)		Iron and manganiferous iron ores (short tons)	
		Percent	Short tons	Foreign	Domestic		
1954–58 (average)	822,452	76.8	631,564	[2] 1,731,563	[2] 44,120	2,375	[2] 2.2
1959	629,307	77.3	486,549	1,275,138	3,829	3,935	2.0
1960	842,818	77.7	654,825	[2] 1,801,038	[2] 17,819	1,821	[2] 2.2
1961	732,813	77.3	566,432	[3] 1,577,519	[3] 9,446	1,685	[2] 2.1
1962	781,112	77.2	602,854	[2] 1,673,227	[2] 17,417	96	[2] 2.2
1963	751,198	77.2	579,852	[2] 1,617,112	(2)	------------	[2] 2.2

[1] Excluding scrap and other secondary materials.
[2] Includes ore used in producing silicomanganese (in the 1954–58 period, for 1955 only).
[3] Includes ore used in producing silicomanganese and metal.

TABLE 8.—Manganese ore used in producing ferromanganese and silicomanganese in the United States, by source of ore

Source	1962		1963	
	Gross weight (short tons)	Mn content, natural (percent)	Gross weight (short tons)	Mn content, natural (percent)
Domestic	17,417	56.5	------------	------------
Foreign:				
Africa	525,349	46.0	755,936	46.1
Brazil	438,355	46.6	374,966	46.2
British Guiana	131,172	42.5	83,909	40.5
Chile	4,509	44.3	4,040	45.4
Cuba	12,950	41.0	16,709	38.9
India	260,530	45.2	161,931	45.4
Mexico	195,737	43.1	113,292	42.3
Philippines	3,492	47.7	10,201	39.8
Other or unidentified	101,133	------------	96,128	------------
Total	1,690,644	45.4	1,617,112	45.3

tons was from domestic sources. The domestic ore and much of the foreign ore would not have met National Stockpile Specification P–81–R for chemical-grade ore. Revisions in foreign ore consumption figures for 1962 and 1961 to 75,000 and 69,000 short tons, respectively, make the total manganese ore consumed by chemicals and miscellaneous industries 78,000 and 75,000 tons, respectively, for those years.

PRICES

Manganese Ore.—All prices for manganese ores are negotiated prices, depending in part on quality and quantity of ore offered, delivery terms, and fluctuations in shipping rates. Commercial short-term delivery prices for metallurgical manganese ore containing 46 to 48 percent manganese, c.i.f. eastern seaboard and gulf ports, were quoted by the American Metal Market as dropping through the year to 60 to 65 cents, nominal, per long ton unit of manganese, import duty extra.

Manganese Alloys.—The average value at producers' furnaces for ferromanganese shipped was $155.93 per short ton, compared with $184.62 in 1962. By February 1, quotations for domestically produced standard high-carbon ferromanganese containing 74 to 76 percent manganese had dropped 1 cent to 8.5 cents per pound of alloy, or $170 per short ton, lump bulk, carload lots, f.o.b. furnaces. This was later designated as nominal, indicating some variations for actual transactions. E&MJ Metal and Mineral Markets continued to quote imported ferromanganese of the same grade, delivered at Pittsburgh, at $158 per long ton. This quotation also was qualified as nominal after March. Effective January 25, the price of speigeleisen containing 19 to 21 percent manganese was cut $6 to $84 per long ton, carlots, f.o.b. Palmerton, Pa. It remained at this price for the remainder of the year.

Manganese Metal.—Effective December 2, the prices for the standard grade of electrolytic manganese metal were decreased 3.25 cents per pound from those which had carried over from 1962. Variations in price continued for different packing, quantities, and special grades. For leading items the new prices became 28.75 cents for carlots and 31.25 cents for ton lots packed in steel drums; palletized or bulk shipments were 28 cents for carlots and 30.5 cents for ton lots. Premiums above the standard prices were maintained at 0.75 cent per pound for hydrogen-removed metal and 4.75 cents per pound for the 5.5 plus percent nitrogen grades of metal.

FOREIGN TRADE

Imports.—The average grade of imported manganese ore was 47.3 percent, the same as in 1962. Brazil again supplied 42 percent of the total ore received; Congo (Leopoldville), 11 percent; Gabon, 10 percent; India, 8 percent; Mexico, 7 percent; Republic of South Africa, 6 percent; and Ghana, 5 percent. Effective August 31, 1963, imports of manganese ore containing 35 percent or more manganese were no longer classified as metallurgical, battery, and chemical grades. Instead, the new statistical classification of the tariff schedules provided a better defined breakdown, based entirely on manganese content: (1) Manganese ores containing 35 percent or over but less than 47 percent manganese, and (2) those containing 47 percent or more manganese.

General imports of ore containing more than 10 percent but less than 35 percent manganese totaled 8,258 short tons. Of this quantity, 6,586 tons was from Ghana and 1,672 tons from Mexico. Imports for consumption totaled 8,235 tons which came from the following countries: Ghana, 3,720 tons; Brazil, 2,413 tons; Mexico, 1,672 tons; and Sudan, 430 tons.

Imports for consumption of ferromanganese totaled 148,630 short tons, 17 percent more than in 1962. Almost all of the imports were commercial, little went to government stockpiles. Imports for consumption of silicomanganese totaled 14,429 short tons (manganese content). Norway supplied 3,957 tons; Japan, 3,192 tons;

Yugoslavia, 2,556 tons; Mexico, 2,493 tons; Spain 1,493 tons; Belgium-Luxembourg, 716 tons; and West Germany, 22 tons. Manganese metal imports for consumption were 2,361 short tons, of which 1,476 tons was from Japan and 885 tons was from the Republic of South Africa. As revised, 1962 manganese metal imports for consumption totaled 1,504 short tons instead of the previously reported 1,989 tons. This was the result of a correction in the reported imports for consumption from the Republic of South Africa to 490 instead of 975 tons. There were no imports for consumption of spiegeleisen in 1963.

Exports.—Ferromanganese exports totaled 678 short tons valued at $155,000, compared with 4,114 tons valued at $629,000 in 1962 and 469 tons valued at $146,000 in 1961. This export classification included silicomanganese. Exports classified as "manganese metal and alloys in crude form and scrap," believed to be almost entirely electrolytic manganese metal, were 2,062 tons valued at $1,229,000, compared with 2,201 tons valued at $1,431,000 in 1962 and 2,234 tons valued at $1,327,000 in 1961. Spiegeleisen exports in 1963 were 1,176 tons valued at $90,000. Canada received 1,146 tons and Italy, 30 tons. Exports classified as "manganese ore and concentrates containing 10 percent or more manganese" totaled 8,296 tons valued at $926,000. They were believed to consist almost entirely of imported manganese dioxide ore exported after grinding, blending, or otherwise classifying.

Tariff.—Duty on manganese ore from most countries continued at 0.25 cent per pound of contained manganese; ore from the Philippines was exempt from duty. Ore from the U.S.S.R. and certain associated countries remained dutiable at 1 cent per pound of contained manganese.

WORLD REVIEW

NORTH AMERICA

Costa Rica.—A test shipment of 600 tons of manganese ore was shipped to Japan from deposits in the Nicoya Peninsula.[2]

Cuba.—A trade agreement was signed with Czechoslovakia to increase trade between the two countries by 45 percent. Manganese is one of several ores to be supplied by Cuba under the agreement.[3] The Charco Redondo mine, renamed the Harlem, was reported to be producing metallurgical manganese in 1963 at its planned capacity rate of 66,000 short tons per year. The Bueycito, Ponupo, El Cristo, and Cambute mines produced both chemical and metallurgical manganese. The chemical grade was produced at an annual rate of 3,600 short tons. The Bueycito and Cambute mines produced most of the chemical-grade material, and relatively little of the metallurgical. The metallurgical product from the Ponupo contained 39 percent manganese; that from El Cristo, 41 percent. The former Bethlehem Steel Company's Felton nodulizing plant, now "Porfirio Hechavarria Santos," reportedly produced 61,000 tons of manganese nodules in 1962, compared with 74,000 tons in 1961.[4]

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[2] Mining Journal (London). V. 261, No. 6687, Oct. 18, 1963, p. 368.
[3] Mining Journal (London). V. 260, No. 6656, Mar. 15, 1963, p. 257.
[4] Hagan Mary. Cuba Fights To Regain Increased Mine Output. Eng. and Min. J., v. 164, No. 10, October 1963, pp. 80, 82.

TABLE 9.—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	
	Gross weight		Mn content		Gross weight		Mn content			
	1962	1963	1962	1963	1962	1963	1962	1963	1962	1963
North America:										
Guatemala	310		170		310		170		$15,516	
Mexico	133,629	147,607	59,876	66,930	135,828	145,390	60,899	65,922	3,897,010	$4,278,712
Total	133,939	147,607	60,046	66,930	136,138	145,390	61,069	65,922	3,912,526	4,278,712
South America:										
Brazil [3]	823,714	875,576	398,129	412,190	887,441	929,419	428,036	438,421	31,504,474	28,487,662
British Guiana [4]	145,188	105,655	61,087	45,141	43,490	115,216	18,805	51,019	945,390	2,530,948
Chile	4,970	1,784	2,203	749	4,970	1,784	2,203	749	127,935	32,005
Peru	6,070	4,025	2,553	1,767	1,461	8,400	643	3,593	37,501	139,766
Total	979,942	987,040	463,972	459,847	937,362	1,054,819	449,687	493,782	32,615,300	31,190,381
Europe:										
Greece	2,873	6,445	1,379	3,068	1,565	6,445	750	3,068	85,817	331,780
Sweden		92		46		92		46		4,182
Total	2,873	6,537	1,379	3,114	1,565	6,537	750	3,114	85,817	335,962
Asia:										
Goa [5]		2,369		1,096						
India	[6] 177,820	169,267	[6] 81,263	77,314	[6] 201,678	232,992	[6] 93,068	106,175	[6] 5,233,044	5,239,105
Philippines	7,459		3,402		7,459		3,402		169,138	
Turkey	6,970	4,443	3,298	2,087	6,942	7,596	3,300	3,532	227,030	207,699
Total	[6] 192,249	176,079	[6] 87,963	80,497	[6] 216,079	240,588	[6] 99,770	109,707	[6] 5,629,212	5,446,804

Africa:										
Angola [7]	1,378	45,752	758	22,118	21,627	52,813	10,861	25,703	610,551	1,393,418
British East Africa	----	----	----	----	----	345	----	195	----	15,302
Congo, Republic of the, and Ruanda-Urundi	88,157	234,044	42,716	117,296	97,242	246,755	47,361	122,723	2,717,186	7,299,495
Ethiopia	6,936	3,854	3,468	1,978	6,936	3,854	3,468	1,978	255,581	147,063
Ghana	204,245	102,047	103,714	52,345	229,733	184,309	115,067	93,349	8,703,310	5,975,538
Morocco	125,003	38,221	66,275	20,097	121,974	40,906	64,670	21,621	6,496,493	1,943,327
Portugese Western Africa, n.e.c	----	----	----	----	----	7,913	----	3,739	----	216,564
Rhodesia and Nyasaland, Federation of	10,800	3,550	5,405	1,792	12,558	3,550	6,277	1,792	400,970	126,986
South Africa, Republic of	195,804	120,568	81,496	50,406	[6] 169,560	239,064	[6] 71,998	99,284	[6] 3,901,037	5,026,432
United Arab Republic (Egypt)	----	----	----	----	13,160	----	6,380	----	555,111	----
Western Africa, n.e.c.[8]	11,019	12,622	5,069	6,311	----	12,622	----	6,311	----	360,000
Western Equatorial Africa, n.e.c.[9]	17,807	215,552	8,727	108,253	38	150,055	20	74,889	1,770	3,649,534
Total	661,149	776,210	317,628	380,596	[6] 672,878	942,186	[6] 326,102	451,584	[6] 23,642,009	26,153,659
Oceania:										
Australia	----	----	----	----	3,986	----	2,012	----	174,528	----
British Western Pacific Islands	----	----	----	----	1,591	----	764	----	29,741	----
Total	----	----	----	----	5,577	----	2,776	----	204,269	----
Grand total	[6] 1,970,152	2,093,473	[6] 930,988	990,984	[6] 1,969,549	2,389,520	[6] 940,154	1,124,109	[6] 66,089,133	67,405,518

[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 material withdrawn from bonded warehouses.

[3] 1963 data adjusted by Bureau of Mines to include material reported by the Bureau of the Census from Uruguay.

[4] 1963 data adjusted by Bureau of Mines to include material reported by the Bureau of the Census from Trinidad and Tobago.

[5] Reported by the Bureau of the Census as Southern and Southeastern Asia, n.e.c. believed to be Goa by the Bureau of Mines.

[6] Revised figure.

[7] 1962 data adjusted by the Bureau of Mines to include material reported by the Bureau of the Census from Belgium-Luxembourg.

[8] Believed to be Ivory Coast.

[9] Believed to be Gabon.

Source: Bureau of the Census.

TABLE 10.—U.S. imports for consumption of ferromanganese, by countries

Country	1962			1963		
	Gross weight (short tons)	Mn content (short tons)	Value	Gross weight (short tons)	Mn content (short tons)	Value
North America:						
Canada	180	135	$29,127			
Mexico	1,549	1,236	196,815	1,420	1,094	$146,476
Total	1,729	1,371	225,942	1,420	1,094	146,476
South America:						
Brazil	5,496	4,231	637,856			
Chile	5,852	4,534	940,318	8,571	6,491	1,257,584
Total	11,348	8,765	1,578,174	8,571	6,491	1,257,584
Europe:						
Belgium-Luxembourg	[1] 4,927	[1] 3,751	[1] 590,946	8,882	6,764	1,020,077
France	46,035	35,403	[1] 5,759,833	42,595	32,791	5,030,875
Germany, West	23,044	17,671	2,658,997	47,866	36,724	4,767,124
Italy	263	217	52,693	440	353	82,000
Norway	1,175	894	127,486			
Spain				6,834	5,307	672,800
Yugoslavia	2,688	2,089	324,450	220	173	21,796
Total	[1] 78,132	[1] 60,025	[1] 9,514,405	106,837	82,112	11,594,672
Asia:						
India	7,538	5,702	1,166,690	2,883	2,196	278,298
Japan	11,946	9,707	2,426,943	8,987	7,263	1,631,828
Total	19,484	15,409	3,593,633	11,870	9,459	1,910,126
Africa:						
Mozambique				1,120	840	107,850
South Africa, Republic of	16,023	12,300	1,844,679	18,812	15,381	1,957,032
Total	16,023	12,300	1,844,679	19,932	16,221	2,064,882
Grand total	[1] 126,716	[1] 97,870	[1] 16,756,833	148,630	115,377	16,973,740

[1] Revised figure.

Source: Bureau of the Census.

TABLE 11.—World production of manganese ore by countries [1 2]

(Short tons)

Country [1]	Percent Mn [3]	1954–58 (average)	1959	1960	1961	1962	1963
North America:							
Costa Rica (exports)	35+						661
Cuba	36–50+	209,604	[4] 58,806	[5] 17,644	[3 4] 46,000	[3] 83,000	[3] 83,400
Mexico [3]	44–46	190,800	181,900	171,400	155,900	184,900	189,300
Panama		[6] 3,321					
United States (shipments)	35+	306,352	229,199	80,021	46,088	24,758	10,622
Total [3]		710,077	469,905	269,100	248,000	292,700	284,000
South America:							
Argentina	30–40	19,174	21,358	24,251	[3] 22,000	11,253	[3] 11,000
Bolivia (exports)					53	291	
Brazil	38–50	548,081	1,138,649	1,101,387	1,120,336	1,290,461	[3] 1,320,000
British Guiana	40–42			123,811	216,203	303,636	157,331
Chile	40–50	48,646	42,744	50,594	35,012	47,578	51,235
Peru	40+	9,473	2,803	1,655	3,879	7,403	1,089
Venezuela	38+	[7] 17,429	3,955				
Total		642,803	1,209,509	1,301,698	1,397,483	1,660,622	[3] 1,540,700

See footnotes at end of table.

TABLE 11.—World production of manganese ore by countries [1] [2]—Continued

Country [1]	Percent Mn [3]	1954-58 (average)	1959	1960	1961	1962	1963
Europe:							
Bulgaria	30+	62,189	28,700	27,600	40,800	38,600	42,400
Greece	35+	18,826	38,581	34,410	31,195	[3] 33,100	[3] 22,000
Hungary	30−	146,250	170,086	135,888	137,610	142,447	[3] 132,300
Italy	30−	53,969	57,520	54,561	54,196	49,053	49,920
Portugal	35+	6,009	7,703	8,197	12,492	12,666	[3] 20,500
Rumania	35	278,628	216,910	192,872	227,076	208,337	[3] 220,500
Spain	30+	41,975	44,924	24,586	17,092	14,101	16,631
U.S.S.R. [8]	-------	5,463,900	6,080,300	6,472,800	6,583,000	7,057,000	[3] 7,385,000
Yugoslavia	30+	6,159	8,911	14,676	15,595	16,357	8,964
Total [1]	-------	6,077,905	6,653,635	6,965,590	7,119,056	7,571,661	[3] 7,898,000
Asia:							
Burma	42+	1,539	606	324	196	213	[3] 220
China [3]	30+	556,000	1,100,000	1,320,000	880,000	880,000	1,100,000
Goa	32-50	147,498	83,584	118,195	109,790	96,732	[4] 115,290
India	35+	1,712,337	1,298,472	1,321,411	1,355,868	1,306,914	1,184,983
Indonesia	35-49	58,495	47,172	12,026	14,007	5,460	[3] 1,700
Iran [9]	30+	4,752	2,425	8,488	2,315	2,205	[3] 1,100
Japan	32-40	272,289	383,699	357,131	335,236	340,162	305,506
Korea, Republic of	30-48	2,312	496	1,521	1,518	1,105	4,580
Malaya	30+	-------	-------	3,222	7,130	341	7,696
Pakistan	42+	-------	32	327	386	15	-------
Philippines	35-51	17,253	38,365	19,159	20,986	13,160	6,769
Thailand	40+	[7] 645	452	582	588	3,194	7,186
Turkey	30-50	5,292	39,341	31,112	33,069	23,422	6,949
Total [3]	-------	2,778,000	2,995,000	3,193,000	2,761,000	2,673,000	2,742,000
Africa:							
Angola	38-48	31,483	39,314	25,728	22,695	9,115	-------
Bechuanaland	30+	[6] 7,228	20,138	25,032	31,737	26,458	11,878
Congo, Republic of the (formerly Belgian)	48+	414,771	425,694	420,671	350,208	329,568	348,547
Ethiopia	51	-------	1,455	10,202	7,716	6,614	-------
Gabon, Republic of	50-52	-------	-------	-------	-------	224,038	701,716
Ghana (exports) [10]	48	622,902	577,694	600,261	431,282	513,622	434,410
Ivory Coast	38+	-------	-------	67,917	137,502	139,265	153,291
Morocco	35-50	470,829	518,711	532,508	629,512	517,377	369,283
Rhodesia and Nyasaland, Federation of:							
Northern Rhodesia	30+	33,425	60,297	59,299	56,901	51,501	38,856
Southern Rhodesia	30+	1,292	2,126	1,676	205	7,977	-------
South Africa, Republic of	30+	784,525	1,069,202	1,316,132	1,562,729	1,614,599	1,441,503
South-West Africa	45+	65,184	49,442	67,439	50,295	-------	-------
Sudan [3]	36-44	[7] 7,700	440	-------	-------	-------	-------
United Arab Republic (Egypt) [11]	35+	15,504	67,318	22,046	2,272	42,577	53,628
Total	-------	2,454,843	2,831,831	3,148,911	3,283,054	3,482,711	3,553,112
Oceania:							
Australia	45-48	60,827	100,768	67,923	97,901	77,851	[3] 40,500
Fiji	40+	23,001	14,566	13,073	3,869	1,202	3,621
New Hebrides	52-55	-------	-------	-------	5,060	21,859	28,016
New Zealand	48+	155	114	134	-------	-------	-------
Papua	46	8	-------	54	2	-------	4
Total	-------	83,991	115,448	81,184	106,832	100,912	[3] 72,100
World total (estimate) [1]	-------	12,748,000	14,275,000	14,959,000	14,915,000	15,782,000	16,090,000

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 165,000 short tons and Sweden approximately 11,000 tons the last 5 years.

2 This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

3 Estimate.

4 Exports.

5 United States imports.

6 Average annual production 1957-58.

7 Average annual production 1956-58.

8 Grade unstated. Source: The Industry of the U.S.S.R., Central Statistical Administration (Moscow).

9 Year ending March 20 of year following that stated.

10 Dry weight.

11 In addition to high-grade ore shown in the table, Egypt produced the following tonnages of less than 30 percent manganese content: 1954-58 (average), 154,816; 1959, 72,752; 1960, 282,191; 1961, 304,663; and 1962, 162,102.

SOUTH AMERICA

Brazil.—Contracts were signed by the Office of Barter and Stockpiling, Foreign Agricultural Service, U.S. Department of Agriculture, for barter of surplus U.S. agricultural products for approximately 200,000 short tons of Brazilian metallurgical manganese ore plus enough additional Brazilian ore to produce 23,500 tons of standard high-carbon ferromanganese in the United States. Deliveries were to be completed within 1 year of contract dates.

Chile.—Manganese ore produced in 1962, mostly from Coquimba Province, had an average grade of 45.6 percent manganese. Manganesos Atacama, S.A., produced 26,000 short tons from its Corral Quemado mines. Cía Manganesos Chile, an affiliate of Cía. Minera Santa Fe (controlled by Minerals and Chemicals—Phillipp Corporation), was the second largest producer, with 21,000 tons. The remaining production was from small mines selling mostly to the State-owned Empresa Nacional de Minería. Most of the year's production was used to make ferromanganese for export to the United States under the 1961 barter agreement. Fábrica Nacional de Carburo y Metalurgia S.A. made 15,000 tons of ferromanganese, while Manganesos Atacama S.A. produced 3,500 tons in 1962.

Peru.—Manganese ore produced in 1963 averaged 42 percent manganese and came entirely from the Gran Bretaña mine at an elevation of 13,500 feet in the Central District of Peru. Exports were 950 short tons.

EUROPE

France.—Ferromanganese production was 302,000 short tons in 1961 and 273,000 in 1960.[5]

U.S.S.R.—The Soviet Union supplied 119,000 short tons of manganese ore to the United Kingdom in 1963, making it the latter's largest single source of ore for the year. The U.S.S.R. contributed 35 percent of total British imports.[6]

United Kingdom.—A new company, Berk Leiner Ltd., was formed by F. W. Berk and Co. Ltd. and P. Leiner and Sons (Wales) Ltd. to produce electrolytic manganese dioxide in a plant to be erected at Treforest, Glamorgan. Production was expected to begin by the end of 1963.[7]

ASIA

Goa.—The Indian Tariff, Import and Export (Control), and Mines Acts became applicable to Goa, October 1, 1963; at the same time restrictions were removed on the movement of goods to and from India.[8] Taxes, including income taxes, of the Indian Government became applicable to Goan manganese mining operations on April 1, 1963.

Production of ferruginous manganese ore in 1962 totaled 230,000 short tons and exports amounted to 111,000 short tons. These exports averaged 25 to 35 percent manganese, 20 to 30 percent iron, 1 to 7 percent silica, 0.02 to 0.07 percent phosphorus, and 3 to 9

[5] Bureau of Mines. Mineral Trade Notes. V. 57, No. 1, July 1963, p. 31.
[6] Metal Bulletin (London). No. 4873, Feb. 18, 1964, p. 19.
[7] Metal Industry (London). V. 103, No. 13, Sept. 26, 1963, p. 420.
[8] Bureau of Mines. Mineral Trade Notes. V. 58, No. 1, January 1964, p. 47.

percent water. Manganese ore produced in 1962 contained more than 35 percent manganese.

India.—High production costs of Indian ferromanganese placed producers at a disadvantage in competing for world markets. Ore, coal, electric power, and railway freight charges accounted for 80 percent of total costs. All four of these items were under the control of the Government in 1963.[9] The annual productive capacity of India's ferromanganese industry was rated at 187,000 short tons at the end of 1962. Production for that year was approximately 65 percent of capacity, and local consumption was estimated by the Indian Bureau of Mines at 50,000 tons.[10] Beginning October 1, 1963, a new, Government-owned company, Minerals and Metals Trading Corporation of India Ltd., (MMTC), took over the personnel, assets and liabilities of the State Trading Corporation, as they pertained to the minerals and metals trade. This included its manganese ore export business.[11]

June 27, 1963, a government-to-government bilateral barter agreement was signed by the Governments of India and the United States. Under terms of the agreement, U.S. cotton and other surplus agricultural products will be exchanged for approximately 143,000 short tons of high-carbon ferromanganese and 336,000 tons of Indian manganese ore. The ore is to be processed in the United States into 155,000 tons of high-carbon ferromanganese and 10,000 tons of manganese metal. Deliveries are to be effected within 18 months of contract dates. By the end of the year, 17 of a total of 23 contracts implementing this agreement had been signed by the Office of Barter and Stockpiling, Foreign Agricultural Service, U.S. Department of Agriculture. Nine were for ferromanganese produced in India and eight for ferromanganese produced in the United States. The contractors dealt originally with India's State Trading Corporation with regards to the Indian portion of the exchange. This function of the Corporation was later assumed by the MMTC. Barter transactions between Indian and foreign private firms to export manganese ore in exchange for steel and other items (so-called "link deals") also became the interest of the MMTC.

Due to its comparatively high price Indian manganese ore met strong competition from other producing countries, particularly for ores containing less than 46 percent manganese. The situation was attributed to the burdens imposed in the form of royalty charges, taxes, railway freight and port charges, and government trading commission charges. As a result, increasing emphasis was placed on barter and link deals. It was estimated that from 40 to 50 percent of the ore produced contained less than 46 percent manganese. Of the ore produced in 1963, 341,000 tons contained less than 35 percent manganese.

Railway operations improved throughout the year. It was announced in December that, except for Assam, for the first time in many years, the country's entire rail system was free of restrictions on movements.

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[9] Journal of Mines, Metals, & Fuels (Calcutta, India). V. 11, No. 8, August 1963, p. 24.
[10] Bureau of Mines. Mineral Trade Notes. V. 57, No. 6, December 1963, pp. 16–17.
[11] Bureau of Mines. Mineral Trade Notes. V. 57, No. 6, December 1963, p. 45.

Iran.—A Council of Ministers Decree, dated September 8, 1963, provided for payment of government subsidies amounting to 20 percent of the f.o.b. price for certain specified ore exports, including manganese ore. Ninety percent of the subsidy was to be paid direct to the exporter, the balance going to the Minister of Economy for use in promoting exports.

Pakistan.—Pakistan Mineral Miners Ltd. mined manganese ore in the Las Bela district, 23 miles inland from the coast in the hills 93 miles northwest of Karachi. The ore was hard and required blasting. Shipments had at least 44 percent manganese, approximately 15 percent silica, 2.5 percent or less iron, and 0.015 percent phosphorus; other impurities were low. The company also planned to produce manganese dioxide of 85 percent grade.[12]

Philippines.—Battery-grade manganese ore was reported to have been produced by Philippine Manganese, Inc., in the second and fourth quarters of 1963. Second-quarter production was 370 short tons, and fourth-quarter production was 330 short tons. The company is the only producer of battery-grade ore, and all of its product went to domestic battery manufacture. Incomplete reports show metallurgical ore to have been produced in 1963 by Zambales Base Metals, Inc., and Fernandez Hermanos, Inc. Part of the production was exported and part was used in the Philippines to make ferromanganese. General Base Metals, Inc., was not a producer in 1963. Total stocks at the end of the year consisted of 6,700 tons of metallurgical ore and 550 tons of battery ore. At the end of 1962 the respective inventories were 5,500 and 40 tons.

Thailand.—Increased demand for battery-grade manganese ore followed the establishment of new plants for the manufacture of dry cells in Thailand. A substantial increase in battery ore production resulted for 1962. Exports of 440 short tons in 1962 were more than 3 times those of 1961.[13]

Turkey.—All manganese ore mining activity was reported to have come to a halt by the end of 1963.

AFRICA

Bechuanaland.—In the second half of 1962, problems with overburden put an end to mining at the Kwakgwe open pit of Marble Lime & Associated Industries, Ltd. in the Bangwaketse Tribal Territory. This left the mine virtually on a standby basis although underground mining had been resumed in July. The Ootse mine of Bamelete Manganese (Pty.) Ltd. was responsible for the greater part of Bechuanaland's manganese ore production for 1962. In addition to reported production, this mine produced approximately 12,600 tons of subgrade material which could be jigged to ore grade.[14]

Congo, Republic of the.—The Benguela Railway carried 295,000 short tons of Katangan manganese ore 838 miles through Angola to the port of Lobito in 1963.[15] Société de Recherche Minière du Sud

[12] Metal Bulletin (London). No. 4866, Jan. 24, 1964, p. 21.
[13] Bureau of Mines. Mineral Trade Notes. V. 58, No. 2, February 1964, p. 23.
[14] South African Mining and Engineering Journal (Johannesburg, Republic of South Africa). V. 74, pt. 2, No. 3690, Oct. 25, 1963, p. 1141.
[15] Skilling's Mining Review. V. 53, No. 10, Mar. 7, 1964, p. 10.

Katanga, controlled by Union Minière, produced 5,000 tons of manganese ore in 1962, averaging 54 percent manganese. Production was halted in the first half of 1963 because of excess stocks and unfavorable prices. The balance of the Congo's 1962 production was by Société Minière de Kisenge (formerly Beceka-Manganese) and averaged 47 percent manganese. The Kisenge work force in 1963 totaled 433, of which 39 were Europeans.

Ethiopia.—Approximately 20,000 tons of high-grade manganese have been shipped in the past 4 years from a deposit in the Ralph M. Parsons Co. concession in the Danakil Depression. The ore was trucked 85 miles from Enkafala, approximately 12 miles southwest of Dallol, to the port of Mersa Fatma from which it was transported in small boats to Massawa, Eritrea, for shipment to Houston, Tex.[16]

Gabon.—The manganese ore reserve at Moanda was approximately 200 million tons of merchantable ore, averaging 48 percent or more manganese, contained in 450 million tons of crude ore as explored on three plateaus—Bangombe, Okouma-Bafoula, and Massengo—covering 35 to 40 square miles. The richest zones of the Bangombe and Okouma-Bafoula plateaus cover 5 square miles and contain 75 million tons of merchantable ore. Initial mining operations have been from Bangombe. Since July 1963, battery-grade product containing 83 percent manganese dioxide has been produced from 5- to 20-millimeter material provided by the washer. This is reduced to 1 millimeter and then concentrated on a battery of 12 shaking tables. This concentrating plant is near the head of the aerial tramway which starts all shipments on their way to the port of Point Noire. Storage capacity is 175,000 short tons at the port, and ships can be loaded at the rate of 1,100 tons per hour.[17] Preliminary export figures for 1963, the first full year of operation, showed that 391,000 short tons went to the United States, 120,000 to France, 85,400 to West Germany, 32,000 to Japan, 3,300 to Spain, and 2,200 to Italy.

Ghana.—In 1963, exports of battery-grade ore were 28,000 short tons, averaging 50 percent manganese; metallurgical-grade ore exports were 406,000 tons, averaging 42 percent manganese. Battery- and chemical-grade manganese ore exported in 1962 totaled 31,000 short tons; metallurgical ore containing more than 30 percent manganese amounted to 482,000 tons; and that containing less than 30 percent manganese amounted to 20,000 tons.

Guinea.—A manganese deposit of some importance was reported to have been discovered in 1962 or early 1963 approximately 150 miles north-northwest of Conakry.[18]

Morocco.—Operations of the Tiouine mine ended in 1962 because of depletion of reserves. Most of the Moroccan chemical ore and half of the metallurgical ore produced in that year came from the Imini mine. Other producers of significance were Bou Arfa, Tiaratine, and Tisgui-Lilane.[19] Of the manganese ore produced in 1962, 110,000 short tons was chemical grade and the balance metallurgical grade. Highly competitive market conditions resulting from entry of new

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16 Quinn, Harold A. Geology and Mining in Ethiopia. World Min., v. 17, No. 3, March 1964, p. 32.
17 Vigier, René. L'Exploitation de la Mine de Manganese de Moanda (Gabon) (Exploitation of the Moanda Manganese Mine (Gabon)). Annales des mines (Paris, France), September 1963, pp. 529–548.
18 Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, p. 38.
19 Mining Journal (London). V. 261, No. 6678, Aug. 16, 1963, p. 151.

high-grade ore sources into world markets, coupled with the end of U.S. stockpile purchases of Moroccan ore, were held responsible for a sharp drop in production in 1963. By the end of August, employment was down to 2,918 from 3,785 at the beginning of the year.

Rhodesia and Nyasaland, Federation of.—The record increase in Southern Rhodesia's production of manganese ore in 1962 was the result of the mining of newly discovered manganese seams in shales of the Sinoia district northwest of Salisbury. These deposits apparently were mined out within the year, however. The Chiwefwe and Kampumba mines of Gypsum Industries Ltd., a Salisbury company, were responsible for most of the manganese ore produced in Northern Rhodesia in 1962[20] and 1963. Most of the Northern Rhodesian manganese ore was exported through the Mozambique port of Lourenco Marques.

South Africa, Republic of.—In the fiscal year ending June 30, 1963, South African Manganese, Ltd., continued to experience difficulties with the manganese-to-iron ratio of ore from its Hotazel mine, but the firm increased production from the mine as well as from the Lohathla section of its southern properties. Some of the company's properties in the Eastern Belt of the Postmasburg field continued to yield some high-grade manganese ore. Development of a new manganese mine was started in the northern sector at the Mamatwan farm. Its product will be blended with that from Hotazel so that ore with a satisfactory manganese-to-iron ratio can be shipped to the company's associate and largest individual customer, African Metals Corp. Ltd., for conversion to ferromanganese. A crushing, screening, and loading plant capable of handling 150,000 tons per year was installed.

In May 1963, the South African Railways Administration accepted delivery from the contractor of the new ore-loading facility at Port Elizabeth. This provides for the use of larger ships with rapid loading and dispatch.[21] Capacity loading rate is 1,500 tons per hour, and maximum storage capacity is 184,000 tons of manganese and iron ores. The bulk of South Africa's manganese ore exports in 1963 went through Port Elizabeth, less than 10 percent going through Lourenco Marques, Mozambique. Some delay in movement of ore by the railways was experienced.

By early 1963, the Electricity Supply Commission had completed its powerlines to the mines of South African Manganese Ltd. and to the Adams and Devon mines of the Associated Manganese Mines of South Africa Ltd. In 1962, the latter company had its Adams and Devon open pits and the underground Black Rock mine in normal operation.

The date for completion of two additional furnaces being erected at the Cato Ridge plant of Ferroalloys Ltd. was extended to early 1964.[22] General Mining and Finance Corp., Ltd., took a financial interest in Marble Lime & Associated Industries Ltd.[23] The latter company planned to increase production of manganese ore from its mine at

[20] Bureau of Mines. Mineral Trade Notes. V. 57, No. 4, October 1963, pp. 39–40.
[21] Mining Magazine (London). V. 109, No. 6, December 1963, p. 360.
South African Mining and Engineering Journal (Johannesburg Republic of South Africa). V. 74, pt. 2, No. 3693, Nov. 15, 1963, pp. 1365–1366.
[22] South African Mining and Engineering Journal (Johannesburg Republic of South Africa). V. 74, pt. 1, No. 3664, Apr. 26, 1963, p. 982.
[23] Mining Journal (London). V. 260, No. 6671, June 28, 1963, p. 658.

Gopani in the western Transvaal near the Bechuanaland border.[24] A small pilot plant for battery-grade ore was built in 1962.[25] South African exports of chemical-grade manganese ore in 1963 were approximately 10,000 tons.[26]

United Arab Republic (Egypt).—Sinai Manganese Co. was constructing a plant to produce 10,000 tons per year of ferromanganese and 25,000 tons of pig iron. The feed materials are to be preheated and partially reduced.[27]

Upper Volta.—A deposit of manganese ore, estimated to contain 5 million tons having a manganese content of 52 percent, was discovered near the Niger border in the northeastern corner of Upper Volta. The deposit is in Tambaou, near the town of Markoye, in an isolated area more than 600 miles from the coast.[28]

OCEANIA

Australia.—Manganese mining in Western Australia did not develop as expected because output failed to meet contract specifications. In an effort to make ore exports more competitive in world markets, the State Government accepted a subsidy plan of the Northern Mineral Syndicate whereby trucks, loading equipment, etc., will be purchased, and the facilities at Port Hedland improved.[29] In northmost Australia, geologists of Australia's Bureau of Mineral Resources found a large deposit of medium-grade manganese ore on Groote Eylandt in the Gulf of Carpenteria off the Arnhem Land coast.[30] Indications were that Australian production of battery-grade manganese ore in 1963 would be approximately 1,100 tons.

New Hebrides.—All manganese ore sales in 1963 were to Japan.[31] The agglomerating plant in 1963 produced 28,000 short tons of agglomerate averaging 52 percent manganese; exports were 26,000 tons, also averaging 52 percent manganese.

Papua.—Four short tons of manganese ore were produced in the Rigo Subdistrict of Papua in 1963.

TECHNOLOGY

Milling and sintering methods and costs were described for a custom mill which was an important supplier of concentrates to the Government under the domestic manganese purchase program of the late fifties. Mining methods and costs for the Black Rock mine of the same company also were given. The Mohave Mining and Milling Co. had milled or sintered material from more than 225 operators.[32]

The second publication of a Bureau of Mines series reviewing processes that have been seriously considered for recovering manganese from low- or off-grade domestic resources was released. Four

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[24] Mining Journal (London). V. 260, No. 6654, Mar. 1, 1963, p. 208.
[25] Bureau of Mines. Mineral Trade Notes. V. 58, No. 1, January 1964, p. 28.
[26] Metal Bulletin (London). No. 4878, Mar. 6, 1964, p. 26.
[27] Mining Journal (London). V. 261, No. 6682, Sept. 13, 1963, p. 241.
[28] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, p. 25.
[29] Mining Magazine (London). V. 108, No. 6, June 1963, p. 353.
[30] E&MJ Metal and Mineral Markets. V. 34, No. 40, Oct. 7, 1963, p. 3.
Mining Journal (London). V. 261, No. 6685, Oct. 4, 1963, p. 318.
[31] Chemical Age (London). V. 91, No. 2324, Jan. 25, 1964, p. 166.
[32] Fillo, P. V. Manganese Mining and Milling Methods and Costs, Mohave Mining and Milling Co. Maricopa County, Ariz. BuMines Inf. Circ. 8144, 1963, 29 pp.

chloride and seven fixed nitrogen processes are covered. The chloride processes—HCl leach, HCl chloridization, HCl chloride volatilization, and $CaCl_2$ chloride volatilization—are classified as principally leaching or principally chloridization, depending on the method of conversion to the chloride from which the final oxide products are obtained. The fixed nitrogen processes—NO_2 leach, HNO_3 leach, HNO_3–NO_2 leach, NH_3–CO_2–H_2O system leach, $(NH_4)_2SO_4$ leach, $(NH_4)_2SO_4$ roast, and ammonium salt roast—all yield high-grade oxide products, and are essentially either leaching or roasting processes.[33]

In pilot-scale studies by the Bureau of Mines at Minneapolis, Minn., a 20-inch-diameter shaft furnace was used to selectively separate manganese from iron contained in unoxidized manganiferous carbonate slate by continuous countercurrent sulfatization in an atmosphere of about 10 percent sulfur dioxide at temperatures between 600° and 850° C. The slate, from the Cuyuna range of Minnesota, contained relatively small quantities of manganese (2 to 10 percent) compared with large quantities of iron (20 to 40 percent). The resulting manganese sulfate was leached with water in a multiple-compartment rotary drum. Sulfate crystals were recovered from the solution by evaporation in a gas-fired submerged combustion unit, operated in series with a rotary drum dryer. Thermal decomposition of the crystals was accomplished in an 8-inch-diameter shaft furnace, employing a two-stage firing technique, to yield a ferrograde manganese oxide product containing 50 to 60 percent manganese, and an exhaust gas strong enough for recycling to the sulfatization step.[34]

In other work by the Bureau at Minneapolis with the same manganiferous carbonate slates, a 4-inch-diameter fluidized bed reactor was used instead of a vertical shaft furnace to accomplish the sulfatization. Two-stage operation was more efficient than single-stage treatment.[35]

Electric smelting tests at Boulder City, Nev., on high-iron manganiferous materials from the Cuyuna range of Minnesota, and from the Pioche district, Nevada, were reported by the Bureau of Mines. The Pioche material was a nodulized flotation concentrate analyzing 29 percent manganese, 13 percent iron, and 17 percent silica. The Cuyuna furnace feed was a sintered concentrate with 13 percent manganese, 43 percent iron, and 18 percent silica, made from an ore analyzing 7 percent manganese, 30 percent iron, and 32 percent silica. Small submerged arc furnaces were used in a two-stage operation. Iron was reduced in the first stage to produce a slag with a favorable manganese-to-iron ratio. The second stage consisted of smelting this slag to ferromanganese. The product was high in silicon, but otherwise met specifications for standard ferromanganese. Overall smelting recovery of manganese was 70 percent for Pioche and 50 percent for Cuyuna.[36]

[33] Norman, Lindsay D., and Ralph C. Kirby. Review of Major Proposed Processes for Recovering Manganese From United States Resources. 2. Chloride and Fixed Nitrogen Processes. BuMines Inf. Circ. 8160, 1963, 35 pp.

[34] Prasky, Charles, F. E. Joyce, Jr., and W. S. Swanson. Differential Sulfatization Process for the Recovery of Ferrograde Manganese. BuMines Rept. of Inv. 6160, 1963, 30 pp.

[35] Prasky, Charles, and G. P. Howard. Sulfatization of Manganiferous Carbonate Slates in a Fluidized Bed Reactor. BuMines Rept. of Inv. 6258, 1963, 16, pp.

[36] Petermann, F. B., and R. S. Lang. Two-Stage Electric Furnace Smelting of High-Iron Manganiferous Materials for Producing Ferromanganese. BuMines Rept. of Inv. 6225, 1963, 10 pp.

In laboratory-scale research at Rolla, Mo., the Bureau of Mines recovered, as manganese carbonate containing 45 percent manganese, approximately 75 percent of the total manganese content of log-washer slimes from Batesville, Ark., and 50 to 75 percent of the manganese contained in Batesville manganiferous limestones. The procedure used was a low-temperature modification of the Dean-Leute ammonium carbamate process in which both reduction and leaching are accomplished by controlled application of sulfurous acid, and the preliminary Dean-Leute roast is eliminated. Manganese content of the slimes is between 15 and 30 percent, whereas the manganiferous limestone averages between 4 and 5 percent manganese. The experiments demonstrated that, by blending the slimes and the manganiferous limestone in the right proportions, certain cost advantages could be gained without reducing overall manganese recovery.[37]

In continued study of the manganese oxides, attention was centered upon the presence of minor elements. From the data assembled, it was tentatively concluded that (1) tungsten, barium, strontium, beryllium, arsenic, antimony, thallium, and germanium appeared more frequently and in greater quantities in the hypogene vein oxides than in the supergene oxides; (2) there was a genetic relation between the hypogene vein oxides, those of hot spring aprons, and those of beds in stratified sedimentary rocks; and (3) the persistent and large-percentage presence of barium, strontium, beryllium, and thallium in deep sea nodules favored the theory that some of the elements were contributed by volcanic exhalations. It was noted, however, that tungsten, arsenic, antimony, and germanium were not found in most of the nodules examined. The frequency and quantity of other minor element constituents of the nodules were compared with their occurrence in the other types of oxides.[38] The possibility of vein manganese oxide deposits of the Southwestern United States serving as guides in the exploration at depth for gold, silver, and base metals was predicated upon an indicated zonal relationship. Mineral deposition at Butte, Mont., is an example of such a relationship.[39]

A low-silicon ferromanganese of medium-carbon grade was introduced under the trade name of "MS" manganese. It was developed particularly for use in making free-machining steels—steels which show a large reduction in machinability for only a very small increase in silicon content. The new alloy was expected to compete with medium-carbon ferromanganese and electrolytic manganese in production of these steels. Made by a patented method, it has a maximum silicon content of 0.35 percent. A typical analysis is 82.5 percent manganese, 0.28 percent silicon, and 1.30 percent carbon.[40]

It was expected that most of the steel to be used in 600 stainless steel subway cars to be built for the New York Transit Authority would be of the "200" series.[41] Production of these manganese-

[37] Falke, W. L. Hydrometallurgical Recovery of Manganese From Manganiferous Slimes and Limestones. BuMines Rept. of Inv. 6361, 1964, 14 pp.
[38] Hewett, D. F., Michael Fleischer, and Nancy Conklin. Deposits of the Manganese Oxides: Supplement. Econ. Geol., v. 58, No. 1, January-February 1963, 51 pp.
[39] Hewett, D. F. Manganese Is a Clue to Deep Base and Precious Metals. Min. World, v. 25 No 8, July 1963, pp. 26-28.
[40] American Metal Market. V. 70, No. 122, June 26, 1963, pp. 1, 6.
Journal of Metals. V. 15, No. 7, July 1963, p. 471.
[41] American Metal Market. V. 70, No. 122, June 26, 1963, pp. 1-2.

nickel stainless steels continued to increase, reaching 39,000 short tons in 1962 and 49,000 (preliminary) tons in 1963.[42]

A copper-aluminum-manganese-nickel alloy with a nominal tensile strength of 205,000 psi and a yield strength of 200,000 psi was announced. The alloy was reported to have excellent hot-working and moderate cold-working capabilities and good oxidation and corrosion resistance. It is believed that it will have applications where high damping action is desired.[43]

Parts of a recent (1962) Soviet publication on manganese poisoning were translated by the Office of Technical Services, U.S. Department of Commerce.[44]

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[42] American Metal Market. V. 71, No. 21, Jan. 30, 1964, p. 4.
[43] Journal of Metals. V. 15, No. 3, March 1963, p. 180.
[44] Lazarev, N. V., and E. N. Levina (eds.) Okesly Margantsa (Manganese Oxides). State Medical Press, Leningrad, 1962; Office of Tech. Services, U.S. Dept. of Commerce, J.P.R.S. 17,557 (partial transl.), Feb. 11, 1963, 23 pp.

Mercury

By John E. Shelton [1]

CONSUMPTION of mercury in 1963 rose to a new high, imports continued to rise, and domestic mine production was the lowest since 1955. The price of mercury rose steadily from $182–$185 per flask in August to $235 per flask at the end of the year.

World output of mercury was 4 percent below that of 1962, with the United States showing the largest drop.

Domestic mine production declined 27 percent to 19,100 flasks as several mines closed or curtailed operations. Domestic mercury consumption, on the other hand, was 19 percent higher than in 1962. The increase was due primarily to installation and expansion of mercury-cell chlorine and caustic soda plants.

TABLE 1.—Salient mercury statistics

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Producing mines	107	71	75	69	56	47
Production .... flasks [1]	26,873	31,256	33,223	31,662	26,277	19,100
Value .... thousands	$6,793	$7,110	$7,002	$6,257	$5,024	$3,618
Imports:						
For consumption .... flasks	40,966	30,141	19,488	12,326	[2] 31,552	42,872
General .... do	42,939	30,260	19,515	12,527	[2] 31,516	43,126
Exports .... do	932	640	357	285	224	187
Reexports .... do	1,587	553	317	180	257	----------
Stocks Dec. 31 .... do	18,297	13,580	19,761	17,533	14,924	12,181
Consumption .... do	51,926	54,895	51,167	55,763	65,301	77,963
Price: New York, average per flask	$258.14	$227.48	$210.76	$197.61	$191.21	$189.45
World:						
Production .... flasks	213,000	223,000	242,000	240,000	[2] 245,000	236,000
Price: London, average per flask	$244.31	$208.61	$197.86	$181.87	$172.79	$171.42

[1] Flasks as used in this chapter refers to a 76-pound flask.
[2] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

Through the Office of Minerals Exploration (OME), the Government offered financial assistance to the extent of 50 percent of the total allowable costs for exploration of eligible domestic mercury deposits. Three exploration projects were active in 1963:

Company:	*Location*	*Total cost*
Alaska Mines & Minerals, Inc.	Aniak district, Alaska	$324,100
J. Selby & Wm. Dawson (assigned to San Simeon Keystone, Inc.).	San Luis Obispo County, Calif.	52,730
Pacific Minerals & Chemicals Co., Inc.	Crook County, Oreg.	69,720

[1] Commodity specialist, Division of Minerals.

The Atomic Energy Commission reported that it held 50,000 flasks of excess mercury. Approximately 46,000 flasks was transferred to the national stockpile. The balance was transferred to various Federal agencies to meet their requirements.

DOMESTIC PRODUCTION

Production of primary mercury in the United States declined for the third consecutive year. Output was 27 percent less than in 1962, the lowest since 1955. All principal mercury-producing States had lower outputs. The number of producing mines dropped to 47. The quantity of ore treated dropped 23 percent, and the average grade of ore treated dropped 0.8 pound per ton to 12.8 pounds. The average grade of ore treated in California rose from 14.4 pounds per ton in 1962 to 15.7 pounds. Production of secondary mercury rose 81 percent.

Despite a 15-percent drop in output, California remained the leading mercury-producing State and supplied 71 percent of the domestic total. The four principal producers—New Idria, Buena Vista, New Almaden, and Culver-Baer accounted for 97 percent of the State total, compared with 94 percent in 1962.

Nevada remained in second place, supplying 26 percent of the domestic total. Production was 25 percent less than in 1962. The Cordero mine was the leading producer in the State and ranked second in the United States. Its production was 27 percent less than in 1962, however, partially because of curtailment of operations due to flooding of the mine.

Output in Alaska was 89 percent less than in 1962 and represented 2 percent of the total domestic production. Operations at the Red Devil mine were stopped, and the mine was allowed to flood. The mine had been in operation since 1942 and had produced over 32,000 flasks of mercury. Production in 1963 was from clean-up operations and from stockpiled ore and residues.

The remainder of the 1963 production, less than 1 percent, was from Arizona, Idaho, and Oregon.

Three properties (each producing 1,000 flasks or more) supplied 89 percent of the total domestic output. The leading producers were:

State:	*County*	*Mine*
California	San Benito	New Indria.
Do	San Luis Obispo	Buena Vista.
Nevada	Humboldt	Cordero.

In addition, the following operations produced 100 flasks or more:

State:	*County*	*Mine*
Alaska	Aniak district	Red Devil.
Arizona	Maricopa	National.
California	Santa Clara	New Almaden.
Do	Sonoma	Culver-Baer.
Nevada	Nye	Ione.

These eight mines produced 97 percent of the domestic output.

TABLE 2.—Mercury produced in the United States, by States

Year and State	Producing mines	Flasks	Value [1]	Year and State	Producing mines	Flasks	Value [1]
1962:				1963:			
Alaska	2	3,719	$711,110	Alaska	2	400	$75,780
California	37	15,951	3,049,991	California	31	13,592	2,575,004
Nevada	14	6,573	1,256,823	Nevada	11	4,944	936,641
Arizona and Oregon	3	34	6,501	Arizona, Idaho, and Oregon	3	164	31,070
Total	56	26,277	5,024,425	Total	47	19,100	3,618,495

[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		Year	Ore treated (short tons)	Mercury produced	
		Flasks	Pounds per ton of ore			Flasks	Pounds per ton of ore
1954–58 (average)	255,752	26,544	7.8	1961	262,108	31,633	9.2
1959	275,903	31,109	8.6	1962	146,523	26,228	13.6
1960	258,071	33,106	9.7	1963	113,255	19,088	12.8

[1] Excludes mercury produced from placer operations and from cleanup activity at furnaces and other plants.

Production of mercury from secondary sources was 81 percent greater than in 1962. Mercury was reclaimed from dental amalgam, oxide and acetate sludges, and battery scrap. The transfer of excess Government mercury to various Government agencies is included in the total.

TABLE 4.—Production of secondary mercury in the United States

Year	*Flasks*
1959	4,950
1960	5,350
1961	8,360
1962	5,800
1963	10,520

CONSUMPTION AND USES

Industrial consumption of mercury rose 19 percent to 78,000 flasks exceeding the alltime record of 65,300 flasks in 1962. Installation of three mercury-cell chlorine and caustic soda plants and expansion at two such plants, combined with increased demand by some of the principal users, resulted in the record-breaking consumption.

New chlorine and caustic soda plants at Compton, Calif., Acme, N.C., and Ashtabula, Ohio, began production, and capacity was expanded at Linden, N.J., and in Louisiana. Mercury required to replace losses in manufacturing chlorine and caustic soda rose 9 percent.

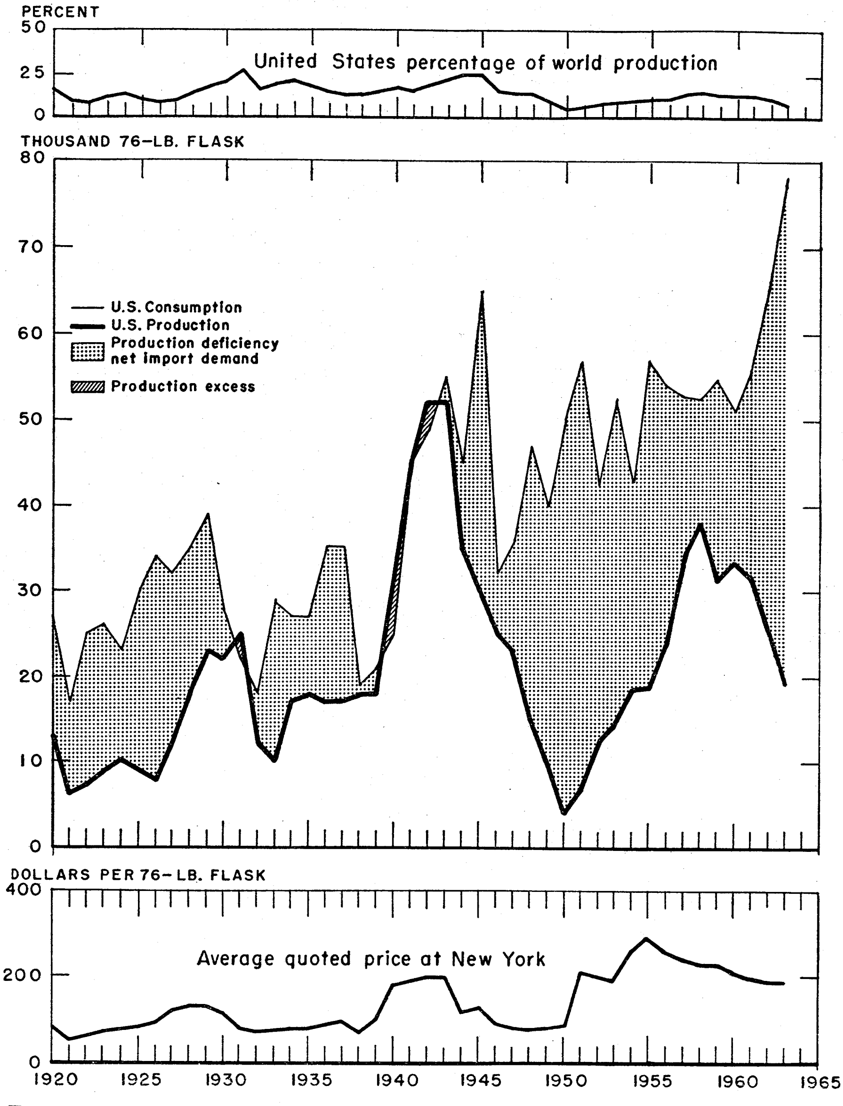

FIGURE 1.—Trends in production, consumption, and price of mercury, 1920–63.

Other uses that consumed more mercury were mildew proofing and antifouling paints, 42 percent; pharmaceuticals, 21 percent; slime-control compounds for paper and pulp manufacturing, 9 percent; general laboratory use, 19 percent; dental preparations, 15 percent; and amalgamation, 2 percent. Usage for agricultural purposes declined 41 percent; catalysts, 30 percent; industrial and control instruments, 5 percent; and electrical apparatus, 4 percent.

TABLE 5.—Mercury consumed in the United States by uses

(Flasks)

Use	1954-58 (average)	1959	1960	1961	1962	1963
Agriculture (includes fungicides, and bactericides for industrial purposes)	7,517	3,202	2,974	2,557	4,266	2,538
Amalgamation	230	265	255	278	299	306
Catalysts	774	965	1,018	707	874	612
Dental preparations [1]	1,405	1,828	1,783	2,154	2,033	2,346
Electrical apparatus [1]	9,670	8,905	9,268	10,255	11,564	11,115
Electrolytic preparation of chlorine and caustic soda	3,434	5,828	6,211	6,056	7,314	7,999
General laboratory use	990	1,110	1,302	1,484	1,752	2,085
Industrial and control instruments [1]	5,802	6,164	6,525	5,627	5,186	4,943
Paint:						
Antifouling	613	993	1,360	915	124	252
Mildew proofing	(2)	2,521	2,861	5,146	4,554	6,403
Paper and pulp manufacture	(3)	4,360	3,481	3,094	2,600	2,831
Pharmaceuticals	1,641	1,717	1,729	2,515	3,378	4,081
Redistilled [1]	9,500	9,331	9,678	9,013	8,987	9,227
Other	10,350	7,706	2,722	5,962	12,370	23,225
Total	51,926	54,895	51,167	55,763	65,301	77,963

[1] A breakdown of the "redistilled" classification showed ranges of 45 to 38 percent for instruments, 14 to 8 percent for dental preparations, 44 to 28 percent for electrical apparatus, and 18 to 8 percent for miscellaneous uses in 1954-62, compared with 44 percent for instruments, 13 percent for dental preparations, 25 percent for electrical apparatus, and 18 percent for miscellaneous uses in 1963.
[2] Data not available.
[3] Included with agriculture.

STOCKS

Consumers' and dealers' stocks of mercury were 23 percent less than at the end of 1962. Withdrawals of metal from inventories for newly installed or expanded chlorine and caustic soda plants were largely responsible for the drop.

Stocks held by producers, usually small in relation to total industry inventories, rose 29 percent and represented 13 percent of the 1963 total.

On December 31, there was 145,525 flasks in Government stockpiles, of which 16,000 flasks was in the supplemental stockpile. Approximately 46,000 flasks was received during the year from the Atomic Energy Commission.

TABLE 6.—Stocks of mercury, December 31

(Flasks)

Year	Producer	Consumer and dealer	Total
1954-58 (average)	1,317	16,980	18,297
1959	1,880	11,700	13,580
1960	2,561	17,200	19,761
1961	2,033	15,500	17,533
1962	1,224	13,700	14,924
1963	1,581	10,600	12,181

PRICES

The average price of mercury for 1963 in the United States was $189.45 per flask, a decrease of almost $2.00 below that of 1962. Prices ranged from a low of $182 to $185 per flask in the third quarter to a high of $240 to $244 at the end of the year. The price at the beginning of the year was $186 to $189 per flask.

In London, mercury was quoted at £61 10s. ($172.20) per flask at the beginning of the year. The quotation dropped to £58 ($162.40) in June. Beginning in August the price rose steadily to £73 ($204.40) at the end of the year. The annual average price was £61 5s. 2d. ($171.42), slightly below the 1962 price.

TABLE 7.—Average monthly prices of mercury at New York and London

(Per flask)

Month	1962		1963	
	New York[1]	London[2]	New York[1]	London[2]
January	$190.00	$167.25	$186.64	$171.37
February	191.50	172.39	187.00	171.01
March	192.00	174.83	187.00	169.44
April	192.00	175.88	184.91	168.04
May	192.00	175.19	183.36	166.86
June	192.00	172.71	182.50	162.41
July	192.00	172.61	182.00	162.45
August	192.00	172.43	182.46	162.38
September	192.00	172.26	187.00	163.67
October	192.00	172.28	192.22	175.14
November	190.40	172.32	200.47	184.65
December	186.60	172.40	217.86	203.45
Average	191.21	172.79	189.45	171.42

[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

Imports.—Imports of mercury for consumption were 36 percent greater than in 1962, the largest since 1956. Of the 42,900 flasks received in 1963, Spain supplied 46 percent, Italy 20 percent, Yugoslavia 10 percent, Mexico 10 percent, and Peru 8 percent. Canada, Chile, and the Philippines supplied the rest. Receipts from Peru were the largest recorded.

Imports of various mercury compounds and preparations totaled 14,899 pounds, less than one-third of the 1962 quantity. Of the total, 5,768 pounds came from Spain, 4,486 from United Kingdom, 2,205 from the Netherlands, 1,802 from Yugoslavia, and 638 from West Germany.

TABLE 8.—U.S. imports for consumption [1] of mercury, by countries

Country	1954–58 (average)		1959		1960		1961		1962		1963	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
North America:												
Canada	85	$22	125	$23	20	$5	24	$4	61	$10	150	$27
Mexico	8,841	1,885	3,516	646	2,419	382	3,023	445	[2] 7,618	[2] 1,064	4,292	585
Total	8,926	1,907	3,641	669	2,439	387	3,047	449	[2] 7,679	[2] 1,074	4,442	612
South America:												
Bolivia	2	(3)	11	2	-----	-----	-----	-----	-----	-----	-----	-----
Chile	108	22	813	164	139	26	82	15	200	31	740	112
Colombia	19	3	-----	-----	30	6	25	4	-----	-----	-----	-----
Peru	211	46	589	112	49	8	-----	-----	-----	-----	3,227	511
Total	340	71	1,413	278	218	40	107	19	200	31	3,967	623
Europe:												
Italy	9,762	1,919	6,146	1,256	3,420	627	2,073	365	10,501	1,800	8,474	1,401
Netherlands	4	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Spain	18,965	3,850	17,111	3,400	12,464	2,278	6,544	1,118	9,826	1,638	19,950	3,176
Sweden	-----	-----	-----	-----	-----	-----	-----	-----	70	10	-----	-----
United Kingdom	570	128	235	48	-----	-----	(4)	(3)	(4)	(3)	-----	-----
Yugoslavia	2,167	514	954	198	900	170	355	62	3,276	537	4,459	696
Total	31,468	6,412	24,446	4,902	16,784	3,075	8,972	1,545	23,673	3,985	32,883	5,273
Asia:												
Philippines	220	47	400	81	-----	-----	-----	-----	-----	-----	1,580	258
Turkey	12	3	100	36	-----	-----	200	35	-----	-----	-----	-----
Total	232	50	500	117	-----	-----	200	35	-----	-----	1,580	258
Oceania:												
Australia	-----	-----	126	23	-----	-----	-----	-----	-----	-----	-----	-----
New Zealand	-----	-----	15	3	47	8	-----	-----	-----	-----	-----	-----
Total	-----	-----	141	26	47	8	-----	-----	-----	-----	-----	-----
Grand total	40,966	[5] 8,440	30,141	5,992	19,488	3,510	12,326	2,048	[2] 31,552	[2] 5,090	42,872	6,766

[1] Data include mercury imported for immediate consumption plus material withdrawn from bonded warehouses.
[2] Revised figure.
[3] Less than $1,000.
[4] Less than 1 flask.
[5] 1954 data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 9.—U.S. imports [1] of mercury, by countries

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	85	125	20	24	61	150
Mexico	9,305	3,631	2,459	3,205	[2] 7,560	4,328
Total	9,390	3,756	2,479	3,229	[2] 7,621	4,478
South America:						
Bolivia	2	11	----------	----------	----------	----------
Chile	257	400	139	82	200	740
Colombia	19	30	----------	115	----------	----------
Peru	211	599	49	----------	----------	3,406
Total	489	1,040	188	197	200	4,146
Europe:						
Italy	10,050	6,175	3,447	2,002	[2] 10,498	8,474
Netherlands	4	----------	----------	----------	----------	----------
Spain	19,625	17,509	12,444	6,544	9,826	19,950
Sweden	----------	----------	----------	----------	70	----------
United Kingdom	613	185	----------	(3)	(3)	----------
Yugoslavia	2,525	954	910	355	3,301	4,498
Total	32,817	24,823	16,801	8,901	[2] 23,695	32,922
Asia:						
Philippines	220	400	----------	----------	----------	1,580
Turkey	23	100	----------	200	----------	----------
Total	243	500	----------	200	----------	1,580
Oceania:						
Australia	----------	126	----------	----------	----------	----------
New Zealand	----------	15	47	----------	----------	----------
Total	----------	141	47	----------	----------	----------
Grand total	42,939	30,260	19,515	12,527	[2] 31,516	43,126

[1] Data are "general" imports; that is, they include mercury imported for immediate consumption plus material entering the country under bond.
[2] Revised figure.
[3] Less than 1 flask.

Source: Bureau of the Census.

Exports.—Exports of mercury, usually small, decreased 17 percent. Of the total of 187 flasks (224 in 1962), 41 (21) went to Canada, 42 (53) to Colombia, 33 (0) to Pakistan, 19 (17) to Venezuela, 12 (24) to Dominican Republic, 9 (16) to Mexico, 6 (27) to Japan, 5 (0) to Indonesia, and the remainder in lots of less than 5 flasks to 11 other countries.

TABLE 10.—U.S. exports of mercury

Year	Flasks	Value	Year	Flasks	Value
1954–58 (average)	932	$240,415	1961	285	$70,622
1959	640	92,255	1962	224	64,024
1960	357	82,957	1963	187	46,357

Source: Bureau of the Census.

TABLE 11.—U.S. reexports of mercury

Year	Flasks	Value	Year	Flasks	Value
1954–58 (average)	1,587	$354,495	1961	180	$33,067
1959	553	119,038	1962	257	42,549
1960	317	62,015	1963	----------	----------

Source: Bureau of the Census.

There were no reexports in 1963.

Tariff.—The duty of 25 cents per pound ($19 per flask) on imports of mercury, in effect since 1922, continued.

WORLD REVIEW

World output of mercury was 9,000 flasks or 4 percent lower than in 1962 due largely to a decrease of 7,177 flasks in U.S. output.

TABLE 12.—World production of mercury by countries [1]

(Flasks) [2]

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Mexico	21,558	16,420	20,114	18,101	18,855	[3] 17,800
United States	26,873	31,256	33,223	31,662	26,277	19,100
South America:						
Chile	1,073	2,007	2,876	1,509	791	[3] 700
Colombia	[4] 85	95	149	191	----------	----------
Peru	591	2,526	3,034	3,001	3,483	[3] [5] 2,600
Europe:						
Austria	11	----------	----------	----------	----------	----------
Czechoslovakia [6]	725	725	725	725	725	[3] 725
Italy	58,503	45,833	55,492	55,434	54,535	54,564
Rumania	387	387	413	350	222	[3] 230
Spain	47,553	51,680	53,369	51,202	52,798	[3] 53,000
U.S.S.R. [3]	19,300	25,000	25,000	25,000	35,000	35,000
Yugoslavia	13,373	13,344	14,069	15,954	16,273	15,838
Asia:						
China [3]	14,500	23,000	23,000	26,000	26,000	26,000
Japan	4,997	5,988	5,791	5,437	4,409	[3] 4,500
Philippines	[4] 2,584	3,539	3,041	3,167	2,767	2,649
Turkey	905	1,479	1,339	1,864	2,687	[3] 3,000
Africa: Tunisia	[4] 57	198	166	54	----------	----------
World total (estimate)	213,000	223,000	242,000	240,000	245,000	236,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] 76-pound flasks.
[3] Estimate.
[4] Average annual production 1955–58.
[5] Exports.
[6] Estimate according to the 50th annual issue of Metal Statistics (Metallgesellschaft), except Czechoslovakia 1963.

TABLE 13.—Italy: Exports of mercury by countries [1]

(Flasks)

Destination	1962	1963	Destination	1962	1963
Austria	490	23	Netherlands	873	838
Belgium-Luxembourg	----------	2,741	Poland	----------	780
Canada	----------	1,726	Rumania	----------	2,666
Finland	----------	499	Sweden	1,584	1,073
France	7,530	8,639	Switzerland	464	307
Germany:			Turkey	----------	775
East	----------	2,074	United Kingdom	3,011	13,068
West	7,177	12,204	United States	6,504	7,803
India	1,920	2,419	Yugoslavia	----------	1,752
Iran	548	----------	Other countries	1,190	2,611
Japan	4,435	13,222			
Korea, South	----------	508	Total	35,726	75,728

[1] This table incorporates some revisions.

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TABLE 14.—Mexico: Exports of mercury by countries [1]

(Flasks)

Destination	1961	1962	Destination	1961	1962
Argentina	----------	320	Japan	8,613	4,341
Canada	197	412	Netherlands	1,599	----------
Colombia	3	1,023	Taiwan	68	204
France	321	----------	United Kingdom	2,165	1,240
Germany:			United States	5,266	13,561
East	----------	108	Other countries	780	525
West	236	----------	Total	19,248	21,734

[1] This table incorporates some revisions.

TABLE 15.—Spain: Exports of mercury, by countries [1]

(Flasks)

Destination	1961	1962	Destination	1961	1962
Australia	192	641	Netherlands	3,221	506
Austria	174	523	Norway	300	435
Belgium-Luxembourg	245	----------	Poland	----------	335
Brazil	813	195	Portugal	364	306
Canada	1,601	600	Sweden	1,716	1,171
Czechoslovakia	----------	610	Switzerland	914	217
Denmark	1,651	----------	United Arab Republic (Egypt)	----------	232
Finland	445	4	United Kingdom	7,221	6,875
France	7,728	4,155	United States	9,394	11,127
Germany:			Other countries	334	151
East	----------	580			
West	11,432	9,751			
India	341	6,798	Total	48,086	45,891
Japan	----------	679			

[1] This table incorporates some revisions.

Italy.—Output in Italy, the leading world producer for the fourth consecutive year, was essentially unchanged from 1962. Exports increased 112 percent.

Mercurio Italiano, established to market production of Italian mercury, was dissolved on January 1 because of antimonopoly rules of the European Common Market.

Japan.—The total output of mercury metal was about the same as that reported for 1962. In addition to domestic mine production, mercury-bearing material mainly from Latin America was imported for refining.

Turkey.—Production of mercury increased about 12 percent compared with that of 1962. The Göksu Maden ve Sanayi A.S. Istanbul mine near Seyhsaban, Kastamonu Province, was the largest producer.

United Kingdom.—Foreign trade data for the United Kingdom indicated that consumption of mercury increased 40 percent. Imports, reexports, and apparent consumption in flasks were as follows:

	1954–58 (average)	1959	1960	1961	1962	1963
Imports	19,880	25,700	25,300	27,000	20,700	24,600
Reexports	6,860	5,000	4,300	8,400	5,800	3,800
Apparent consumption	13,020	20,700	21,000	18,600	14,900	20,800

TABLE 16.—United Kingdom: Imports of mercury by countries

(Flasks)

Country	1962	1963	Country	1962	1963
Canada		238	Spain	6,120	6,520
China	6,505	3,505	Turkey	2,230	1,543
Italy	3,027	11,510	U.S.S.R.	1,546	
France		750	Yugoslavia	100	79
Mexico	1,129	207	Other countries	22	115
Netherlands	4	100			
Peru	42		Total	20,725	24,567

Reexports of mercury in flasks were as follows:

Destinations:	1962	1963
Australia	312	250
Belgium	227	136
Ceylon	86	28
Denmark	256	300
Finland	649	49
France	282	442
Germany, West	216	44
Hungary	233	232
India	570	310
Ireland	125	87
Netherlands	182	131
Pakistan	287	151
Poland	1,082	
Rhodesia and Nyasaland, Federation of	84	89
South Africa, Republic of	512	489
Sweden	150	557
Other countries	521	538
Total	5,774	3,833

TABLE 17.—Yugoslavia: Exports of mercury by countries [1]

(Flasks)

Destination	1961	1962	Destination	1961	1962
Austria	2,025	1,677	Poland	900	900
Czechoslovakia	300	300	Sweden	750	450
Finland	145		Switzerland		128
France	872	400	United Kingdom	400	
Germany, West	550	353	United States	2,501	4,000
India	1,100		Other countries	7	19
Israel		700			
Italy	3	580	Total	9,683	9,532
Norway	130	25			

[1] This table incorporates some revisions.

TECHNOLOGY

The geology of the Red Devil mine, Alaska, was described.[2] The Red Devil ore, consisting of cinnabar that is generally associated with abundant stibnite in a quartz-rich gangue, was formed along and near intersections between the altered dikes and northwestward-trending faults that largely are parallel to the bedding of sedimentary rocks.

[2] MacKevett, E. M., Jr., and H. C. Berg. Geology of the Red Devil Quicksilver Mine, Alaska. Geol. Survey Bull. 1142-G, August 1963, 16 pp.

The alloy systems of mercury-indium and mercury-tin were investigated.[3]

Redesigning the mercury cell by incorporating bigger anodes in wider cells resulted in doubling the chlorine production rate in about half of the floor space.[4] Experimental studies of the design of anodes for mercury cells indicated that cell resistance caused by chlorine bubbles can be reduced by using anodes drilled with ¼-inch holes and counter bores with 10-degree slopes.[5] Hazards such as exposure of electrical circuits, corrosion of equipment, and excessive quantities of mercury vapor, chlorine or hydrogen in the atmosphere were discussed.[6] These hazards can be reduced by careful cellroom design combined by effective safety measures during operations. During the manufacture of chlorine in mercury cells subsidiary reactions such as the formation of oxygen, hydrogen, carbon dioxide, and chlorate and the reduction of dissolved chlorine, cause loss of current efficiency.[7]

A new process for the manufacture of sodium metal is to be used by the Tekkosha Co., Japan.[8]

A process to recover mercury salts from brine by anion exchange resins was developed.[9]

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[3] Coles, B. R., M. F. Merriam, and Z. Fisk. The Phase Diagram of the Mercury-Indium Alloy System. J. Less-Common Metals (Amsterdam, Netherlands), V. 5, No. 1, February 1963, pp. 41–48.
Taylor, Duane F., and Claire L. Burns. An Investigation of the Constitution of the Mercury-Tin System. J. Res. NBS, v. 67A, No. 1, January–February 1963, pp. 55–70.

[4] Chemical Engineering. Redesigned Mercury Cells Yields More Chlorine. V. 70, No. 6, Mar. 18, 1963, pp. 88–89.

[5] Gardiner, W. C., and W. J. Sakowski. Anode Design for Mercury Cells. Electrochem. Technical, v. 1, No. 1–2, January–February 1963, pp. 53–56.

[6] Chemical Trade Journal and Chemical Engineer (London). Hazards of Electrolysis in Horizontal Mercury Cells. V. 152, No. 3960, May 3, 1963, pp. 706–707.

[7] Cowley, W. E., B. Lott, and J. H. Entwisle. Influence of Brine Quality on Mercury Cell Current Efficiency. Chemical Trade Journal and Chemical Engineer (London), v. 153, No. 3984, Oct. 18, 1963, p. 580.

[8] Chemical Trade Journal and Chemical Engineer (London). New Sodium Process for Japan. V. 153, No. 3972, July 26, 1963, p. 138.

[9] Scholten, Herman G., and Glenn E. Prielipp (assigned to The Dow Chemical Co., Midland, Mich.). Mercury Recovery and Removal. U.S. Pat. 3,085,859, Apr. 16, 1963.

Mica

By Benjamin Petkof [1]

SALE or usage of domestically produced sheet and scrap mica continued to increase despite the very sharp reduction in the sales of sheet mica. Consumption of all forms of sheet mica (block, film, and splittings) declined slightly. Total imports of mica were at the highest level of the 5-year period, 1959 to 1963. Exports of mica and mica products were slightly lower than in 1962.

TABLE 1.—Salient mica statistics

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Domestice, sold or used by producers:						
Sheet mica____thousand pounds__	710	706	587	526	[1] 363	103
Value____________thousands__	$2,771	$3,419	$3,108	$3,386	[1] $1,299	$13
Scrap and flake mica thousand short tons__	90	102	98	99	108	109
Value____________thousands__	$1,963	$2,665	$2,698	$2,417	$2,639	$2,776
Ground mica [2] thousand short tons__	94	107	98	103	114	117
Value____________thousands__	$5,862	$5,646	$5,193	$5,468	$6,489	$6,805
Consumption, block and film thousand pounds__	3,472	2,868	2,776	2,536	2,811	2,293
Value______________thousands__	$4,784	$4,449	$3,988	$3,630	$3,490	$2,782
Consumption, splittings thousand pounds__	7,552	7,223	6,227	5,514	6,728	6,687
Value______________thousands__	$3,939	$3,464	$2,875	$2,266	$2,813	$2,588
Imports for consumption thousand short tons__	12	11	11	7	10	13
Exports________________________do____	4	5	4	4	4	4
Consumption, apparent,[3] sheet thousand pounds__	11,839	12,675	9,219	8,356	[1] 11,582	9,112
World: Production________________do____	310,000	350,000	365,000	365,000	390,000	400,000

[1] Revised figure.
[2] Domestic and some imported scrap mica.
[3] Sheet mica sold or used, plus imports of unmanufactured and manufactured sheet mica, minus exports of sheet mica.

DOMESTIC PRODUCTION

Sheet Mica.—Sheet mica, sold or used by producers, declined to less than one-third the quantity sold or used in 1962. Cessation of the Government purchasing program in 1962 accounted for the continuing decline. North Carolina maintained its status as the leading mica-producing State with about 90 percent of total domestic production.

Scrap and Flake Mica.—Grinders increased the quantity of scrap and

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flake mica sold or used by about 2 percent over that of 1962. The value increased almost 5 percent, giving the highest valuation for scrap and flake mica since 1959. North Carolina was again the largest producer with about 56 percent of the total tonnage.

Ground Mica.—Sales and valuation of ground mica continued to increase. Sales rose by 3 percent and valuation by 5 percent. Dry-ground mica constituted 87 percent of the tonnage. The remainder was wet-ground. Production was reported by 28 grinders in 25 dry-grinding plants and 7 wet-grinding plants. The Hayden Mica Co. of Massachusetts sold its ground mica operations to Franklin Mineral Products Co., Wilmington, Mass.

The Feldspar Corp., Middletown, Conn., and the Mineral Processing Co., Santa Fe, N. Mex., were listed as new producers of dry-ground mica. Deneen Mica Co. in Connecticut, ceased operating its dry-grinding plant at Middletown, Conn. International Minerals & Chemical Corp. did not operate its dry-grinding plant at Spruce Pine, N.C.

TABLE 2.—Mica sold or used by producers in the United States

Year and State	Sheet mica						Scrap and flake mica [2]		Total	
	Uncut punch and circle mica		Uncut mica larger than punch and circle [1]		Total sheet mica		Short tons	Value	Short tons	Value
	Pounds	Value	Pounds	Value	Pounds	Value				
1954–58 (average)	445,774	$42,507	264,260	$2,728,981	710,034	$2,771,488	89,720	$1,963,095	90,074	$4,734,583
1959	383,529	36,653	322,866	3,382,837	706,395	3,419,490	101,541	2,665,337	101,893	6,084,827
1960	330,246	21,628	257,155	3,086,343	587,401	3,107,971	97,912	2,697,510	98,204	5,805,481
1961	265,444	21,774	260,563	3,363,986	526,007	3,385,760	99,044	2,416,819	99,360	5,802,579
1962	263,123	23,450	[3] 99,893	[3] 1,275,828	[4] 363,016	[4] 1,299,278	107,702	2,639,297	[3] 107,883	[3] 3,938,575
1963:										
California							977	13,678	977	13,678
Colorado							440	7,235	440	7,235
North Carolina	87,828	8,906	5,133	3,698	92,961	12,604	61,598	1,497,345	61,644	1,509,949
South Dakota	10,000	300			10,000	300	(5)	(5)	(5)	(5)
Undistributed [6]							46,308	1,258,123	46,313	1,258,423
Total	97,828	9,206	5,133	3,698	102,961	12,904	109,323	2,776,381	109,374	2,789,285

[1] Includes the full-trimmed mica equivalent of hand-cobbed mica, 1954–62.
[2] Includes finely divided mica recovered from mica and sericite schist and mica that is a byproduct of feldspar and kaolin beneficiation.
[3] Revised figure.
[4] Quantity and value of sheet mica in New Hampshire revised to 37,508 pounds valued at $396,132 from 35,450 pounds valued at $373,694.
[5] Included with "Undistributed" to avoid disclosing individual company confidential data.
[6] Figures include Alabama, Arizona, Connecticut, Georgia, Idaho, 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		Wet-ground		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1954–58 (average)	81,022	$3,912	13,256	$1,950	94,278	$5,862
1959	93,121	3,516	14,059	2,130	107,180	5,646
1960	86,225	3,422	12,121	1,771	98,346	5,193
1961	90,519	3,747	12,176	1,721	102,695	5,468
1962	99,936	4,351	13,851	2,138	113,787	6,489
1963	101,943	4,596	15,308	2,209	117,251	6,805

[1] Partly estimated.

CONSUMPTION AND USES

Sheet Mica.—Domestic consumption of sheet mica (block, film, and splittings) decreased 6 percent to 9 million pounds from 9.5 million pounds in 1962.

The quantity of muscovite block and film, fabricated domestically, decreased 19 percent to slightly under 2.3 million pounds. This quantity consisted of 5 percent Good Stained or better, 38 percent Stained, and 57 percent lower than Stained. Electronic applications, such as tubes and capacitors, consumed 65 percent of all qualities. Production of tubes consumed 88 percent of the Stained or better qualities. Fabrication of muscovite block and film mica was reported by 20 companies in 10 States. New Jersey had the most operating plants during the year. New Jersey, New York, and North Carolina, with five, three, and four plants, respectively, produced 52 percent of the domestically fabricated block and film mica.

Consumption of splittings decreased slightly but did not drop below the 1962 level. Muscovite splittings from India continued to constitute the bulk of the consumption (96 percent by weight); the remainder was principally phlogopite splittings from the Malagasy Republic. Mica splittings were fabricated by 11 companies at 12 plants in 9 States. Operations at four plants—two in New York, one in New Hampshire, and one in Massachussets—required 4.5 million pounds of the splittings, 67 percent of the total consumed.

Built-Up Mica.—Various forms of built-up mica were produced by domestic fabricators of splittings for use primarily as an electrical insulating material. Tape was the form in greatest demand (29 percent), followed closely by segment plate (24 percent) and molding plate (23 percent). Consumption of built-up mica was almost 4 percent greater than in 1962, with only a small increase in valuation.

Reconstituted Mica.—General Electric Co., at Schenectady, N.Y., and Samica Corp. (subsidiary of Minnesota Mining & Manufacturing Co.), at Rutland, Vt., were the only producers, and continued to make this material by papermaking techniques from specially delaminated mica scrap. This sheet material continued to displace built-up mica in various applications.

Synthetic Mica.—Molecular Dielectrics, Inc., Clifton, N.J., and Synthetic Mica Co., Division of Mycalex Corp. of America, West Caldwell, N.J., continued commercial production of synthetic mica flake for use in glass-bonded mica ceramic materials. Molecular Dielectrics continued recovery of high-quality synthetic mica crystals for splitting and punching. This material was commercially used for special electronic tubes and other applications. Haveg Industries, Inc., Wilmington, Del., manufactured glass-bonded synthetic mica products but did not produce its own mica.

Other Substitutes for Sheet Mica.—Farnam Manufacturing Co., Inc., Asheville, N.C., continued to make a heat-resistant electrical-insulation product from natural mica, which had been finely divided and bonded with water-soluble aluminum phosphate. Production was in the form of rigid sheets and various shapes.

Ground Mica.—Sales of ground mica increased 3 percent over those of 1962, and sales of both wet- and dry-ground mica showed the same trend. Roofing materials, joint cement, and paint continued as the leading users of ground mica. Other end uses requiring ground mica were rubber, plastics, well drilling, welding rods, and wallpaper.

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 1963

(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	963	33,304	1,784	36,051	6,018	58	6,076	42,127
Stained	4,351	824,787	10,206	839,344	2,716	21,334	24,050	863,394
Lower than Stained [1]	5,533	497,453	31,378	534,364	9,612	744,298	753,910	1,288,274
Total	10,847	1,355,544	43,368	1,409,759	18,346	765,690	784,036	2,193,795
Film:								
First quality	5,390	----------	--------	5,390	----------	----------	----------	5,390
Second quality	60,244	----------	--------	60,244	----------	115	115	60,359
Other quality	2,100	----------	--------	2,100	----------	----------	----------	2,100
Total	67,734	----------	--------	67,734	----------	115	115	67,849
Block and film:								
Good Stained or better [2]	66,597	33,304	1,784	101,685	6,018	173	6,191	107,876
Stained [3]	6,451	824,787	10,206	841,444	2,716	21,334	24,050	865,494
Lower than Stained	5,533	497,453	31,378	534,364	9,612	744,298	753,910	1,288,274
Total	78,581	1,355,544	43,368	1,477,493	18,346	765,805	784,151	2,261,644
Phlogopite: Block (all qualities)	--------	----------	703	703	----------	30,308	30,308	31,011

[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 1963, 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	5,926	2,196	1,145	23,117	110	32,494
Stained	13,425	12,613	71,563	676,066	61,731	835,398
Lower than Stained	157,485	186,105	55,615	436,851	317,790	1,153,846
Total	176,836	200,914	128,323	1,136,034	379,631	2,021,738
Nonruby:						
Good Stained or better	1,372	----------	400	7,861	----------	9,633
Stained	655	4,774	2,875	19,692	----------	27,996
Lower than Stained	22,578	14,780	9,450	640	86,980	134,428
Total	24,605	19,554	12,725	28,193	86,980	172,057
Film:						
Ruby:						
First quality	905	1,050	770	570	----------	3,295
Second quality	21,059	24,203	10,486	3,886	----------	59,634
Other quality	----------	----------	----------	----------	2,100	2,100
Total	21,964	25,253	11,256	4,456	2,100	65,029
Nonruby:						
First quality	----------	----------	1,220	875	----------	2,095
Second quality	30	20	675	----------	----------	725
Other quality	----------	----------	----------	----------	----------	----------
Total	30	20	1,895	875	----------	2,820

[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:						
1954–58 (average)	6,974	$3,514	[1] 578	[1] $425	7,552	$3,939
1959	6,726	3,098	[2] 497	[2] 366	7,223	3,464
1960	5,915	2,642	312	233	6,227	2,875
1961	5,274	2,077	240	189	5,514	2,266
1962	6,382	2,559	346	254	6,728	2,813
1963	6,406	2,413	281	175	6,687	2,588
Stocks Dec. 31:						
1954–58 (average)	4,962	2,947	[2] 349	[2] 277	5,311	3,224
1959	3,057	1,387	347	244	3,404	1,631
1960	2,839	1,270	316	212	3,155	1,482
1961	2,546	1,212	258	167	2,804	1,379
1962	3,588	([3])	143	([3])	3,731	([3])
1963	2,908	([3])	172	([3])	3,080	([3])

[1] Includes Canadian, 1954–55 and 1957–58.
[2] Includes Canadian.
[3] Data not available.

TABLE 7.—Built-up mica[1] sold or used in the United States, by products

(Thousand pounds and thousand dollars)

Product	1962		1963	
	Quantity	Value	Quantity	Value
Molding plate	1,105	$2,639	1,143	$2,965
Segment plate	1,253	2,951	1,214	2,917
Heater plate	506	1,532	524	(2)
Flexible (cold)	573	1,812	602	1,755
Tape	1,293	5,992	1,441	5,911
Other	94	523	83	2,065
Total	4,824	15,449	5,007	15,613

[1] Consists of alternate layers of binder and irregularly arranged and partly overlapped splittings.
[2] Included with "Other" to avoid disclosing individual company confidential data.

TABLE 8.—Ground mica sold by producers in the United States, by uses

Use	1962		1963	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Roofing	38,767	$1,199	38,980	$1,370
Wallpaper	783	118	1,269	188
Rubber	7,081	803	6,979	728
Paint	20,801	1,806	23,597	1,890
Plastics	3,624	198	(1)	(1)
Welding rods	1,447	78	1,169	58
Joint cement	21,778	1,524	24,625	1,603
Well drilling	12,895	420	(1)	(1)
Other uses[2]	6,611	343	20,632	968
Total	113,787	6,489	117,251	6,805

[1] Included with "Other uses" to avoid disclosing individual company confidential data.
[2] Includes mica used for molded electric insulation, house insulation, Christmas tree snow, annealing, and other purposes.

PRICES

Prices offered by mica fabricators for domestic clear sheet mica (roughly trimmed), as reported in E&MJ Metal and Mineral Markets, remained unchanged from 1962 and 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 throughout the year in the E&MJ Metal and Mineral Markets at $30 to $40 per short ton, depending on quality.

Prices listed for dry- and wet-ground mica remained unchanged since March 1956.

TABLE 9.—Price of dry- or wet-ground mica in the United States in 1963 [1]

Mica	Value	Mica	Value
Dry-ground:		Wet-ground [2]—Continued	
Paint, 100 mesh	4	Rubber	8
Plastic, 100 mesh	4	Rubber, less than carlots [3]	8¾
Roofing, 20 to 80 mesh	3	Wallpaper	8¾
Wet-ground: [2]		Wallpaper, less than carlots [3]	9
Biotite	6½	White, 5 to 10 microns	8¼
Biotite, less than carlots [3]	7¼	White, 5 to 10 microns, less than carlots [3]	9
Paint or lacquer, 325 mesh	8¼		
Paint or lacquer, 325 mesh, less than carlots [3]	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

Imports.—Total imports of all forms of mica for consumption were about 26 percent greater than in 1962. Almost all classes of manufactured mica showed a decline in quantities imported. Unmanufactured classifications showed an increase or remained about the same. Total value declined about 21 percent. This decline was due primarily to the lower valuation of sheet mica.

Exports.—Total exports of mica and mica products decreased slightly. Ground mica accounted for the bulk of the exports and decreased about 183,000 pounds. Exports of unmanufactured mica rose about 38 percent. Exports of other manufactured mica exceeded 200,000 pounds.

TABLE 10.—U.S. imports and exports of mica

Year	Imports for consumption								Exports	
	Uncut sheet and punch		Scrap		Manufactured		Total		All classes	
	Pounds	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1954–58 (average)	1,911,673	$3,746	6,115	[1] $74	5,150	$7,604	12,221	$11,424	4,326	$1,541
1959	3,220,412	7,305	4,644	57	5,042	7,443	11,296	14,805	5,102	1,239
1960	1,088,021	2,081	6,240	86	4,266	6,139	11,050	8,306	4,012	1,311
1961	852,648	1,841	3,024	41	3,763	6,115	7,213	7,997	3,799	1,227
1962	[2] 1,110,739	[2] 1,796	4,458	55	5,403	7,922	[2] 10,416	9,773	4,028	1,363
1963	1,133,521	1,615	8,150	132	4,353	5,950	13,070	7,697	4,021	1,392

[1] Data known to be not comparable with other years.
[2] Revised figure.

Source: Bureau of the Census.

TABLE 11.—U.S. imports for consumption of mica, by kinds and countries [1]

Year and country	Unmanufactured									
	Waste and scrap, valued not more than 5 cents per pound				Untrimmed phlogopite mica from which no rectangular piece exceeding 2 inches in size may be cut		Other			
	Phlogopite		Other				Valued not above 15 cents per pound, n.e.s.		Valued above 15 cents per pound	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1954-58 (average)	237,094	$2,679	11,993,573	$71,049	8,010	$1,890	142,485	$11,338	1,761,178	[2] $3,732,810
1959	-----	-----	9,287,998	56,825	-----	-----	132,420	7,872	3,087,992	7,297,452
1960	-----	-----	12,480,715	86,272	-----	-----	118,980	8,600	969,041	2,071,509
1961	96,138	1,212	5,951,448	40,053	-----	-----	68,619	4,085	784,029	1,837,127
1962	-----	-----	8,916,421	55,150	-----	-----	55,336	4,841	[3] 1,055,403	[3] 1,791,215
1963:										
North America:										
Canada	180,530	5,860	-----	-----	-----	-----	-----	-----	-----	-----
Mexico	-----	-----	-----	-----	-----	-----	-----	-----	21,819	20,284
South America:										
Argentina	-----	-----	-----	-----	-----	-----	110,793	2,386	45,229	18,707
Brazil	-----	-----	957,664	21,270	-----	-----	70,358	6,543	608,742	933,744
Europe:										
Switzerland	-----	-----	-----	-----	-----	-----	-----	-----	2,646	2,621
United Kingdom	-----	-----	-----	-----	-----	-----	-----	-----	132	1,913
Asia:										
Ceylon	-----	-----	-----	-----	-----	-----	-----	-----	2,100	1,494
India	-----	-----	14,111,697	93,526	-----	-----	-----	-----	[4] 196,231	[4] 493,535
Africa:										
British East Africa	-----	-----	-----	-----	-----	-----	-----	-----	39,657	87,053
French Somaliland	-----	-----	-----	-----	-----	-----	-----	-----	2,205	1,881
Malagasy Republic	44,092	1,500	-----	-----	-----	-----	-----	-----	30,622	39,877
Rhodesia and Nyasaland, Federation of	-----	-----	-----	-----	-----	-----	-----	-----	40	410
South Africa, Republic of	-----	-----	1,006,073	9,732	-----	-----	-----	-----	2,947	5,034
Total	224,622	7,360	16,075,434	124,528	-----	-----	181,151	8,929	952,370	1,606,553

[1] Changes in Minerals Yearbook 1962, p. 899 should read as follows: Valued above 15 cents per pound—India 248,167 pounds ($724,975); total all countries 1,055,403 pounds ($1,791,215).

[2] Data known to be not comparable with other years.

[3] Revised figure.

[4] Adjusted by the Bureau of Mines.

Source: Bureau of the Census.

TABLE 11.—U.S. imports for consumption of mica, by kinds and countries [1]—Continued

Year and country	Manufactured-films and splittings							
	Not cut or stamped to dimensions				Cut or stamped to dimensions		Total films and splittings	
	Not above 12/10,000 of an inch in thickness		Over 12/10,000 of an inch in thickness					
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1954-58 (average)	7,813,997	$3,077,270	2,214,854	$3,184,435	51,459	$877,293	10,080,310	$7,138,998
1959	7,059,064	2,806,063	2,726,667	2,643,361	80,696	1,261,977	9,866,427	6,711,401
1960	7,184,944	3,035,162	989,099	1,220,861	82,487	1,122,087	8,256,530	5,378,110
1961	5,800,568	2,572,106	1,469,972	1,812,709	67,116	1,140,572	7,337,656	5,525,387
1962	8,615,571	2,814,751	1,746,221	2,554,567	98,645	1,686,564	10,460,437	7,055,882
1963:								
North America:								
Jamaica			15,087	14,970	535	1,340	15,622	16,310
Mexico					5,132	108,382	5,132	108,382
South America:								
Argentina			1,323	1,435			1,323	1,435
Brazil	28,376	13,533	844,978	757,115	3,224	12,294	876,578	782,942
Europe:								
Germany, West					10	650	10	650
United Kingdom	100	841	2,773	17,971	7,257	128,263	10,130	147,075
Asia:								
Hong Kong					156	837	156	837
India	6,184,532	1,861,801	674,430	1,018,019	47,081	693,645	6,906,043	3,573,465
Japan	14,876	4,140	4,100	4,124	7,093	229,283	26,069	237,547
Africa:								
British East Africa			7,537	7,118			7,537	7,118
French Somaliland	35,889	31,324					35,889	31,324
Malagasy Republic	556,874	418,994	1,524	2,990			558,398	421,984
Total	6,820,647	2,330,633	1,551,752	1,823,742	70,488	1,174,694	8,442,887	5,329,069

Year and country	Manufactured-cut or stamped to dimensions, shape or form		Manufactured-other					
			Mica plates and built-up mica		All mica manufactures of which mica is the component material of chief value		Ground or pulverized	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1954-58 (average)	31,880	$45,303	45,198	$128,966	69,301	$286,508	72,648	$4,353
1959	5,310	9,144	30,403	29,065	135,326	690,088	46,049	2,965
1960	6,742	8,801	72,384	65,451	152,867	683,793	46,000	2,760
1961	793	1,617	57,609	49,966	105,777	537,270	23,000	1,380
1962	1,537	7,582	141,739	104,872	132,920	748,502	69,000	3,935
1963:								
North America:								
Canada					16,337	72,132	23,000	1,178
Jamaica					481	881		
Mexico	408	449			11,518	42,787		
South America: Brazil					33,678	159,460		
Europe:								
Belgium-Luxembourg			127,425	99,681	13,313	29,991		
France					787	26,699		
Italy					242	1,681		
Netherlands					3,169	15,525		
Norway							8,488	463
United Kingdom					7,896	80,192		
Asia:								
India	1,252	11,177			13,494	69,651		
Japan					1,283	8,986		
Total	1,660	11,626	127,425	99,681	102,198	507,985	31,488	1,636

[1] Changes in Minerals Yearbook 1962, p. 899 should read as follows: Valued above 15 cents per pound—India 248,167 pounds ($724,975); total all countries 1,055,403 pounds ($1,791,215).

TABLE 12.—U.S. exports of mica and manufactures of mica, by countries

Year and destination	Unmanufactured		Manufactured			
			Ground or pulverized		Other	
	Pounds	Value	Pounds	Value	Pounds	Value
1954-58 (average)	650,846	$68,700	7,644,500	$422,482	358,350	$1,050,119
1959	1,072,894	126,492	8,915,109	459,425	216,040	652,863
1960	701,926	113,101	7,077,245	370,217	243,354	828,461
1961	334,211	141,730	7,074,850	395,563	190,320	689,238
1962	430,856	166,268	7,427,420	432,013	197,441	765,005
1963:						
North America:						
Bahamas					687	1,671
Barbados					36	392
Canada	52,699	31,731	2,713,787	127,000	112,930	482,600
Canal Zone					1,141	3,543
Costa Rica			6,000	585		
Dominican Republic			149,787	9,886		
El Salvador	70	250	6,000	244		
Guatemala			38,284	2,360	1,400	1,497
Honduras					90	242
Jamaica	2,200	3,700				
Mexico	13,798	5,655	247,488	12,109	12,457	50,693
Netherlands Antilles					488	2,160
Panama	90	322	10,000	1,054	877	7,231
Trinidad and Tobago			15,000	1,475	328	532
South America:						
Argentina			13,200	992	6,617	15,054
Bolivia			30,000	2,400		
Brazil					7,059	16,017
Chile					2,018	10,860
Colombia	6,852	1,227	163,304	10,068	10,246	16,890
Ecuador			76,800	4,361		
Peru			261,402	13,892	2,166	7,577
Surinam			5,000	531		
Uruguay					440	1,491
Venezuela	110	278	343,834	22,049	3,946	16,994
Europe:						
Austria					154	930
Belgium-Luxembourg			259,791	19,125	104	979
Denmark			19,886	1,054	407	3,288
France			806,915	59,493	1,336	5,940
Germany, West	55,311	35,487	798,570	41,536	2,236	5,507
Greece			13,440	1,212	1,000	3,092
Iceland			10,000	754		
Italy	152,040	14,949	330,769	19,085	4,097	16,932
Netherlands	23,593	2,341	243,350	16,559	384	1,740
Norway					12,296	49,509
Spain			55,000	4,158	59	545
Sweden			35,260	3,205	2,446	10,818
United Kingdom	13,204	6,319	37,900	3,032	1,656	7,137
Asia:						
Bahrein					154	322
Hong Kong	656	826	16,000	1,280	1,226	6,146
India	592	1,490	12,307	946	2,039	15,448
Indonesia			13,852	1,288		
Israel	7,373	2,150			447	1,535
Japan	254,713	37,364	100,000	4,760		
Korea, Republic of					45	179
Lebanon			34,257	1,086		
Pakistan	801	2,016	15,400	900	162	1,272
Philippines	10,000	900	125,599	10,662	1,142	3,973
Saudi Arabia					132	1,300
Taiwan			4,000	320		
Thailand			4,000	320		
Turkey	325	568				
Viet-Nam					96	550
Africa:						
Congo, Republic of the, and Ruanda-Urundi			9,050	534	248	624
Morocco			2,800	224		
South Africa, Republic of			150,396	8,430	250	2,166
United Arab Republic (Egypt)			26,400	2,310		
Oceania:						
Australia			33,600	1,796	9,204	55,407
New Zealand			6,000	234		
Total	594,427	147,573	7,244,428	413,309	204,246	830,783

Source: Bureau of the Census.

WORLD REVIEW [2]

World mica production was estimated at 400 million pounds, only slightly increased from 1962.

Brazil.—During 1963, Brazil exported about 1,380 tons of mica. Classification of exports was not available. Valuation of the exports in dollars was not feasible owning to the wide fluctuation of Brazilian currency during the year.

The U.S. Department of Agriculture announced a barter project with Brazil which included some block mica.

Canada.—During 1962, phlogopite mica was produced in southwestern Quebec and southeastern Ontario. Sheet and dry-ground scrap phlogopite was mined by Blackburn Brothers, Ltd., near Cantley, Quebec, a short distance from Ottawa. The Magcobar Mining Co., Ltd., produced ground muscovite at Rosalind, Alberta, from a muscovite schist obtained from Cedarside in east-central British Columbia. Canada continued to depend on India for muscovite sheet and on the United States for wet-ground muscovite.[3]

India.—Exports of all varieties of unmanufactured mica were about 37,600 tons, valued at about $18.6 million. This was an increase of 3,600 tons in quantity, but a decrease of $1.4 million in value, from the 1962 figures. About 48 percent of the exports consisted of block, film, and splittings.

The annual general meeting of the Mica Export Promotion Council drew attention to the disorganization of the mica trade which has been the major factor responsible for the difficulties of the Indian mica industry. Mica exports have increased, but earnings have fallen. It has been reported that 30 percent of the mines have ceased production. The low price for mica was blamed on poor quality-control of exports which obligated the exporter to accept the purchaser's determination of the consignment's grade. The Central Government banned exports on a consignment basis. In addition, institution of a quality-control system and preshipment inspection was advocated.[4]

The Central Glass and Ceramics Research Institute of Calcutta has developed a mica-base, corrosion-resistant lubricating grease, and an apparatus for the rapid classification of mica. The Institute also is investigating the use of mica in aluminum, roadmaking, and fire-resistant paints.[5]

Korea, Republic of.—A report reviewed the locations and deposits of mica in Korea.[6]

Malagasy Republic.—Malagasy continued to be the world's largest supplier of phlogopite mica, exporting 164,000 pounds of block, splittings, and scrap, valued at about $929,000. During 1963, mica mining decreased owing to the termination of U.S. stockpile purchases. Employment in splitting shops decreased about one-third. The con-

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[2] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

[3] Reeves, J. E. Mica: 1962 Preliminary Report. Canada Dept. Mines and Tech. Surveys, Miner. Proc. Div. (Ottawa, Canada), May 1962, p. 1.

[4] Journal of Mines, Metals and Fuels (Calcutta, India). V. 9, No. 9, September 1963, p. 22.

[5] Bureau of Mines. Mineral Trade Notes. V. 57, No. 6, December 1963, pp. 32–33.

[6] Gallagher, David. Mineral Resources of Korea. USOM/Korea, Min. Branch, Ind. and Min. Div., v. 4B, 1963, pp. 103–109.

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TABLE 13.—World production of mica by countries [1] [2]

(Thousand pounds)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada (shipments):						
Block	82	49	176	154		
Splittings	4	---	---	22	1,204	1,069
Ground	1,133	591	791	1,433		
Scrap	375	174	734	205		
United States (sold or used by producers):						
Sheet	710	706	587	526	363	103
Scrap	179,440	203,082	195,824	198,088	215,404	218,646
South America:						
Argentina:						
Sheet	254	110	190	119	273	99
Scrap	29	---	---	---	---	---
Brazil	3,205	2,553	4,440	9,101	3,885	[3] 2,758
Europe:						
Austria [4]	342	216	317	194	33	---
France	26	670	686	304	190	[5] 190
Norway, including scrap	3,990	12,059	6,393	7,716	2,205	---
Spain	22	11	(6)	---	---	---
Sweden (ground)	397	328	348	---	---	---
Yugoslavia	[7] 11	4	4	9	22	9
Asia:						
India (exports):						
Block	6,100	6,305	5,216	4,592	4,396	3,979
Splittings	14,632	15,988	17,469	18,208	18,838	15,595
Scrap	25,882	29,242	42,829	35,355	[8] 45,523	[8] 55,547
Taiwan, including scrap	18	(6)	---	---	---	---
Africa:						
Angola:						
Sheet	40	20	26	4	---	---
Scrap and splittings	681	384	721	51	108	---
Kenya	4	22	2	(6)	2	2
Malagasy Republic (phlogopite):						
Block	123	269	256	223	181	214
Splittings	1,367	1,922	1,973	2,002	2,780	1,914
Morocco:						
Sheet	2	---	---	---	---	---
Scrap	4	---	---	---	---	---
Mozambique, including scrap	26	13	2	4	2	---
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia, Sheet	4	(6)	(6)	---	---	---
Southern Rhodesia:						
Block	126	106	90	64	33	57
Crude and scrap	---	---	754	101	172	227
South Africa, Republic of:						
Sheet	4	(6)	2	2	2	40
Scrap	5,088	3,761	6,711	5,441	4,901	4,683
South-West Africa	---	234	---	---	150	1,197
Sudan:						
Block	[9] 79	882	---	---	---	---
Scrap						
Tanganyika (exports):						
Sheet	141	117	179	196	218	236
Scrap	196	190	---	---	---	---
Oceania: Australia:						
Block	49	33	9	---	---	---
Scrap	44	187	648	185	---	---
Damourite	1,144	1,100	1,252	1,138	1,087	[5] 1,100
World total (estimate) [1] [2]	310,000	350,000	365,000	365,000	390,000	400,000

[1] Mica is also produced in China, Rumania, and U.S.S.R., but data on production are not available; estimates for these countries are included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Exports.
[4] Including reclaimedf rom dumps; in 1961 and 1962 from dumps only.
[5] Estimate.
[6] Less than 500 pounds.
[7] Average annual production 1956–58.
[8] Includes condenser film as follows: 1962, 412 thousand pounds; 1963, 234 thousand pounds.
[9] Average annual production 1957–58.

tinuance of the industry is dependent on the creation of new markets for Malagasian phlogopite mica.[7]

Tanganyika.—The principal producer, H. Strickland, operated in the Bundali Hills of the Southern Highlands Province and exported directly to the United Kingdom. Attempted large-scale mica production was abandoned by the Anglo-American Vulcanized Fiber Co., Ltd., in the Tungwa area of the Southern Highlands Province.[8]

TECHNOLOGY

Natural Mica.—Publications have been issued describing some pegmatites of South Dakota and associated deposits of mica.[9] Several geological maps have been issued showing mica deposits and mines in North Carolina.[10]

Phlogopite mica deposits of Malagasy were described in two reports.[11]

The significance of mica and feldspars in granite was discussed. Separate thermodynamic stages (magmatic and hydrothermal) were suggested for the formation of feldspars and micas. Sometimes the feldspars are thought to indicate more extensive metamorphism than the micas.[12]

Microscopic and chemical investigations were performed on biotite in granitic rocks of the Kirovograd, Zhitomir, and Korosten regions of the U.S.S.R. Crystallochemical formulas for the biotite were derived.[13]

The heat capacity of muscovite mica was measured from 50° to 298° K.[14]

An investigation was carried out to determine the feasibility of recovering fine mica from an impounded tailing obtained from a crushing and screening operation. Conventional methods yielded concentrate assaying about 95 percent mica from material that contained 17 percent mica. Test results were verified by the operation of a small continuous flotation pilot plant.[15]

Samples of muscovite of three different color varieties were subjected to heat treatments at temperatures up to 600° C. The effects on

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[7] Bureau of Mines. Mineral Trade Notes. V. 58, No. 4, April 1964, pp. 36–39.
[8] Bureau of Mines. Mineral Trade Notes. V. 57, No. 4, October 1963, p. 42.
[9] Kupfer, D. H. Geology of the Calamity Peak Area, Custer County, South Dakota. U.S. Geol. Survey Bull. 1142–E, 1963, 23 pp.
Redden, J. A. Geology and Pegmatites of Fourmile Quadrangle, Black Hills, South Dakota. U.S. Geol. Survey Prof. Paper 297–D, 1963, pp. 199–291.
[10] Bryant, Bruce. Geology of the Blowing Rock Quadrangle, North Carolina. U.S. Geol. Survey, Quad. May GQ–243, 1963.
Overtstreet, W. C., J. W. Whitlow, A. M. White, and W. R. Griffitts. Geologic Map of the Southern Part of the Casar Quadrangle, Cleveland, Lincoln and Burke Counties, North Carolina. U.S. Geol. Survey Miner. Inv. Field Studies Map MF–257, 1963.
Overstreet, W. C., R. G. Yates, and W. R. Griffitts. Geology of the Shelby Quadrangle, North Carolina. U.S. Geol. Survey Misc. Geol. Inv. Map I–384, 1963.
Yates, R. G. Preliminary Geologic Map of the Northwest Quarter of the Shelby Quadrangle, Cleveland and Rutherford Counties, North Carolina. U.S. Geol. Survey Miner. Inv. Field Studies Map MF–258, 1963.
[11] American Chemical Society. Chemical Abstracts. V. 59, No. 3, Aug. 5, 1963, col. 2522.
Murdock, Thomas G. Mineral Resources of the Malagasy Republic. BuMines Inf. Circ. 8196, 1963, pp. 123–129.
[12] American Chemical Society. Chemical Abstracts. V. 59, No. 6, Sept. 16, 1963, col. 6144.
[13] American Chemical Society. Chemical Abstracts. V. 58, No. 7, Apr. 1, 1963, col. 6582.
[14] Weller, W. W., and E. G. King. Low-Temperature Heat Capacity and Entropy at 298.15° K of Muscovite. BuMines Rept. of Inv. 6281, 1963, 4 pp.
[15] Browning, James S., and Thomas L. McVay. Concentration of Fine Mica. BuMines Rept. of Inv. 6223, 1963, 7 pp.

apparent optic axial angle, absorption spectrum, and color of the specimens were observed. Substantial spectral changes occurred with heat treatment. Axial angle variation depended on the severity of the thermal treatment and the variety of the material. Color variation again was dependent on thermal treatment.[16]

Muscovite mica from the Harts Range of Central Australia was studied. Absorption, optical crystallographic, and chemical studies were made of this material. The specimens tested were classified on the basis of absorption characteristics.[17]

Samples of mica from various sources were etched in hydrofluoric acid, and the patterns were studied by optical and light profile techniques in an attempt to determine the growth history of the crystals. Parameters of the etched pits were observed, and the pitting could be classified into four main categories. Mechanisms of crystal growth, based on these observations, were discussed.[18]

A sericite mica, free of unfavorable characteristics such as high cost and difficulty in wetting, has been marketed. The material was reported to disperse easily in aqueous and oleoresinous paint vehicles. The sericite improved the paint film's toughness and produced flatting and good suspension in paint.[19]

Muscovite was treated with molten lithium nitrate at 300° C for the removal of interlayer potassium. A decrease in the apparent b-axis length was observed as a function of the potassium content over a range of 8.8 to 0.7 percent potassium. The b-axis of one variety of mica decreased from 9.024 to 8.988 A as the potassium content changed from 8.79 to 3.31 percent.[20]

The incorporation of mica into the formula of paints based on cashew-nutshell liquids improved the corrosion resistance of the paint.[21]

The crystal structure of an iron-rich mica has been developed by least square and Fourier techniques. The crystal structure was monoclinic, and unit cell dimensions were given. Two formulas were given for the weight of the unit cell.[22]

Reconstituted Mica.—A method for making lamellar sheets of mica by an electrophoretic technique using small particle size synthetic mica was patented. Synthetic fluorphlogopite was ground to a small particle size range of 5 to 25 microns. The small particles were separated, suspended in a suitable medium, deposited electrophoretically on a metallic electrode, dried, and stripped.[23]

The electrophoretic deposit of mica on different types of anodes was studied on a laboratory scale. Depositions were made on anodes

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[16] Ruthberg, Stanley. Thermal Behavior of Muscovite Sheet Mica. NBS J. Res., v. 76A (Phys. and Chem.), No. 6, November–December 1963, pp. 585–590.

[17] Finch, J. A Colorimetric Classification of Australian Pegmatitic Muscovite. Am. Mineral., v. 48, No. 5–6, May–June 1963, pp. 525–554.

[18] Patel, A. R., and S. Ramanathan. Comparative Study of the Etch Patterns on Muscovite From Different Sources. Am. Mineral., v. 48, No. 5–6, May–June 1963, pp. 691–698.

[19] Chemical Engineering. Mica. V. 70, No. 12, June 10, 1963, p. 112.

[20] Burns, Allan F., and Joe L. White. Removal of Potassium Alters b-Dimension of Muscovite. Science, v. 139, Jan. 4, 1963, pp. 39–40.

[21] American Chemical Society. Chemical Abstracts. V. 59, No. 9, Oct. 28, 1963, col. 10341.

[22] American Geological Institute. GeoScience Abstracts. V. 5, No. 1, January 1963, p. 33.

[23] McNeill, William, Joseph E. Chrostowski, and Thomas J. Mackus. Method of Making Lamellar Sheets of Fluorphlogopite Mica. U.S. Pat. 3,100,186, Aug. 6, 1963.

of various materials, with and without binders. The effect of pH and anode oxidation was considered.[24]

A new high-temperature laminate based on a proprietary bonding process combined with mica sheet has been developed and may fill the insulation gap between organic materials and ceramics. The material can be machined and molded and can be used to 1,400° F. The laminate also exhibits good thermal, electrical, and mechanical properties.[25]

Synthetic Mica.—The results of research on lead and barium disilicic fluormicas have been published. Unit cell parameters, optical data, chemical composition, density, melting point, and mechanical and dieletric properties were discussed. Both fluormicas exhibited monoclinic structure but would not cleave sufficiently to provide usable mica splittings. Ceramics with good machinability and excellent mechanical and dielectric properties were produced.[26]

Fluorphlogopite mica was synthesized in an electric furnace from readily available and inexpensive starting materials. Olivine, clay, feldspar, and sand were used. Melts of these starting materials yielded greater than 95 percent mica. The synthetic material made by this process was considered suitable for metallurgical use, but because of a metallic byproduct was not suitable for electrical or electronic usage.[27]

Water-swelling fluormicas and fluormontmorillonoids synthesized from inorganic materials were shown by the use of various laboratory techniques to be typical two-silica-layer, platy compounds. The properties and stability of the compounds were established, and a paper was produced from this synthetic material.[28]

Optical and X-ray studies of large crystals of fluorophlogopite showed that single crystals are not always formed and that polymorphs and twins occurred. The polymorphic and twinned forms were described and discussed.[29]

A fluorgermanium mica and a boron phosphate micalike orthorhombic crystal have been successfully synthesized. The materials were analyzed by polarizing microscope and X-ray diffraction methods. These methods verified the mica structure of the germanium crystal and disproved the structure of the boron phosphate material. Refractive index and cell constants were observed for both materials. The dielectric properties of the fluorgermanium mica were similar to those of fluorphlogopite up to 1,000° F.[30]

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[24] Hirayama, Chikara, and Daniel Berg. Studies on the Electrophoretic Deposition of Mica. Electrochem. Technol., v. 1, No. 7–8, July–August 1963, pp. 224–227.

[25] Missiles and Rockets. V. 13, No. 20, Nov. 11, 1963, p. 23.

[26] Miller, John L., Jr., I. L. Turner, and H. R. Shell. Lead and Barium Disilicic Fluormicas. BuMines Rept. of Inv. 6228, 1963, 9 pp.

[27] Shell, H. R., and Wilbur Warwick. Synthetic Mica From Low Cost Raw Materials. BuMines Rept. of Inv. 6077, 1963, 19 pp.

[28] Johnson, Robert C., and Haskiel R. Shell. Water-Swelling Synthetic Fluormicas and Fluormontmorillonoids. BuMines Rept. of Inv. 6235, 1963, 57 pp.

[29] Bloss, F. Donald, Gerald V. Gibbs, and David Cummings. Polymorphism and Twinning in Synthetic Fluorophlogopite. J. Geol., v. 71, No. 5, September 1963, pp. 537–547.

[30] Schatz, Elihu A. Isomorphous Substitution for Silicon in Fluorphlogopite. J. Am. Ceram. Soc.—Ceram. Abs., v. 46, No. 2, February 1963, p. 71.

Molybdenum

By R. W. Holliday [1]

MOLYBDENUM production capacity expanded in the United States and abroad during 1963, in response to continuing strong worldwide demand for the metal and its compounds. Substantial enlargement of domestic mining and milling operations was either in the advanced stages of planning or actually underway. Canada and Chile both increased their output of concentrate significantly, and Peru produced more than 1,000 tons of byproduct molybdenite concentrate from a new copper mine. Growth of foreign steel production assured a sustained, heavy demand for molybdenum, and at yearend indications were that 1964 might well be the first in a series of recordbreaking years for this important mineral commodity.

TABLE 1.—Salient molybdenum statistics

(Thousand pounds of contained molybdenum and thousand dollars)

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Concentrate:						
Production	55, 947	50, 956	68, 237	66, 563	51, 244	65, 011
Shipments	57, 065	51, 603	69, 941	66, 753	50, 506	65, 839
Value [1]	$62, 573	$64, 655	$87, 406	$87, 925	$69, 333	$91, 096
Consumption	35, 283	37, 448	44, 784	42, 261	40, 990	49, 241
Imports for consumption	63					
Stocks, Dec. 31: Mine and plant	4, 741	4, 074	3, 481	2, 815	3, 490	2, 436
Primary products:						
Production	34, 385	36, 294	43, 427	41, 050	40, 074	48,756
Shipments	35, 001	41, 658	45, 777	47, 106	46, 673	49, 599
Consumption	[2] 17, 549	32, 350	31, 837	32, 621	35, 674	37, 478
Stocks, Dec. 31: Producer	4, 654	5, 958	8, 157	5, 074	3, 068	4, 504
World: Production	70, 600	[3] 71, 500	[3] 89, 100	[3] 88, 200	[3] 75, 100	91, 600

[1] Largely estimated by Bureau of Mines.
[2] 1956–58 only.
[3] Revised figure.

DOMESTIC PRODUCTION

Molybdenum Mines.—American Metal Climax, Inc. produced 47,424,000 pounds of molybdenum in a molybdenite concentrate, according to the annual report to its stockholders. The mine produced an average 35,500 tons of crude ore per day and a total of 12,782,000 tons during the year. The Climax Molybdenum Company a Division of

[1] Commodity Specialist, Division of Minerals.

American Metal Climax, Inc., initiated a $40 million program of expansion in Colorado. A new plant at Climax for the hydrometallurgical recovery of molybdenum from oxide ores was expected to produce 3 million pounds of molybdenum annually by 1966. Production from Ceresco Ridge, an ore zone contiguous to the Climax mine, was scheduled for 1965 at the rate of 5,000 tons per day. Development work started at the Urad mine in Clear Creek County, Colo. The Urad mine has a long history of production by selective mining from vein deposits. The new development, presumably, will utilize a bulk method to produce a larger tonnage of relatively low grade ore, although details were not announced. Peak production of about 5,000 tons per day was expected by 1967.

The Molybdenum Corporation of America reportedly was readying plans for large scale production from the Questa mine in New Mexico. This property also has a long history of production by selective mining methods and is expected to convert to bulk mining methods.

Exploration of the Apex deposit, owned by Nye Metal Inc., was initiated early in 1963 under terms of a contract with the Office of Minerals Exploration, U.S. Department of the Interior. The deposit is near the town of Apex in Gilpin County, Colo.

Byproduct Sources.—Molybdenite was recovered as a byproduct from copper mines in Arizona, Nevada, New Mexico, Utah, and from one tungsten mine in California. Molybdenum from these sources comprised 27 percent of the total domestic output.

Two new operations expected to be producing sometime in 1964, were to add 3 million or more pounds per year to the byproduct total, depending on the recovery ratios and ore tenor. Duval Corp. continued development of its Ithaca Peak copper-molybdenum property, northwest of Kingman, Ariz. Production, expected ultimately to reach 12,000 tons per day, was scheduled to begin in 1964. Molybdenum content was reported to be about 0.9 pound per ton of crude ore. In December, American Smelting and Refining Company announced plans for a molybdenum recovery unit at its Mission copper mine in Pima County, Ariz. Initial production was scheduled for late 1964. This mine produced more than 6 million tons of crude ore in 1962.

Two firms (Mines Development, Inc. of Edgemont, S. Dak., and Kermac Nuclear Fuels Corp., Grants, N. Mex.) recovered molybdenum from composites of uranium bearing ores and the ash residues of uranium bearing lignite.

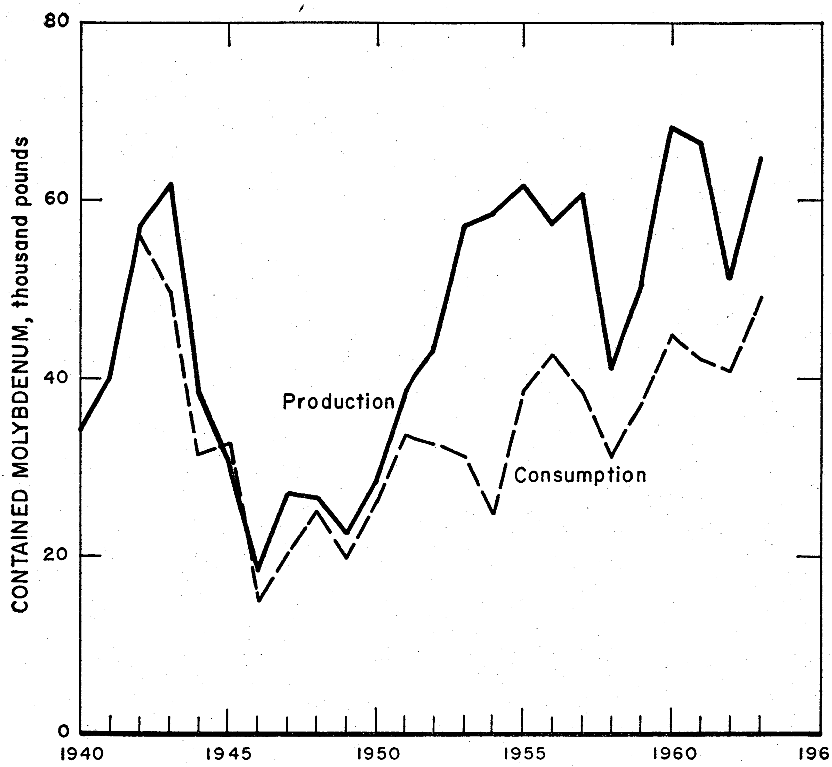

FIGURE 1.—Domestic molybdenum concentrate production, 1940–63, and consumption, 1942–63.

CONSUMPTION AND USES

In 1963 domestic consumption of concentrate was at a record peacetime rate. About 6.4 million pounds was exported in the form of molybdic oxide, ferromolybdenum, or other intermediate products for conversion to final form in foreign plants.

Consumption of such products in the United States increased from 35.7 million pounds in 1962 to the 37.5 million pounds in 1963 shown in table 3.

The expansion in steel production plus the trend toward better quality steel were reflected in greater use of molybdenum by the steel industry. Use in ferrous alloys (except high-speed steel) increased, comprising 83 per cent of total molybdenum consumption in 1963 compared with 80 percent of the total in 1962.

Molybdenum-tungsten alloys and the new TZM alloy of molybdenum containing small amounts of titanium and zirconium, reportedly found increasing demand during the year.

Improved quality and a wider range in the available sizes of molybdenum sheet were noteworthy advances announced by several firms.

Molybdenum was used extensively in catalysts according to a two-part report.[2] Petroleum refiners were said to consume $105 million

[2] Chemical Week. Catalysts, Part I. V. 93, No. 7, Aug. 17, 1963, pp. 50–63. Chemical Week. Catalysts, Part II. V. 93, No. 8, Aug. 24, 1963, pp. 51–64.

of catalysts yearly (all types) and chemicals producers consumed $90 million worth. The oil industry (hydrotreating process) was estimated to consume 4.1 million pounds of catalysts containing 15 percent of molybdenum. This would total about 600,000 pounds compared with consumption in catalysts, reported to the Bureau of Mines, of 688,000 pounds.

Other uses for molybdenum were in the electronics industry, in pigments, in catalysts, and in fertilizer.

Technical grade molybdic oxide (roasted concentrate) was the raw material for producing all types of molybdenum salts and compounds and was the form most used for addition of molybdenum to iron or steel. Purified molybdic oxide, produced from the technical grade by sublimation or by chemical means, was used for producing metal powder, chemically pure salts and compounds, and master alloys used in manufacturing high-temperature alloys.

Consumption of technical and purified molybdic oxide comprised 66 percent of the domestic consumption of molybdenum products. Consumption of ferromolybdenum accounted for 24 percent.

TABLE 2.—Production, shipment, and stocks of molybdenum products in the United States

(Thousand pounds of contained molybdenum)

	Product					
	Molybdic oxide [1]		Metal powder		Ammonium molybdate	
	1962	1963	1962	1963	1962	1963
Received from other producers	3,948	1,824	11	60	484	335
Gross production during year	36,748	44,951	2,586	1,679	2,024	1,615
Used to make other products listed here	8,922	10,550	227	200	1,839	1,143
Net production	27,826	34,401	2,359	1,479	185	472
Shipments:						
Domestic consumers	29,264	29,490	2,302	1,595	659	663
Exports	3,519	5,937	4	----------	18	2
Total	32,783	35,427	2,306	1,595	677	665
Producer stocks, Dec. 31	1,694	2,492	463	419	156	298

	Product—Continued				Total	
	Sodium molybdate		Other [2]			
	1962	1963	1962	1963	1962	1963
Received from other producers	4	32	279	16	4,726	2,267
Gross production during year	366	462	9,338	11,943	51,062	60,650
Used to make other products listed here	----------	1	----------	----------	10,988	11,894
Net production	366	461	9,338	11,943	40,074	48,756
Shipments:						
Domestic consumers	433	469	10,008	10,940	42,666	43,157
Exports	2	3	464	500	4,007	6,442
Total	435	472	10,472	11,440	46,673	49,599
Producer stocks, Dec. 31	46	67	709	1,228	3,068	4,504

[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.

TABLE 3.—Consumption of molybdenum products by end uses in 1963

(Thousand pounds of contained molybdenum)

End use	Molybdic oxides [1]	Ferro-molybdenum [2]	Molybdenum metal powder	Ammonium molybdate	Sodium molybdate	Other [3]	Total 1963
Steel:							
High-speed	1,334	646				109	2,089
Hot-work tool	243	186				75	504
Other tool	246	181					427
Stainless	2,909	2,053				34	4,996
Other alloy [4]	15,896	1,848				129	17,873
Steel-mill rolls	1,741	166					1,907
Gray and malleable castings	439	2,834				14	3,287
Welding rods		238					238
High-temperature alloys	586	269	3			538	1,396
Molybdenum powder:							
Wire, rod, and sheet			822				822
Other (forging billets, etc.)	2	3	720			1	726
Chemicals:							
Inorganic pigments	519			11	24		554
Organic pigments	123			6	224	1	354
Catalysts	664			23	1		688
Miscellaneous [5]	80	687	34	24	9	783	1,617
Total	24,782	9,111	1,579	64	258	1,684	37,478
Stocks at consumer plants, Dec. 31	3,383	1,750	22	13	26	277	5,471

[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] Includes quantities that were believed used in producing high-speed and stainless steels because some firms failed to specify individual uses.
[5] Includes magnets, other special alloys, friction material, lubricants, pesticides, refractories, packings, etc.

STOCKS

The national (strategic) stockpile contained 79,043,336 pounds of molybdenum on December 31, 1963, reduced during the year by the 5,019,466 pounds released to industry. The industrial inventory in concentrate and compounds, reported to the Bureau of Mines by individual firms totaled 12,411,000 pounds.

PRICES

Prices were unchanged during the year. E&MJ Metal and Mineral Markets quoted molybdenite concentrate and primary products per pound of contained molybdenum, f.o.b. point of shipment, as follows: Concentrate, 95 percent molybdenum sulfide (MoS_2), $1.40; molybdic trioxide (MoO_3), in bags $1.59, and in cans $1.60. Molybdenum powder in wholesale lots, carbon-reduced, was quoted at $3.35 and hydrogen-reduced at $3.55. Ferromolybdenum, per pound of contained molybdenum, 5,000 pounds or more, f.o.b. New York (58 to 64 percent molybdenum), powdered, packed, was quoted at $1.95; other sizes, packed, at $1.89.

FOREIGN TRADE

Imports.—There were no imports for consumption of molybdenum ore and concentrate into the United States. The following import data are not strictly comparable with earlier years because of changes in the tariff classifications, effective August 31, 1963:

Molybdenum or molybdenum carbide, ingots, shot, bars, or scrap imports totaled 344,886 pounds valued at $152,994; molybdenum sheets, wire, or other forms not specifically provided for totaled 16,960 pounds valued at $172,844; ferromolybdenum (molybdenum content) totaled 73,728 pounds valued at $174,962.

Exports.—Exports of molybdenum in ore and concentrate (including roasted concentrate) increased in quantity by 71 percent and in value by 72 percent compared with 1962. West Germany received 23 percent of the total; United Kingdom received 22 percent; France received 18 percent; Japan received 16 percent; Austria received 8 percent; and 16 other countries together received the remaining 13 percent. The increase represented a substantial recovery from the very low 1962 level resulting from a supply shortage.

Ferromolybdenum, valued at $379,173, was exported to 12 countries; 53 percent was shipped to Canada and 18 percent to Japan. Molybdenum wire, bare, except welding rods and wires, totaled 30,892 pounds valued at $631,397; of this total the U.S.S.R. received 17,837 pounds valued at $307,898. Molybdenum powder exports of 16,741 pounds, valued at $57,674, were exported mostly to Sweden. Molybdenum metal and alloys in crude form and scrap were exported mostly to Canada and totaled 139,202 pounds valued at $178,542. Semifabricated forms, not elsewhere classified, totaled 9,109 pounds valued at $109,990.

TABLE 4.—Molybdenum reported by producers as shipments for export from the United States

(Thousand pounds of contained molybdenum)

Product	1962	1963
Molybdenite concentrate	10,112	18,825
Molybdic oxide	3,519	5,937
All other primary products	488	505

TABLE 5.—U.S. exports of molybdenum products

(Pounds, gross weight)

Product	1962	1963
Ferromolybdenum [1]	189,823	239,034
Metal and alloys in crude form and scrap	75,211	139,202
Wire	12,088	30,892
Powder	25,219	16,741
Semifabricated forms (mainly rods, sheets, and tubes)	8,961	9,109

[1] Ferromolybdenum contains about 60 to 65 percent molybdenum.

Source: Bureau of the Census.

Tariff.—Duties on molybdenum were published in Tariff Schedules of the United States Annotated (1963), issued by the United States Tariff Commission and effective August 31, 1963. Selected items are listed in table 7.

TABLE 6.—U.S. exports of molybdenum ore and concentrate (including roasted concentrate), by countries

Destination	1962		1963	
	Molybdenum content (pounds)	Value	Molybdenum content (pounds)	Value
North America:				
Canada	777, 560	$983, 865	689, 561	$915, 305
Mexico	5, 977	7, 223	3, 047	4, 550
Total	783, 537	991, 088	692, 608	919, 855
South America:				
Argentina	1, 868	2, 370	766	1, 114
Brazil			4, 663	7, 019
Chile	16, 000	26, 400	9, 600	15, 456
Colombia			522	784
Venezuela			52, 676	77, 366
Total	17, 868	28, 770	68, 227	101, 739
Europe:				
Austria	1, 370, 777	2, 237, 578	2, 189, 892	3, 572, 473
Belgium-Luxembourg	1, 268	1, 820	24, 300	38, 285
Denmark	9, 514	14, 271		
France	2, 896, 360	4, 165, 260	4, 717, 796	6, 809, 024
Germany, West	1, 791, 970	2, 671, 481	6, 210, 251	9, 186, 938
Italy	1, 256, 715	1, 807, 367	1, 293, 833	1, 868, 202
Netherlands	224, 170	365, 005	60, 074	88, 790
Poland and Danzig	76, 496	144, 830		
Spain	4, 075	6, 221	5, 415	8, 147
Sweden	827, 104	1, 153, 379	1, 354, 195	2, 050, 506
Switzerland	29, 956	48, 438		
United Kingdom	4, 165, 884	5, 992, 140	5, 778, 771	8, 202, 668
Total	12, 654, 289	18, 607, 790	21, 634, 527	31, 825, 033
Asia:				
Hong Kong	1, 829	2, 798	2, 425	3, 752
India			590	836
Japan	2, 022, 258	3, 148, 998	4, 141, 581	6, 500, 265
Philippines	10, 400	17, 212	3, 680	6, 087
Taiwan	1, 453	2, 110		
Total	2, 035, 940	3, 171, 118	4, 148, 276	6, 510, 940
Africa: South Africa, Republic of	2, 458	3, 914	1, 428	2, 258
Oceania: Australia	60, 570	97, 898		
Grand total	15, 554, 662	22, 900, 578	26, 545, 066	39, 359, 825

Source: Bureau of the Census.

TABLE 7.—United States import duties

(Per pound)

Item	Articles	Rate of duty [1]
601. 33	Molybdenum ore (molybdenum content)	24 cents on molybdenum content.
607. 40	Ferromolybdenum (molybdenum content)	20 cents on molybdenum content plus 6 percent ad valorem.
	Molybdenum:	
628. 72	Unwrought (molybdenum content)	Do.
628. 74	Wrought	25.5 percent ad valorem.
	Chemical elements:	
419. 60	Molybdenum compounds (molybdenum content)	20 cents on molybdenum content plus 6 percent ad valorem.
420. 22	Potassium molybdate (molybdenum content)	Do.
421. 10	Sodium molybdate (molybdenum content)	Do.
473. 18	Molybdenum orange	10 percent ad valorem.
417. 28	Ammonium molybdate	20 cents on molybdenum content plus 6 percent ad valorem.

[1] Not applicable to communist countries.

WORLD REVIEW

Canada.—A comprehensive review[3] of the Canadian molybdenum industry was published in 1963. A second volume[4] described the geology of known deposits and a map accompanying this volume showed the locations of 282 occurrences.

TABLE 8.—World production of molybdenum in ores and concentrates by countries[1] [2]

(Thousand pounds)

Country[1]	1954–58 (average)	1959	1960	1961	1962	1963
Australia	2	(3)		2	2	
Austria	4					
Canada	761	749	767	771	818	1,000
Chile	2,914	5,064	4,083	4,037	5,256	6,704
China[4]	2,200	3,300	3,300	3,300	3,300	3,300
Japan	542	842	840	807	825	732
Korea, Republic of	37	49	97	71	163	154
Mexico	66	57	132	7	128	90
Norway	392	498	542	531	575	[4] 550
Peru	(3)				[5] 11	1,323
Philippines		97	62	249	249	234
Portugal	9					
South Africa, Republic of	[6] 11					
U.S.S.R.[4]	(7)	9,900	11,000	11,900	12,500	12,500
United States	55,947	50,956	68,237	66,563	51,244	65,011
Yugoslavia	4	[4] 4				
World total (estimate)[1]	70,600	71,500	89,100	88,200	75,100	91,600

[1] Molybdenum is also produced in Bulgaria, North Korea, Rumania, South-West Africa, and Spain, but production is negligible.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Less than 500 pounds.
[4] Estimate.
[5] Exports.
[6] Average annual production 1957–58.
[7] Data not available; estimate by author of chapter included in total.

British Columbia.—Active exploration in at least five localities suggested a substantial potential productive capacity. Noranda Mines, Ltd., announced plans for an 800-ton-per-day concentrator at its Boss Mountain mine in the Cariboo district of central British Columbia. Initial production was expected in 1964. Southwest Potash Corp., a subsidiary of American Metal Climax Co., was conducting a diamond-drilling campaign on Hudson Bay Mountain, near Smithers, British Columbia. Kennco Explorations incorporated a company known as British Columbia Molybdenum, Ltd., for exploration in the Alice Arm area. Endako Mines, Ltd., at Endako was being developed by Canadian Exploration, Ltd.[5] The Bethlehem Copper Corp., Ltd., at its Highland Valley property was reported to be investigating the feasibility of recovering byproduct molybdenite from copper ore.

Quebec.—Gaspe Copper Mines, Ltd., a subsidiary of Noranda Mines, Ltd., started shipping molybdenite concentrate from its plant at Murdochville during the last half of 1963. Production was reported as

[3] Schneider, V. B. Molybdenum. Mineral Resources Division, Canada Dept. Mines and Tech. Surveys (Ottawa), Mineral Report 6, 1963, 176 pp.
[4] Vokes, F. M. Molybdenum Deposits of Canada. Canada Dept. Mines and Tech. Surveys, Geological Survey of Canada, Economic Geology Report No. 20, 1963, 332 pp.
[5] Western Miner and Oil Review. The Discovery Post. V. 36, No. 9, September 1963, p. 18.

2,000 pounds of contained molybdenum per day from a flotation circuit that treated 500 tons per day of copper concentrate.

Molybdenite Corporation of Canada, Ltd., continued production from its Lacorne mine, 23 miles northwest of Val d'Or, Quebec. This firm held a substantial interest in Preissac Molybdenite Mines, Ltd., developing a molybdenite property on the east shore of Indian Peninsula, about 12 miles north of Cadillac.

Chile.—Production of molybdenite concentrate increased by 25 percent as compared with the previous year. Of 6,058 short tons produced, Chile Exploration Co. accounted for 2,743 tons; Andes Copper Mining Co., 1,738 tons; and Braden Copper Co., 1,577 tons. Exports of 4,916 tons were virtually equal to exports in 1962. Export destinations in the first quarter of 1963 were not available. During the last three quarters all exports were to Western Europe with West Germany (1,732 tons), Netherlands (586 tons), United Kingdom (493 tons), and Sweden (489 tons) receiving the largest quantities.

France.—According to the Bureau de Documentation Minière, molybdenum ore consumption has increased with the production of high grade steel in recent years. Consumption totaled 4,400 short tons (metal content) in 1961 compared with 2,800 tons in 1960.

Peru.—Southern Peru Copper Corp. produced 1,087 tons of concentrate containing 90.2 percent molybdenite (MoS_2). The plant opened in 1962 and operated throughout 1963.

U.S.S.R.—Increased productive capacity for molybdenum was evident in the announcement of two new operating plants, a copper-molybdenum combine in Agarak, Transcaucasia, and a large molybdenum "project" in Armenia. However, details were lacking.

A comparison [6] of U.S. and Soviet procedures for recovering molybdenite from copper ores was published. A conclusion was that ores in the Iron Curtain countries were higher in grade than the U.S. ores. However, because Soviet ores had a larger percentage of oxidized material, they were more difficult to treat than U.S. ores.

TECHNOLOGY

Results of research by the steel industry were evident in the growing use of molybdenum in alloy steels, which accounted for about 83 percent of the total domestic consumption of molybdenum in 1963. However, scientists explored many other fields of essential molybdenum research.

Investigators studied unalloyed molybdenum and nonferrous alloys in efforts to satisfy high-temperature and other special materials requirements. Other investigators worked in such diverse fields as electronics, catalysts, lubricants, and agriculture. Research also was active in exploration, mining research, and extractive metallurgy in 1963.

A comprehensive review [7] of the physical, mechanical, and metallurgical properties of molybdenum and nine of its alloys considered

[6] Crabtree, E. H. An Expert Compares Soviet Bloc and Western Copper-Molybdenum Recovery Practices. Eng. and Min. J., v. 164, No. 12, December 1963, pp. 81–83.

[7] Schmidt, F. F., and H. R. Ogden. The Engineering Properties of Molybdenum and Molybdenum Alloys. Battelle Memorial Inst., DMIC Rept. 190, Sept. 20, 1963, 284 pp.

most promising for high-temperature use was published. Three other reports [8] relating to molybdenum alloys were published by Defense Metals Information Center. One of these, DMIC Report 182, included a brief discussion of the "rhenium alloying effect" which has been found to improve both the workability and low-temperature ductility of molybdenum (as well as tungsten and chromium).

The use of molybdenum for special applications is illustrated by a molybdenum-30 percent tungsten alloy which exhibits exceptional resistance to molten zinc. This alloy and TZM, a molybdenum-0.5 percent titanium, -0.08 percent zirconium alloy, were considered to be among the more promising molybdenum base materials of construction for high-temperature use.

Fabrication studies comprised a substantial part of the research on molybdenum and its alloys. Reports describing numerous studies, including sheet rolling, extrusion, and property investigations were summarized in DMIC publications.[9]

An investigation of the problems involved in extruding refractory metals and the effects of die coatings, billet shapes, lubricants, extrusion ratios, and other factors was reported.[10] Successful conversion of refractory alloy ingots into the flats and bars needed for investigation was accomplished but additional research was recommended.

Significant improvement in the quality of commercially available molybdenum sheet was noted during the year as a result of improved techniques and installation of new industrial rolling facilities.

The Climax Molybdenum Co. announced plans for a $2.5 million laboratory at Ann Arbor, Mich., to be completed in 1964. The company also announced development of a new hydrometallurgical process for recovering molybdenum from the oxide minerals which heretofore could not be processed. The new process is expected to produce 3 million pounds of metal per year by 1966.

An old technique, use of composite materials, continued the giant strides that in recent years have revolutionized the structural materials industry. A review [11] outlined the current state of composite materials development. The concept includes such diverse combinations as paint on wood, metal alloys, honeycomb construction, and a variety of other combinations. Cladding, bonding, diffusion, dispersion, coating, fiber reinforcing, alloying, laminating, and powder compacting are listed as some, but possibly not all, of the ways to make a materials system. Molybdenum was used in alloys, in fiber reinforced material, in honeycomb cores for reentry structures, and other applications.

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[8] English, J. J. Binary and Ternary Phase Diagrams of Columbium, Molybdenum, Tantalum and Tungsten. Battelle Memorial Inst., DMIC Report 183 Supplement to DMIC Rept. 152, Feb. 7, 1963 (122 phase diagrams).

Evans, R. M. Designations of Alloys for Aircraft and Missiles. Battelle Memorial Inst., DMIC Memorandum 177, Sept. 4, 1963, 58 pp.

Jaffee, R. I., and G. T. Hahn. Structural Considerations in Developing Refractory Metal Alloys. Battelle Memorial Inst., DMIC Rept. 182, Jan. 31, 1963, 30 pp.

[9] Hauck, J. A. DMIC Review of Recent Developments Molybdenum and Molybdenum-Base Alloys. Battelle Memorial Inst., Jan. 4, 1963, 1 p.; Mar. 22, 1963, 2 pp.; June 28, 1963, 2 pp.; Sept. 27, 1963, 2 pp.

Imgram, A. G., and H. R. Ogden. The Effect of Fabrication History and Microstructure on the Mechanical Properties of Refractory Metals and Alloys. Battelle Memorial Inst., July 10, 1963, 65 pp.

Strohecker, D. E., and D. H. Owens. A Guide to the Literature on High Velocity Metalworking. Battelle Memorial Inst., DMIC Rept. 179, Dec. 3, 1962, 244 pp.

[10] Perlmutter, I., and Vincent De Pierre. Extruding Refractory Metals. Metal Prog., v. 84, No. 5, November 1963, pp. 90–95, 128, 130, 132, 134, 136.

[11] Steel. The Materials System. V. 153, No. 17, Oct. 21, 1963, pp. 89–112.

A report[12] summarizing information on refractory composites for use above 2,500° F. included reviews of the status of oxidation resistant coatings for molybdenum and a comprehensive reference volume[13] on high-temperature protective coatings.

Mines Development, Inc., of Edgemont, S. Dak., reported[14] recovery of byproduct molybdenum from a feed made up partly of ash residues derived from the burning of uranium-bearing lignite from North and South Dakota.

Molybdenum parts, or parts spray-coated with molybdenum, were said to give superior service in such applications as piston rings involving sliding friction. Presumably, traces of sulfur in the lubricating oil were beneficial rather than detrimental. According to one report, greatly increased bearing life, through use of molybdenum metal parts sliding against sulfur compounds, was indicated by the results of an investigation sponsored by the Bureau of Naval Weapons.[15] Several metallic sulfides, previously not considered to be useful as lubricants, showed a preferential lubricating effect with molybdenum.

A survey[16] of advances to date in the field of fused salt electrochemistry included sections on molybdenum and a bibliography listing 477 references.

The Bureau of Mines program included research on the separation of molybdenite from copper sulfides and on the recovery of rhenium from molybdenite concentrate. Work embracing a solvent extraction-electrolytic procedure for recovering rhenium was completed and a report published.[17] Other Bureau research in progress during the year involved electrolytic extraction of molybdenum, melting and casting studies, reduction and thermal decomposition of molybdenum compounds, and electrodeposition of molybdenum coatings. Two reports[18] on thermodynamic properties of molybdenum compounds were published.

Another published Bureau report[19] was one describing studies of the feasibility of employing low-temperature, nonaqueous baths for electrodepositing some of the refractory metals. Results of this study were considered negative in that no successful deposits were obtained.

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[12] Battelle Memorial Inst. Summary of the Seventh Meeting of the Refractory Composites Working Group (Mar. 12–14, 1963). DMIC Rept. 184, May 30, 1963, 48 pp.

[13] Huminik, John, Jr. High-Temperature Inorganic Coatings. Reinhold Publishing Corp., New York, 1963, 310 pp.

[14] Seeton, Frank A. Mines Development, Inc., Deco Trefoil, v. 27, No. 5, November–December 1963, pp. 7–18.

[15] Iron Age. Bearings Stand Up to High Heat as Metal and Sulfide Combine. V. 192, No. 1, July 4, 1963, pp. 88–89.

[16] Reddy, Thomas B. The Electrochemistry of Molten Salts. Electrochem. Technol., v. 1, No. 11–12, November–December 1963, pp. 325–351.

[17] Churchward, P. E., and J. B. Rosenbaum. Sources and Recovery Methods for Rhenium. BuMines Rept. of Inv. 6246, 1963, 16 pp.

[18] Weller, W. W., and K. K. Kelley. Low-Temperature Heat Capacities and Entropies at 298.15° K of Sodium Dimolybdate and Sodium Ditungstate. BuMines Rept. of Inv. 6191, 1963, 5 pp.

Wicks, C. E., and F. E. Block. Thermodynamic Properties of 65 Elements—Their Oxides, Halides, Carbides, and Nitrides. BuMines Bull. 605, 1963, 146 pp.

[19] Meredith, Robert E., and Thomas T. Campbell. Electrodeposition Studies of Molybdenum, Tungsten, and Vanadium in Organic Solvents. BuMines Rept. of Inv. 6303, 1963, 15 pp.

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Nickel

By Glen C. Ware[1]

CONSUMPTION of nickel in the United States in 1963 was 125,000 tons, 5 percent more than in 1962. The ferrous and nonferrous industries accounted for 68 percent of the total consumption.

Nickel imports were 3 percent less than in 1962, reflecting the cessation of imports for the stockpiles. Canada supplied 98 percent of the total imports; however, 7 percent of them came by way of Norway.

LEGISLATION AND GOVERNMENT PROGRAMS

The National Stockpile and Naval Petroleum Reserves Subcommittee of the Committee on Armed Services, U.S. Senate, 88th Congress, with Senator Stuart Symington as Chairman, conducted hearings on strategic and critical material stockpiles of the United States. The testimony of these hearings was published.[2]

Chapter III, part 13b dealt with Freeport Sulphur Co. nickel contracts DMP–105–106–134; part 25 dealt at length with Hanna Nickel Smelting Co. nickel contracts DMP–49–50–51; and part 26 dealt with Falconbridge Nickel Mines Ltd. contract DMP–60.

TABLE 1.—Salient nickel statistics

(Short tons)

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Mine production	8,040	13,374	14,079	13,133	13,110	13,394
Plant production:						
Primary [1]	6,634	11,606	[2] 14,303	11,176	11,217	11,432
Secondary	10,891	9,438	9,431	10,688	11,108	10,763
Imports for consumption	129,400	112,000	103,000	127,000	123,000	119,000
Exports	21,364	13,073	54,109	55,493	27,641	60,927
Consumption	106,779	112,661	108,159	118,515	118,677	124,478
Stocks Dec. 31: Consumer [3]	14,178	14,125	11,369	18,298	13,450	17,191
Price cents per pound	74	74	74	74–81¼	81¼–79	79
World: Production	271,000	314,000	359,000	[4] 403,000	401,000	384,000

[1] Comprises metal from domestic ore and nickel recovered as a byproduct of copper refining.
[2] Contains 1,773 tons of primary nickel produced from imported Cuban concentrate.
[3] Does not include scrap.
[4] Revised figure.

[1] Commodity specialist, Division of Minerals.
[2] U.S. Senate. Inquiry Into the Strategic and Critical Material Stockpiles of the United States. Hearings before the National Stockpile and Naval Petroleum Reserves Subcommittee of the Committee on Armed Services. 88th Cong., 1st sess., 1963, 126 pp.

DOMESTIC PRODUCTION

Primary Nickel.—Hanna Mining Co. produced all domestic mine output of nickel, 892,900 dry short tons of ore containing 13,400 tons of nickel. Hanna Nickel Smelting Co. at Riddle, Oreg., processed the ore into 21,800 tons of ferronickel, having a nickel content of 10,700 tons. In addition, refineries at Carteret and Perth Amboy, N.J., Laurel Hill, N.Y., El Paso, Tex., and Tacoma, Wash., recovered 707 tons of nickel in the form of sulfate as a byproduct of copper refining. Refined nickel salts (chiefly nickel sulfate) containing 2,766 tons of nickel were produced in the United States in addition to the nickel sulfate recovered as a byproduct of copper refining. Total production of refined salts was 3,473 tons (nickel content), and shipments to consumers contained 2,918 tons of nickel.

TABLE 2.—Nickel produced in the United States

(Short tons, nickel content)

	1954–58 (average)	1959	1960	1961	1962	1963
Primary:						
Byproduct of copper refining	543	493	623	625	648	707
Domestic ore	6,091	11,113	[1] 13,680	10,551	10,569	10,725
Secondary	10,891	9,438	9,431	10,688	11,108	10,763

[1] Contains 1,773 tons of primary nickel produced from imported Cuban concentrate.

Secondary Nickel.—In 1963, 10,800 tons of nickel was recovered from nonferrous scrap in the United States, 3 percent less than in 1962.

Nickel recovered from ferrous, nickel-base scrap is not included in the secondary-nickel tables. Ferrous, nickel-base, scrap alloys are those in which the metal of highest percentage is nickel, but which contain so much iron, chromium, cobalt, and other constituents of ferrous alloys that they must be classed as ferrous alloys. Examples are Inconel and Nichrome. Both nonferrous and ferrous nickel-base alloys may be used as alloying ingredients in ferrous alloys, but ferrous nickel-base alloys cannot be used to make nonferrous alloys.

Consumption of nonferrous, nickel-base scrap decreased to 12,700 tons, 4 percent less than in 1962.

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	1962	1963	Form of recovery	1962	1963
New scrap:			As metal	1,252	1,619
Nickel-base	3,460	3,616	In nickel-base alloys	2,037	2,079
Copper-base	1,713	2,005	In copper-base alloys	2,552	2,679
Aluminum-base	558	581	In aluminum-base alloys	901	998
Total	5,731	6,202	In ferrous and high temperature alloys [1]	2,154	1,087
Old scrap:			In chemical compounds	2,212	2,301
Nickel-base	4,469	3,646			
Copper-base	548	537	Total	11,108	10,763
Aluminum-base	360	378			
Total	5,377	4,561			
Grand total	11,108	10,763			

[1] Includes only nonferrous nickel scrap added to ferrous and high-temperature alloys.

TABLE 4.—Stocks and consumption of new and old nickel scrap in the United States in 1963

(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	166	1,072	753	294	1,047	191
Monel metal	366	1,499	505	979	1,484	381
Nickel silver [1]	641	3,774	313	3,377	3,690	725
Miscellaneous nickel alloys	9	4,537	7	4,525	4,532	14
Nickel residues	33	63	-------	9	9	87
Total	574	7,171	1,265	5,807	7,072	673
Foundries and plants of other manufacturers:						
Unalloyed nickel	167	2,307	1,637	668	2,305	169
Monel metal	169	578	123	495	618	129
Nickel silver [1]	3,630	7,886	8,133	55	8,188	3,328
Miscellaneous nickel alloys	23	513	-------	489	489	47
Nickel residues	643	2,171	1,948	282	2,230	584
Total	1,002	5,569	3,708	1,934	5,642	929
Grand total:						
Unalloyed nickel	333	3,379	2,390	962	3,352	360
Monel metal	535	2,077	628	1,474	2,102	510
Nickel silver [1]	4,271	11,660	8,446	3,432	11,878	4,053
Miscellaneous nickel alloys	32	5,050	7	5,014	5,021	61
Nickel residues	676	2,234	1,948	291	2,239	671
Total	1,576	12,740	4,973	7,741	12,714	1,602

[1] Excluded from totals because it is copper-base scrap, although containing considerable nickel.

CONSUMPTION AND USES

Nickel consumption was 124,500 tons, a 5-percent increase over the 1962 figure. Increases were experienced in all categories except nonferrous alloys and magnets, which had respective declines of 12 and 15 percent. Major uses of nickel made the following gains: stainless steels, 15 percent; electroplating, 10 percent; and high-temperature and electrical-resistance alloys, 5 percent.

The leading categories of nickel uses in 1963 were ferrous, 48 percent of the year's consumption; nonferrous, 20 percent; electroplating, 16 percent; high-temperature and electrical-resistance alloys, 11 percent; and all other uses, 5 percent.

TABLE 5.—Nickel (exclusive of scrap) consumed in the United States, by forms

(Short tons)

Form	1954–58 (average)	1959	1960	1961	1962	1963
Metal	80,707	87,751	87,399	101,394	103,485	110,365
Oxide powder and oxide sinter	17,155	20,710	19,392	15,883	13,760	12,461
Matte	7,432	2,899	17	16	3	2
Salts [1]	1,485	1,301	1,351	1,222	1,429	1,650
Total	106,779	112,661	108,159	118,515	118,677	124,478

[1] Figures do not cover all consumers.

TABLE 6.—Nickel (exclusive of scrap) consumed in the United States, by uses

(Short tons)

Use	1954-58 (average)	1959	1960	1961	1962	1963
Ferrous:						
Stainless steels	25,965	32,249	30,086	34,213	29,711	34,140
Other steels	16,084	18,342	15,331	18,238	18,608	19,727
Cast irons	4,950	4,857	4,605	4,649	5,503	5,901
Nonferrous [1]	29,579	25,606	26,567	28,789	28,215	24,794
High-temperature and electrical-resistance alloys	8,782	10,518	10,095	11,294	12,862	13,505
Electroplating:						
Anodes [2]	15,017	14,644	15,847	15,737	16,953	18,621
Solutions [3]	1,124	883	970	770	904	1,050
Catalysts	1,630	1,712	1,545	1,519	1,566	1,613
Ceramics	372	373	365	366	439	554
Magnets	807	1,028	778	773	910	777
Other	2,469	2,449	1,970	2,167	3,006	3,796
Total	106,779	112,661	108,159	118,515	118,677	124,478

[1] Comprises copper-nickel alloys, nickel silver, brass, bronze, beryllium alloys, magnesium and aluminum alloys, Monel, Inconel, and malleable nickel.
[2] Figures represent quantity of nickel used for production of anodes, plus cathodes used as anodes in plating operations.
[3] Figures do not cover all consumers.

TABLE 7.—Nickel (exclusive of scrap) in consumer stocks in the United States, by forms

(Short tons)

Form	1954-58 (average)	1959	1960	1961	1962	1963
Metal	11,351	9,567	9,009	12,199	12,477	15,575
Oxide powder and oxide sinter	2,059	4,334	2,143	5,856	783	1,395
Matte	330	24	7	5	9	6
Salts	438	200	210	238	181	215
Total	14,178	14,125	11,369	18,298	13,450	17,191

STOCKS

In addition to the consumer stocks reported in table 7, the Federal Government had in stockpile as of December 31, 1963, 228,361 tons of nickel, which included 167,097 tons in the national (strategic) stockpile and 61,264 tons in the Defense Production Act (DPA) inventory. Of the total amount, 50,000 tons was declared within the objective, 169,864 tons was declared in excess, and 8,497 tons still on order was also declared in excess.

PRICES

Nickel prices have remained firm throughout the year. Prices, including 1.25 cents U.S. import duty, were as follows:

	Cents
Inco, electrolytic, f.o.b. Port Colborne, Ontario	79
Falconbridge, electrolytic, f.o.b. Thorold, Ontario	79
Sherritt Gordon, briquets, f.o.b. Port Colborne, Ontario, or Fort Saskatchewan, Alberta	79

	Cents
Sherritt Gordon, powder, Niagara Falls, Ontario:	
Grades C and F	84
Grade S	79
Le Nickel, rondelles, at New York, and with freight equaled Port Colborne, Ontario	79
Hanna, nickel in ferronickel (no charge for 45 percent iron), Riddle, Oreg., with freight equaled oxide sinter	75.25
Nickel oxide sinter, at Buffalo, N.Y., or other established U.S. points of entry, on nickel plus cobalt content	75.25

FOREIGN TRADE

Imports.—The United States imported 119,000 tons of nickel in ore, matte, metal, oxide, slurry, and scrap, 3 percent less than in 1962. Of the total imports, 91 percent was nickel metal and 8 percent was nickel oxide. Canada provided 91 percent of the imports and Norway, 7 percent; the raw materials of the latter originated in Canada. France supplied 1,006 tons of nickel metal and 544 tons of nickel oxide; these were of New Caledonian origin.

Exports.—The United States exported 61,000 tons of nickel-bearing materials consisting mostly of nickel and nickel-alloy metals in scrap. This amounted to an increase of 120 percent compared with the 1962 figure. Shipments to Japan were 67 percent of the total; to Canada, 12 percent; to Italy, 11 percent; and to Sweden, United Kingdom, and West Germany 3 percent each.

Tariff.—The duty of 1.25 cents per pound of refined nickel was unchanged; nickel ore, oxide powder and oxide sinter, matte, slurry, and residues continued to enter duty free.

TABLE 8.—U.S. imports for consumption of nickel products, by classes

(Short tons)

Class	1954-58 (average)	1959	1960	1961	1962	1963
Ore and matte	10,759	4,071	184	(1)	14	34
Metal (pigs, ingots, shot, cathodes, etc.)[2]	95,156	82,888	79,662	115,985	[3] 115,972	108,127
Oxide powder and oxide sinter	32,963	[4] 30,062	[4] 24,584	14,613	8,661	12,887
Slurry [5]	102	839	4,477	258	406	1,753
Refinery residues [6]	492					
Scrap [2]	533	619	135	278	601	703
Total: Gross weight	140,005	118,479	109,042	131,134	[3] 125,654	123,504
Nickel content (estimated)	129,400	112,000	103,000	127,000	123,000	119,000

[1] Less than 1 ton.
[2] Separation of metal from scrap on basis of unpublished tabulations.
[3] Revised figure.
[4] Adjusted by Bureau of Mines.
[5] Nickel-containing material in powders, slurry, or any form, derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals.
[6] Reported to Bureau of Mines by importers.

Source: Bureau of the Census.

TABLE 9.—U.S. imports for consumption of new nickel products, by countries

(Short tons)

Country	Metal		Oxide powder and oxide sinter			
	1962	1963	1962		1963	
	Gross weight	Gross weight	Gross weight	Nickel content	Gross weight	Nickel content [1]
North America: Canada	106,432	98,319	8,511	6,410	12,191	9,357
South America: Brazil		1				
Europe:						
France	330	1,006	150	120	696	544
Germany, West	1,002	19				
Netherlands		15				
Norway	[2] 7,580	8,277				
United Kingdom	628	477				
Total	[2] 9,540	9,794	150	120	696	544
Asia: Japan					(3)	(3)
Oceania: French Pacific Islands		13				
Grand total	[2] 115,972	108,127	8,661	6,530	12,887	9,901

Country	Slurry and other [4]				Ore and matte			
	1962		1963		1962		1963	
	Gross weight	Nickel content	Gross weight	Nickel content	Gross weight	Nickel content	Gross weight	Nickel content
North America: Canada	406	[2] 107	1,640	567	14	8	1	(3)
South America: Colombia							33	1
Europe:								
Germany, West			3	2				
Greece			109	5				
Norway			1	(3)				
United Kingdom							(3)	(3)
Total			113	7			(3)	(3)
Grand total	406	[2] 107	1,753	574	14	8	34	1

[1] Effective Sept. 1, 1963, content no longer reported; September–December content estimated by Bureau of Mines.
[2] Revised figure.
[3] Less than 1 ton.
[4] 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.

Source: Bureau of the Census.

TABLE 10.—U.S. exports of nickel products, by classes

Class	1961		1962		1963	
	Short tons	Value	Short tons	Value	Short tons	Value
Ore, concentrates, and matte	1,766	$495,254	45	$15,923	12	$4,976
Nickel and nickel-alloy metals in ingots, bars, rods, sheets, plates, strips, and other crude forms	7,152	13,702,988	7,990	16,494,663	9,991	17,158,703
Nickel and nickel-alloy metal scrap	44,479	11,265,674	17,520	4,301,446	49,116	10,120,194
Nickel and nickel-alloy semifabricated forms, not elsewhere classified	1,037	3,980,160	803	3,462,592	714	3,198,688
Nickel-chrome electric-resistance wire except insulated	254	1,079,325	190	965,478	189	953,154
Nickel catalysts	805	1,455,809	1,093	1,963,293	905	1,748,599
Total	55,493	31,979,210	27,641	27,203,395	60,927	33,184,314

Source: Bureau of the Census.

WORLD REVIEW[3]

World output of nickel was 384,000 tons, 4 percent less than in 1962. The free world production was 271,000 tons, a decline of about 6 percent from last year. Of this total, Canada produced 81 percent; New Caledonia, 12 percent; and the United States, 4 percent.

TABLE 11.—World production of nickel by countries[1]

(Short tons)

Country	1954-58 (average)	1959	1960	1961	1962	1963
North America:						
Canada[2]	168,448	186,555	214,506	232,991	237,044	219,941
Cuba:						
Content of oxide	17,554	19,658	[3] 12,547	[4] 16,320	[4] 16,222	[4] 16,200
Estimated content of sulfide		200	1,600		2,080	2,200
United States:						
Byproduct of copper refining	543	493	623	625	648	707
Recovered nickel in domestic ore refined	6,091	11,113	11,907	10,551	10,569	10,725
Total	192,636	218,019	241,183	260,487	266,563	249,773
South America:						
Brazil (content of ferronickel)	65	80	105	110	115	[4] 115
Venezuela (content of ore)	[5] 23	29	14			
Total	88	109	119	110	115	[4] 115
Europe:						
Albania (content of nickeliferous ore)[4]	[6] 1,000	1,800	2,700	3,300	3,300	3,300
Finland:						
Content of nickel sulfate	120	92	126	177	179	172
Content of concentrates		324	2,369	2,200	2,680	3,230
Germany, East (content of ore)[4]	[5] 110	110	110	110	110	110
Greece (content of nickeliferous ore)	[7] 575					
Poland (content of ore)	1,219	1,405	1,382	1,453	1,458	[4] 1,400
U.S.S.R. (content of ore)[4]	51,800	60,000	64,000	83,000	90,000	90,000
Total[4]	54,800	63,700	70,700	90,200	97,700	98,200
Asia:						
Burma (content of speiss)	139	159	81	112	182	112
Indonesia (content of ore)		237	440	695	490	[4] 500
Total	139	396	521	807	672	[4] 612
Africa:						
Morocco (content of cobalt ore)	154	266	280	284	316	302
Rhodesia and Nyasaland, Federation of: Southern Rhodesia (content of ore)	28		24	64	86	131
South Africa, Republic of (content of matte and refined nickel)	2,813	[4] 2,900	[4] 3,200	[4] 2,900	[4] 2,700	[4] 2,700
Total	2,995	[4] 3,166	[4] 3,504	[4] 3,248	[4] 3,102	[4] 3,133
Oceania: New Caledonia (recoverable)[8]	20,255	28,810	43,325	48,600	32,400	[4] 32,200
World total (estimate)	271,000	314,000	359,000	403,000	401,000	384,000

[1] This table incorporates some revisions.
[2] Comprises refined nickel and nickel in oxide produced and recoverable nickel in matte exported.
[3] Exclusive of unknown tonnage produced and stored at Nicaro since Sept. 20, 1960.
[4] Estimate.
[5] Average annual production 1955-58.
[6] One year only, as 1958 was the first year of commercial production.
[7] Average annual production 1956-58.
[8] Comprises nickel content of matte and ferronickel produced in New Caledonia plus estimate of recoverable nickel in ore exported. Mine production (nickel content of ore) was as follows: 1954-58 (average) 27,650 tons; 1959, 36,200 tons; 1960, 59,000 tons; 1961, 58,800 tons; 1962, 37,500 tons and 1963, estimated 59,100 tons.

[3] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

NORTH AMERICA

Canada.—Canada produced 219,900 tons of nickel in 1963, a decrease of 7 percent from the record production of 237,000 tons in 1962. Despite this drop in overall production, The International Nickel Co. of Canada, Ltd. (Inco), delivered 175,365 tons of nickel compared with 159,085 tons in 1962, an increase of 10 percent. Included in the 1963 deliveries, Inco sold 1,120 tons of nickel at the same prices at which they acquired them from the U.S. Government or its suppliers.

Ore production from Inco's Ontario and Manitoba mines was 13.6 million tons in 1963 compared with 13.8 million in 1962. At the Copper Cliffs North mine, the No. 1 shaft was sunk to its planned depth of 4,134 feet. Development of this mine has begun. Development of mines at Creighton, Garson, and Murray continued as a preparation for deep level exploration. At yearend, Inco's operating mines in Ontario and Manitoba had reached a cumulative total of about 535 miles of underground development.

As of December 31, 1963, Inco, in the Sudbury District and in Manitoba, had a proven ore reserve of 302 million tons, with a nickel-copper content of 9.1 million tons. Explorations were conducted in Central America, South Pacific, and Africa. The company's exploration expenditures during 1963 amounted to $6.4 million, compared with $5.9 million for 1962. About one-third of the expenditures in these 2 years was for exploration in the Thompson area, Manitoba.[4]

Annual production capacity has been increased from the planned 75 million pounds to 90 million pounds of nickel, bringing Inco's total annual capacity from its facilities in the Sudbury District and at Thompson to at least 400 million pounds.[5]

Inco's refining plants at Port Colborne, Ontario, operated at a lower level in 1963 than in 1962, with subsequent reduction in employment. The employment cutback, however, did not affect Inco's overall nickel output in the Sudbury area because of increased nickel production of sinter and oxide at Copper Cliff.[6] Two new chemical plants have been completed recently at Inco's (Mond) refinery in Clydach, Wales. The first plant was specifically designed for production of nickel chloride, and the second installation was an extension of existing cobalt and nickel sulfate production facilities. The former plant went into operation in January 1963, and the latter, April 1963.[7]

Inco is enlarging its research and development facilities in Canada, the United States, and the United Kingdom. In Canada, the company announced plans to establish a research facility in the Ontario Research community outside of Toronto. Both process and product research will be undertaken there. In the United States, construction of Inco's new research laboratory in Sterling Forest, near Suffern, N.Y., began and will be completed in 1964. In the United Kingdom,

[4] The International Nickel Co. of Canada, Ltd. Annual Report. 1963, pp. 7–19.
[5] Todd, F. F. Inco at Thompson. Western Miner and Oil Review (Vancouver), v. 36, No. 12, December 1963, pp. 24–25.
[6] Wall Street Journal. International Nickel Co. To Lay Off 275 Oct. 16 at Refinery in Ontario. V. 162, No. 71, Oct. 9, 1963, p. 9.
[7] Metal Industry. Additional Plant at Nickel Refinery. V. 103, No. 12, Sept. 19, 1963, p. 386.

work continued on the enlargement of the research laboratory at Birmingham, England.

Falconbridge Nickel Mines Ltd. delivered 26,623 tons of nickel in 1963 compared with 30,531 tons in 1962. Of the latter figure, 22,431 tons was sold to commercial establishments and the remainder, 8,100 tons, to the U.S. Government. Commercial sales, therefore, had a net gain of 19 percent despite a 13-percent decline in overall nickel sales, and a 17-percent cutback in production.

Ore milled to produce concentrates in 1963 was 2,116,000 tons compared with 2,354,000 tons in the previous year. Total ore and concentrate smelted amounted to 433,000 tons compared with 488,000 tons in 1962. Both ore milled and concentrate smelted were off about 10 percent compared with 1962. Falconbridge's total mine development advances in 1963 were 42,000 feet and total diamond drilling, 344,000 feet.

The developed ore reserve in Falconbridge's mines was 27 million tons with 1.60 percent nickel content and the indicated ore reserve at Sudbury district was 24 million tons with 1.22 percent nickel content. Drilling and other mine development programs were also initiated by the Marbridge Mines Ltd., a firm jointly owned by Falconbridge and Marchant Mining Co., Ltd. Development work consisted of deepening the shaft from 900 feet to 1,200 feet. At the 900-foot level drillhole samples gave ore reserves estimated at 143,000 tons with a 2.28 percent nickel content.[8]

Falconbridge's new $1 million metallurgical laboratory was officially opened in October at Thornhill, Ontario. The three-story structure houses a staff of 50 scientists, engineers, and technicians.[9]

Sherritt Gordon Mines Ltd. sold substantially more nickel in 1963 than it produced, reducing the firm's inventory which had built up in 1962. In 1963, the company sold 12,264 tons of nickel compared with 9,384 tons in 1962, an increase of 31 percent. Its nickel production was 10,486 tons in 1963 compared with 12,157 tons in 1962, a decrease of 14 percent. In addition, the firm's refinery produced a total of 1,480 tons of nickel on a toll basis, compared with 1,445 tons in 1962. Production of nickel for its own account was limited by the amount of feed available. To prevent a recurrence of this situation, the firm has made a long-term contract for the purchase of feed. The company mined and milled 1,346,000 tons of ore from its Lynn Lake, Manitoba property, an increase of 7 percent over that of 1962. The grade of ore, however, was unusually low. At the end of the year Sherritt Gordon's ore reserve was calculated to be 11.9 million tons with a grade of 0.96 percent nickel and 0.58 percent copper. Sherritt Gordon's exploration and development during the year amounted to 14,843 feet of drifting and cross-cutting, 4,241 feet of raising, 793 feet of shaft sinking, and 160,260 feet of surface diamond drilling. In addition, a considerable amount of flying with airborne geophysical equipment was done in northwestern Manitoba and eastern Saskatchewan.

[8] Falconbridge Nickel Mines Ltd. Annual Report. 1963, pp. 3–15.
[9] Precambrian Mining in Canada (Winnipeg). Falconbridge Opens New Metallurgical Laboratory. V. 36, No. 10, October 1963, pp. 18–19.

Sherritt Gordon set up a pilot plant specifically designed around a treatment process developed in the company's research laboratory for the recovery of nickel and cobalt from laterite ores. Large deposits of these ores occur in many tropical areas and are difficult and costly to treat. Results from test runs of the pilot plant have been satisfactory.[10]

Giant Mascot Mines Ltd. treated 314,000 tons of ore in 1963 compared with 282,000 tons in 1962; produced 20,000 tons of nickel-copper concentrate; and recovered 2,100 tons of nickel. The grade of nickel ore treated was 0.85 percent. Giant's ore reserve stood at about 1 million tons with an average nickel content of 0.95 percent. Development during the year consisted of about 3,000 feet of raising and 4,000 feet of drifting. It was concentrated on the 3,250-foot level in order to open up the 1600, 1900, and Pride of Emory ore zones. Explorationwas also completed at various levels of Pride of Emory and other ore zones.[11]

Nickel Mining and Smelting Corp. changed its name to Metal Mines Ltd. Its Gordon Lake Division in northwestern Ontario experienced difficulties during early part of the year in reaching mill capacity of about 700 tons per day because of poor ground conditions in the mine. By May, however, the tonnage had reached 500 tons per day. During the year the Gordon Lake Division milled 136,970 tons of ore with a nickel content of 1,377 tons. Although Metals Mines Ltd. did not carry out any exploratory development work in 1963, it did complete the planned development of various orebodies for mining and established a new ore-pass system. The development included 336 feet of cross-cutting, 722 feet of drifting, 3,694 feet of raising, and 13,460 feet of underground diamond drilling. Ore reserves at yearend totaled 1.2 million tons, grading 1.51 percent nickel.[12]

Raglan Nickel Mines Ltd. carried out a major exploration program in 1963 on its Ungova properties in northern Quebec. The grade of ore averaged 1.59 percent nickel and 0.81 percent copper. A drilling program on the eastern tract at the end of the season brought the drill-indicated tonnage for the Raglan Lake section to 356,000 tons of ore, grading 2.74 percent nickel and 0.48 percent copper. At yearend Raglan's drill-indicated ore reserve on the western tract was 10 million tons of ore, grading 1.53 percent nickel and 0.78 percent copper or 8 million tons at a grade of 1.70 percent nickel and 0.87 percent copper.[13]

McIntyre Porcupine Mines Ltd. reached a depth of 300 feet in its 1,000-foot production shaft at Belleterre. The company has purchased the hydroelectric plant of Belleterre Quebec Mines and plans to construct a new 400-ton milling plant next year. The ore reserve is estimated to be 550,000 tons with an average grade of 2.1 percent combined nickel-copper content.[14]

Cuba.—The nickel plant at Moa Bay is operating at 15 percent capacity. The Nicaro plant is running at about 80 percent capacity.

[10] Sherritt Gordon Mines Ltd. Annual Report. 1963, pp. 3–6.
[11] Giant Mascot Mines Ltd. Annual Report. 1963, 12 pp.
[12] Metal Mines Ltd. Annual Report. 1963, pp. 1–8.
[13] Raglan Nickel Mines Ltd. Annual Report. 1963, pp. 1–3.
[14] Northern Miner (Toronto). New Nickel Mine for McIntyre Mill Next Year. No. 35, Nov. 21, 1963, pp. 1, 12.

The concentrates from the plants are going to the U.S.S.R. or Czechoslovakia for further processing.[15] New Cuban projects include the construction of new facilities to mill some 10 million tons of ferrous material and to refine nickel concentrates at Moa Bay.[16]

SOUTH AMERICA

Brazil.—The Votorantim group and the Government of the State of Goiás have organized Niqueis do Brazil S.A. (NIBRASA) to mine nickel ore near São José do Tocantins (Níquelandia), Goiás, Brazil. The deposits contain more than 4 million tons of potential ore containing a minimum of 2 percent nickel.[17]

EUROPE

Greece.—Officials of the Larymna plant announced plans to start mining nickel and iron ores by the middle of 1964. Société le Nickel holds an important interest in Larco S. A. which has been formed to operate the mine.[18]

ASIA

China.—Soviet economic pressure reportedly forced the Chinese to seek a source of nickel outside the U.S.S.R. They are reported to have negotiated through an organization in Portuguese Macao for ore from New Caledonia.[19]

Indonesia.—Estimated total production for 1963 was approximately 49,500 tons. The ore reserves in an area of about 35 square miles were estimated to total 1.1 million tons with a nickel content of 3.2 percent.

Japan.—Japan imported 747,000 tons of nickel ore and concentrate in 1963, compared with 744,000 tons in 1962. The chief source of Japan's nickel ores and concentrates was New Caledonia, which supplied 94 percent of the total. Japan produced approximately 7,000 tons of nickel and 52,000 tons of ferronickel.

Turkey.—Gunes Madencilik, Ltd., a Turkish subsidiary of Asiatic Mining Co., investigated promising nickel occurrences in the Divrigi area of central Turkey. Exploration was underway to determine whether minable nickel-copper ore can be developed in the company's exploration permit areas.[20]

OCEANIA

New Caledonia.—Société le Nickel produced 18,000 short tons of nickel in metallurgical products in 1963 compared with 17,000 short tons in 1962. All of these products were exported in both years. Exports of ore in 1963 were 628,000 tons containing 14,400 tons of

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[15] Chemical Week. Cuba CPI Rolls On. V. 93, No. 12, Sept. 21, 1963, pp. 65–68.
E&MJ Metal and Mineral Markets. Cuban Nickel Output Moving Into High Gear. V. 34, No. 39, Sept. 30, 1963, pp. 3, 10.

[16] Chemical Engineering. Pulling Back the Curtain on Cuba's CPI. V. 70, No. 21, Oct. 14, 1963, pp. 98, 100, 102.

[17] Engineering and Mining Journal. V. 164, No. 8, August 1963, p. 176.

[18] Mining Journal (London). Iron and Nickel in Greece. V. 216, No. 6697, Dec. 27, 1963, p. 617.

[19] Steel. The Sino Giant Looks Elsewhere for Nickel. V. 153, No. 11, Sept. 9, 1963, pp. 127–128.

[20] Mining Journal (London). Nickel Exploration in Turkey. V. 261, No. 6685, Oct. 4, 1963, pp. 306–307.

recoverable nickel, compared with 657,000 tons in 1962 containing 15,600 tons of recoverable nickel. The total production and export of recoverable nickel in 1963 was 32,200 tons, essentially the same as in 1962. The composition of the exports were different, however. In 1963, matte, ferronickel, and ore comprised 36, 19, and 45 percent, respectively, of the exports; in 1962 they comprised 19, 33, and 48 percent, respectively.

TECHNOLOGY

The Federal Bureau of Mines research staff developed a method for producing high-purity nickel,[21] a process for recovering nickel and cobalt from high-temperature alloy scrap,[22] and an accurate method for determining trace amounts of these elements in tungsten.[23] The research staff also studied high-temperature corrosion of nickel and cobalt in air and oxygen.[24]

Wide interest continued in thoriated nickel, a high-temperature, high-strength alloy introduced in 1962 by the E. I. du Pont de Nemours & Co., Inc. Two recently published articles gave detailed mechanical and physical properties of the new alloy.[25] Chromally Corp. developed a new coating, designated as "SUE," specifically for TD-Nickel. TD-Nickel with the new coating has withstood oxidation at 2,200° F for 100 hours. This is an increase of nearly 200° F over other superalloys. The combination promises to find application in the missile and nuclear fields.[26]

Wide interest also continued in search of high-temperature, high-strength materials. Metco Inc. introduced a process to apply a refractory coating of nickel aluminide to metals. It consists of spraying nickel-coated aluminum grains through a conventional or a plasma flame gun, forming nickel aluminide by a selfsustained exothermic reaction which is initiated by the heat of the plasma flame.[27] To overcome the welding difficulties encountered heretofore with superalloys, General Electric Co. developed a new superalloy, designated as Renè 62. The new alloy retains high strength up to 1,500° F.[28]

The exceptional properties of 18-percent nickel maraging steel elicited further investigation. Under a contract from the National Aeronautics and Space Administration, Douglas Aircraft Co. has been conducting an intensive study of this alloy.[29] Patents for a number

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[21] Brooks, P. T., and J. B. Rosenbaum. Separation and Recovery of Cobalt and Nickel by Solvent Extraction and Electrorefining. BuMines Rept. of Inv. 6159, 1963, 30 pp.

[22] Higley, L. W., Jr. Reclaiming S-816 High Temperature Alloy Scrap. BuMines Rept. of Inv. 6230, 1963, 12 pp.

[23] Spano, E. F., T. E. Green, and W. J. Campbell. Determination of Cobalt and Nickel in Tungsten by a Combined Ion Exchange X-Ray Spectographic Method. BuMines Rept. of Inv. 6308, 1963, 20 pp.

[24] Doerr, R. M. High-Temperature Corrosion Studies. Nickel and Cobalt in Air and Oxygen. BuMines Rept. of Inv. 6231, 1963, 20 pp.

[25] Stuart, R. E., and C. D. Starr. New Design Data on TD-Nickel. Mat. in Design Eng., v. 58, No. 2, August 1963, pp. 81–85.

[26] Iron Age. Practical Nickel Alloy. V. 192, No. 22, Nov. 28, 1963, p. 69.
Missiles and Rockets. New Coatings Boost Superalloy Temperature. V. 13, No. 17, Oct. 21, 1963, p. 23.
Steel. Antioxidation Coating Offered for TD-Nickel. V. 153, No. 18, Oct. 28, 1963, p. 30.

[27] Light Metal Age. Nickel Aluminide. V. 21, No. 5, August 1963, p. 18.

[28] American Metal Market. Renè 62: Weldable Superalloy. V. 70, No. 237, Dec. 12, 1963, p. 7.
McHenry, H. T., J. F. Barker, and R. J. Stuligross. Renè 62: A Strong Superalloy for Welded Structures. Metal Prog., v. 84, No. 6, December 1963, pp. 86–99.

[29] Metalworking News. Study 18 Percent Ni Maraging Steel at Douglas. V. 4, No. 175, Dec. 30, 1963, p. 9.

of maraging steels have been granted to The International Nickel Company of Canada, Ltd. (Inco), by the U.S. Patent Office. Among them were patents for steels with 20 to 25 percent nickel. Inco officials have confirmed the report that the company is now making available to qualified producers royalty-free licenses, under its patents, covering the maraging steels.[30] The company also has issued a preliminary data sheet on its new superalloy, MC–102. The new high-temperature casting alloy is an age-hardenable material having good oxidation resistance and mechanical properties up to at least 900° C.[31]

New superalloys were introduced by a number of firms. Beryllium Corp. developed a new alloy, Berylco Nickel 440. The new material has high mechanical properties up to 800° F and combines the tensile and yield strengths of super-strength steels.[32] Firth Sterling, Inc., introduced two new high-temperature, high-strength nickel alloys designated as FS–X–750 and FS–718. The cmpany reported these new superalloys are readily forged and welded.[33] The research department of Inco reported that the addition of more than a eutectic amount of nickel improved the hot hardness of aluminum-silicon systems.[34]

The new process of Du Pont for cladding dissimilar metals and alloys by an explosive bonding method that metallurgically bonds plates without heat or the use of intermediate materials.[35] Carbon steel clad with nickel, stainless steel, and various Hastelloys-clad plates has been produced in developmental quantities by the process.[36] Semiconductors clad with another metal, in a process developed by Metals & Controls, Inc., have a rate of heat dissipation three times that of conventional ones. This permits higher operating power levels.[37]

At the opposite extreme of high-temperature materials, two new nickel alloy steels known as Cryomet 9 and Cryomet 10 were developed for cryogenic use by Samuel Fox and Co., Ltd. They have good forming and welding qualities, allowing easy fabrication.[38]

Several new nickel powders were introduced by nickel producers. Inco marketed a new grade of carbonyl nickel designated as Type 100, which is substantially less expensive than previous grades of carbonyl nickel powders. The new powder is extremely pure and uniform in size and structure.[39] Sherritt Gordon Mines Ltd. also introduced a new nickel powder. Designated as grade E, the new powder is 99.9 plus percent pure with very uniform particle sizing. The

[30] Precambrian-Mining in Canada (Winnipeg). International Nickel Granted Patents for Maraging Steels. V. 36, No. 11, November 1963, p. 28.
[31] Chemical Age (London). Nickel Alloy. V. 90, No. 2314, Nov. 16, 1963, p. 786.
[32] Iron Age. Nickel Alloy Provides Strength, Elasticity. V. 192, No. 14, Oct. 3, 1963, p. 79.
Steel. Beryllium Corp. Offers New Nickel Alloy. V. 153, No. 14, Sept. 30, 1963, p. 45.
[33] Metalworking News. Firth Produces Two New Ni Alloys. V. 4, No. 171, Dec. 2, 1963, p. 8.
[34] Hanafee, J. E. Effect of Nickel on Hot Hardness of Aluminum-Silicon Alloys. Modern Castings, v. 44, No. 4, October 1963, pp. 514–520.
[35] Chemical and Engineering News. Explosive Bonding Used to Clad Plate. V. 41, No. 42, Oct. 21, 1963, p. 50.
[36] American Metal Market. Explosive Forming Scores Another Advance. V. 70, No. 197, Oct. 11, 1963, pp. 1, 15.
Materials in Design Engineering. V. 58, No. 6, November 1963, p. 5.
[37] Iron Age. Cladding Aids Transitors. V. 192, No. 10, Sept. 5, 1963, p. 15.
[38] Metal Industry. Nickel Steels for Cryogenics. V. 103, No. 9, Aug. 29, 1963, p. 287.
[39] European Chemical News (London). Nickel Carbonyl. V. 4, No. 85, Aug. 30, 1963, p. 30.
Metal Industry. Uniformly Sized Carbonyl Nickel. V. 103, No. 14, Oct. 3, 1963, p. 460.

principal application will be in the electronics field for the manufacture of getter materials.[40]

New developments also took place in bright metal plating and in electrical resistance materials and catalysts. The Hanson-Van Winkle-Munning Co. developed two high-speed sulfamate nickel-plating solutions to be used in duplex plating. The baths can be operated up to twice the speed of the conventional Watts plating process.[41] Riverside-Alloy Metal Division, H. K. Porter Co., developed three new electrical resistance alloys designated as Chromic-A, Chromic-C, and Excelsior. The new alloys are reported to last longer than present materials.[42]

Girdler Catalysts, a division of Chemetron Corp., formulated a new methanation catalyst to withstand exposure to high temperatures. The new substance, known as G–65, is said to make possible an 85-percent increase in throughput by allowing methanation units to be operated over a range of 650 to 800° F.[43] Summarizing the work of Dr. R. J. Jasinski, American Metal Market reported that nickel boride may be substituted for platinum to catalyze hydrogen reactions at the anode of a hydrogen-oxygen fuel cell. Using nickel boride instead of platinum, the cost of the catalyst is reduced considerably.[44]

A field test kit for use in the scrap metal industry for the identification of the common nickel alloys has been placed on the market.[45] Inco installed an automated alloy analyzer in the firm's research facilities at Bayonne, N.J. The instrument, once programed and loaded, can be left unattended until all samples have been analyzed. It will handle 11 elements at each programing and up to 90 alloy samples can be loaded at one time. All results are taped automatically for interpretation and permanent record.[46]

F. B. Howard-White wrote a comprehensive book on the history of nickel from its discovery to the present state of technology.[47] The Office of Technical Services made available I. I. Kornilov's excellent monograph on nickel, translated into English.[48] The test deals principally with the occurrence, the discovery, and the chemical and physical properties of nickel as well as with the metallurgy of the element.

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[40] Chemical Trade Journal and Chemical Engineer (London). Close Particle Sizing Nickel Powder. V. 153, No. 3972, July 26, 1963, p. 140.

[41] Chemical and Engineering News. Nickel Sulfamate Plating Can Double Production. V. 41, No. 39, Sept. 30, 1963, p. 44.

[42] American Metal Market. Introduce New Electrical Resistance Alloy. V. 70, No. 206, Oct. 24, 1963, p. 7.

[43] Chemical Engineering. Methanation Catalyst. V. 70, No. 20, Sept. 30, 1963, p. 58. Chemical Week. V. 93, No. 22, Nov. 30, 1963, p. 56.

[44] Ruth, J. P. Variety of Metallics Involved in Fuel Cell Research. American Metal Market, v. 70, No. 179, Sept. 17, 1963, p. 13.
American Metal Market. Fuel Cell Breakthrough: Use of Nickel-Boride Cuts Costs. V. 70, No. 176, Sept. 12, 1963, pp. 1, 9.

[45] American Metal Market. Nickel Test Kit. V. 70, No. 191, Oct. 3, 1963, p. 24.

[46] Iron Age. Alloy Analysis Goes Automatic. V. 192, No. 6, Aug. 8, 1963, p. 54.

[47] Howard-White, F. B. Nickel: An Historical Review. D. Van Nostrand Co., Princeton, N.J., 1963, 350 pp.

[48] Kornilov, I. I. Nikel' i Ego Splavy (Nickel and Its Alloys) Akademiya Nauk SSSR., Institute Metallurgii im. A. A. Baikova, Moscow, U.S.S.R. 1958; U.S. Dept. of Commerce, Office of Tech. Services, Israel Program for Scientific Translations, Ltd., v. 1, 1963, 348 pp.

Patents were issued on the recovery of nickel from ores,[49] various alloys,[50] separation and refining of nickel,[51] nickel coatings,[52] methods for preparing nickel carbonyls,[53] types of nickel welding electrodes,[54] and a method for the stabilization of polypropylene with nickel salts of amino acids.[55]

A method was reduced to practice in which high-purity nickel chloride was prepared by leaching nickel-copper matte with hydrochloric acid and subsequently crystallizing the nickel chloride from the solution.[56]

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[49] Aveston, J., D. A. Everest, and G. H. E. Sims (assigned to National Research Development Corp.). Brit. Pat. 926,873, May 22, 1963.

Borvali, M. Y., P. Grolla, P. Hubscher, and F. Reynaud (two-thirds assigned to Societe d'Electro-Chimie d'Electro-Metallurgie et des Acieries Electriques d'Ugine, one-third to Societe de Produits Chimiques Bozel-Maletra, Paris, France). Process of Sulphonitric Attack of Arseniureted and/or Sulpharseniureted Ores or Materials, Particularly of Cobalt and/or Nickel. U.S. Pat. 3,107,977, Oct. 22, 1963.

Hills, R. C. (assigned to Freeport Sulphur Co., New York). Recovery of Nickel and Cobalt by Reduction and Leaching. U.S. Pat. 3,100,700, Aug. 13, 1963.

Sherrit Gordon Mines Ltd. Recovery of Nickel and Cobalt from Ore Leach Solutions. Brit. Pat. 939,921, Oct. 16, 1963.

[50] Abkowitz, S., and R. A. Woodall (assigned to Special Metals, Inc., New Hartford, N.Y.). Hot Workable Nickel Base Alloy. U.S. Pat. 3,107,167, Oct. 15, 1963.

Averbach, B. L. (assigned to Weinschel Engineering Co., Inc., Gaithersburg, Md.). Low Temperature Coefficient Alloy. U.S. Pat. 3,114,662, Dec. 17, 1963.

Cape, A. T. (assigned to Coast Metals, Inc., Little Ferry, N.J.). Nickel-Base Brazing Alloys. U.S. Pat. 3,108,861, Oct. 29, 1963.

Gittus, J. H. (assigned to The International Nickel Co., Inc., New York). Creep-Resistant Nickel-Chromium-Cobalt Alloy. U.S. Pat. 3,107,999, Oct. 22, 1963.

Gittus, J. H., and R. M. Cook (assigned to The International Nickel Co., Inc., New York). Nickel-Chromium Base Alloy. U.S. Pat. 3,110,587, Nov. 12, 1963.

Mobley, P. R. (assigned to General Electric Co., New York). Brazing Alloy. U.S. Pat. 3,110,588, Nov. 12, 1963.

[51] Brandt, B. J. (assigned to The International Nickel Co., Inc., New York). Electrorefining Nickel. U.S. Pat. 3,114,687, Dec. 17, 1963.

Cotteta, J. E. (assigned to Philco Corp., Philadelphia, Pa.). Method and Solution for Selectively Stripping Electroless Nickel From a Substrate. U.S. Pat. 3,104,167, Sept. 17, 1963.

Goldstein, E. M. Process for Separating Cobalt and Nickel From Ammoniacal Solutions. U.S. Pat. 3,107,996. Oct. 22, 1963.

[52] Foulke, D. G., W. B. Stoddard, Jr., O. Kardos, and W. B. Kleiner (assigned to Hanson-Van Winkle-Munning Co.). Electrodeposition of Nickel. U.S. Pat. 3,111,466, Nov. 19, 1963.

Michael, G., W. Strauss (assigned to Dehydag, Deutsche Hydrierwerke G.m.b.H., Dusseldorf, Germany). Nickel Electroplating Baths. U.S. Pat. 3,116,225, Dec. 31, 1963.

Tsu, I., and M. C. Fritsch (assigned to International Business Machines Corp., New York). Electrodeposition of Magnetic Cobalt-Nickel Alloys. U.S. Pat. 3,111,463, Nov. 19, 1963.

[53] Schmeckenbecher, A. F. (assigned to General Aniline and Film Corp., New York). Preparation of Iron and Nickel Carbonyls. U.S. Pat. 3,112,179, Nov. 26, 1963.

[54] Wasserman, R. D., and J. F. Quaas (assigned to Eutectic Welding Alloys Corp.). Coated Welding Rod. U.S. Pat. 3,084,074, Apr. 2, 1963.

Witherell, C. E. (assigned to The International Nickel Co., Inc., New York). Nickel-Copper Alloy Welding Electrode. U.S. Pat. 3,107,176, Oct. 15, 1963.

[55] Soeder, M. L. (assigned to Hercules Powder Co., Wilmington, Del.). Stabilization of Polypropylene With Nickel Salts of Amino Acids. U.S. Pat. 3,102,107, Aug. 27, 1963.

[56] Thornhill, P. G. (assigned to Falconbridge Nickel Mines Ltd., Toronto). Recovery of Nickel. U.S. Pat. 3,085,054, Apr. 9, 1964.

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Nitrogen

By Richard W. Lewis [1]

ANNUAL production capacity of domestic anhydrous ammonia increased by over 1 million short tons in 1963. Total capacity at yearend was estimated to be nearly 9 million tons. Again, a substantial expansion of nitrogen (gas and liquid) production facilities took place, indicating an increase of about 20 percent in total plant capacity.

TABLE 1.—Salient statistics of the nitrogen industry
(Thousand short tons of contained nitrogen)

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Production as ammonia	2,990	3,871	4,118	4,429	[1] 4,920	5,617
Production as high-purity nitrogen gas	174	544	725	1,045	[1] 1,683	2,032
Imports for consumption of nitrogen compounds	291	288	279	325	383	354
Exports of nitrogen compounds	219	230	211	173	246	219
Consumption [2]	2,984	[1] 3,756	[1] 3,940	[1] 4,342	[1] 4,715	5,010
World: Production [2]	9,992	13,005	14,184	15,403	16,320	17,630

[1] Revised figure.
[2] Figures are estimated and exclude nitrogen gas.

DOMESTIC PRODUCTION

The domestic ammonia production was increased by 14 percent over that of 1962. Many new ammonia producing units went on stream during the year which created an over capacity. Producers were optimistic, however, and several new production units were either under construction or being planned for 1964.

Nitrogen gas output increased 21 percent and the outlook was for continued growth for several years. The popularity of the small "make-it-yourself" nitrogen units declined in favor of the large industrial gas companies.

Facilities for producing nitrogen compounds, other than ammonia, also were increased, especially nitric acid, urea, and ammonium nitrate.

The following anhydrous ammonia (NH_3) units were put on stream during the year:

[1] Commodity specialist, Division of Minerals.

Company	Plant location	Added NH_3 capacity (tons per year)
American Oil Co	Texas City, Tex	210,000
Central Nitrogen, Inc	Terre Haute, Ind	125,000
Coastal Chemical Corp	Pascagoula, Miss	70,000
Columbia Nitrogen Corp	Augusta, Ga	100,000
Consumers Cooperative Association	Hastings, Nebr	70,000
Cooperative Farm Chemicals Association	Lawrence, Kans	52,500
John Deere Chemical Co	Pryor, Okla	35,000
Frontier Chemical Co	Wichita, Kans	15,000
W. R. Grace & Co	Big Springs, Tex	70,000
Hawkeye Chemical Corp	Clinton, Iowa	140,000
Monsanto Chemical Corp	Muscatine, Iowa	70,000
The New Jersey Zinc Co	Palmerton, Pa	35,000
Nitrin, Corp	Cordova, Ill	140,000

Anhydrous ammonia production facilities either under construction or planned during 1963 are as follows:

Company	Plant location	Added NH_3 capacity (tons per year)	Completion date
Allied Chemical Corp	Omaha, Nebr	100,000	1964.
E. I. du Pont de Nemours & Co., Inc	Victoria, Tex	100,000	1964.
Farmers Chemical Association, Inc	Tyner, Tenn	75,000	1964.
Farmers Union State Exchange	Fremont, Nebr	70,000	1964.
Lone Star Producing Co	Kerens, Tex	115,000	Fall 1964.
Odessa Natural Gasoline Co	Odessa, Tex	25,000	Early 1964.
Pittsburgh Plate Glass Co	Natrium, W. Va	(1)	(1)
J. R. Simplot Co	Pocatello, Idaho	52,500	1964.
Southern Farm Supply Association of Amarillo.	Plainview, Tex	(1)	(1)
Tuloma Gas Products Co	Texas City, Tex	210,000	1964.
Western Ammonia Corp	Dimmitt, Tex	27,000	Early 1964.

[1] Unannounced.

Several new urea plants were completed, were in the planning stages, or were under construction. John Deere Chemical Co. planned to add a 250-ton-per-day plant to its facility at Pryor, Okla., and Premier Petrochemical Co. was constructing a new plant near Pasadena, Tex. that would produce 70,000 tons annually. Farmers Chemical Assoc., Inc. built a 100-ton-per-day plant at Chattanooga, Tenn. Southern Nitrogen Co., Inc. expected to increase production by 28,000 tons annually at its Savannah, Ga. plant. Phillips Pacific Chemical Co. completed the first urea plant in the Northwest at Kennewick, Wash., which was to produce 55 tons per day of ammonium-nitrate-urea solutions. Ketona Chemical Corp. added a 20-ton-per-day plant to its Birmingham, Ala. facility.

The nitric acid industry experienced a heavy expansion of production facilities. Nitram Chemicals, Inc., included a substantial unit (capacity undisclosed) for producing nitric acid in its multimillion dollar fertilizer plant near Tampa, Fla. Nitrin Corp. put on stream a 400-ton-per-day nitric acid plant at Cordova, Ill. Central Nitrogen, Inc. began production in a 350-ton-per-day plant at Terre Haute, Ind. At Clinton, Iowa, Hawkeye Chemical Corp. had an acid plant with a daily capacity of 340 tons ready for startup in the fall. Tennessee Valley Authority began construction on a new unit to produce 65-percent acid, and E. I. du Pont de Nemours & Co., Inc. planned

TABLE 2.—Nitrogen production in the United States

(Short tons of contained nitrogen)

	1959	1960	1961	1962	1963 [1]
Anhydrous ammonia: Synthetic plants [2]	3,717,186	3,962,272	4,282,160	4,778,106	5,465,757
Ammonia compounds, coking plants:					
Ammonia liquor	12,098	12,241	10,990	11,166	11,873
Ammonium sulfate	131,613	134,034	125,951	124,112	131,034
Ammonium phosphates	9,946	9,769	10,111	6,909	8,283
Total	3,870,843	4,118,316	4,429,212	4,920,293	5,616,947
Nitrogen gas [2]	543,875	724,724	1,045,357	1,682,643	2,032,006

[1] Preliminary figures.
[2] Bureau of the Census Current Industrial Reports.

to increase production of high-concentration nitric acid at its Repauno Works, Gibbstown, N.J.

Many of the new ammonia units put on stream in 1963 had adjacent ammonium nitrate units which raised production capacity of this compound an estimated 600,000 tons.

TABLE 3.—Major nitrogen compounds produced in the United States

(Thousand short tons, gross weight)

Compounds	1962	1963 [1]
Ammonium chloride [2]	23	(3)
Ammonium nitrate [2]	3,406	3,939
Ammonium sulfate [2]	1,697	1,785
Ammonium phosphate [4]	1,590	2,597
Nitric acid [2]	3,670	4,197
Urea [5]	1,020	1,157

[1] Preliminary figures.
[2] Bureau of the Census Current Industrial Report M28A.
[3] Data not available.
[4] 1962 estimated. 1963 Bureau of the Census Current Industrial Reports M28D.
[5] U.S. Tariff Commission.

Many new air separation plants for the production of oxygen and nitrogen (gas or liquid) were placed on stream, were under construction, or were planned during the year. Also, some existing plants were expanded. The following list of these additions is not necessarily complete:

Company	Plant location	Capacity (tons per day)
Air Products and Chemicals, Inc	Delaware City, Del. (new)	500
	Chicago, Ill. (new-planned)	200
Air Reduction Pacific Co	City of Industry, Calif. (expansion)	240
	Pacific Northwest (new-planned) [1]	160
Air Reduction Sales Co	Albion, Mich. (new)	200
	Alton, Ill. (new)	345
	Beaumont, Tex. (new)	130
	New Orleans, La. (new)	1,000
	Warren, Ohio (new)	(2)
American Cryogenics, Inc	Decatur, Ala. (new)	75
	Odessa, Tex. (new)	30
	Santa Fe Springs, Calif. (expansion)	400
Union Carbide Corp., Linde Co	Gary, Ind. (new-planned)	520
	Huntsville, Ala. (expansion)	190

[1] Location undecided.
[2] Data not available.

CONSUMPTION AND USES

Consumption of nitrogen compounds was 6 percent greater than in 1962. According to Department of Agriculture reports, nitrogen consumed by agriculture as fertilizer in the year ending June 30, 1963, was 16 percent or 533,649 tons greater than in the preceding 12-month period.

It is estimated that in 1963 approximately 80 percent of the nitrogen consumed went into fertilizer materials.

PRICES

In general, prices on fertilizer-grade anhydrous ammonia and ammonium nitrate remained steady throughout the year. Ammonium sulfate had the price advanced in July. Urea prices in California and the Pacific Northwest did not follow those quoted in the Oil, Paint and Drug Reporter. Competition from German, Belgian, Norwegian, and Japanese shippers caused the price to fluctuate, and 40-ton bulk shipments were, at times, sold at $80 per ton and possibly lower.

TABLE 4.—Price quotations for major nitrogen compounds in 1963

(Per short ton)

Compound	Jan. 7	Dec. 30	Effective date of change
Ammonium nitrate, fertilizer-grade, 33.5 percent N (nitrogen):			
Canadian, carlots, f.o.b. shipping point, bags	$70.00	[1] $67.00	Nov. 4
Domestic, f.o.b. works, bags	70.00	[1] 67.00	Nov. 4
Ammonium nitrate, domestic with dolomite, 20.5 percent N, bags, carlots, Hopewell, Va	48.00	48.00	
Ammonium sulfate, standard granular, bulk, f.o.b. works	28.00	30.00	July 8
Anhydrous ammonia, fertilizer, tanks, works, freight equalized east of Rockies	92.00	[2] 92.00	
Cyanamide, fertilizer-mixing grade, 21 percent N, granular, bags, Niagara Falls, Ontario	59.00	59.00	
Sodium nitrate, domestic, crude,[3] carlots, works, bulk	44.00	44.00	
Sodium nitrate, imported, crude,[3] carlots, port warehouse, bulk	44.00	44.00	
Urea:			
Industrial, 46 percent N, bags, carlots, ton lots, f.o.b. plant	100.00	100.00	
Agricultural, 45 percent N, bags, carlots, delivered	96.00	[4] 92.00	Nov. 4

[1] Quoted at $64 per ton from August 5 to November 4.
[2] Quoted at $84 per ton from August 5 to October 7.
[3] Quote changed from "crude" to "commercial" on December 16.
[4] Quoted at $89 per ton from August 5 to November 4.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE

Nitrogen compounds (gross weight) imported for consumption decreased 22 percent from that of 1962. A reduction in shipments of many imported items was noted; the most significant reduction was of sodium nitrate, which was only about one-fourth of the 1962 tonnage. Imports of urea, however, increased 53 percent.

Total exports of nitrogen compounds were about 9 percent under the tonnage shipped in 1962. Shipments of fertilizer-grade ammonium nitrate, ammonium sulfate, and urea decreased 44, 16, and 62 percent, respectively. Keen foreign competition for the nitrogenous fertilizer world markets was responsible for the reduction in U.S. export sales.

TABLE 5.—U.S. imports for consumption and exports of major nitrogen compounds
(Short tons)

Compounds	1962 Gross weight	1962 N content	1963 Gross weight	1963 N content
Imports:				
Industrial chemicals: Ammonium nitrate	442	155	58	20
Fertilizer materials:				
Ammonium nitrate containing over 32 percent nitrogen	216,153	72,411	[1] 161,948	[1] 54,253
Ammonium nitrate mixtures containing 32 percent and less nitrogen, including ammonium nitrate-calcium carbonate mixtures, except solutions	122,006	25,621	[1] 45,614	[1] 9,579
Ammonium phosphates	131,578	19,737	129,710	19,457
Ammonium sulfate	244,998	51,450	234,507	49,246
Calcium cyanamide	36,946	9,237	28,896	7,224
Calcium nitrate	58,167	9,016	41,675	6,460
Nitrogen solutions	68,645	24,026	77,920	27,272
Synthetic nitrogenous fertilizer materials, not elsewhere specified	58,600	11,720	[2] 50,849	[2] 10,170
Potassium nitrate, crude	[3] 3,187	[3] 382	4,446	534
Potassium-sodium nitrate mixtures, crude	[3] 27,301	[3] 4,095	38,080	5,712
Sodium nitrate	[3] 434,004	[3] 69,441	119,546	19,127
Urea, not elsewhere specified	188,040	85,558	287,212	130,681
Anhydrous ammonia	(4)	(4)	[4] 17,453	[4] 14,346
Total	[3] 1,590,067	[3] 382,849	1,237,914	354,081
Exports:				
Industrial chemicals:				
Ammonium nitrate	690	242	1,663	582
Anhydrous ammonia and chemical-grade aqua (ammonium content)	4,717	3,877	3,479	2,860
Fertilizer materials:				
Ammonium nitrate	41,609	[3] 13,939	23,309	7,812
Ammonium phosphates and other nitrogeneous phosphatic-type fertilizer materials	120,520	18,078	185,282	27,792
Ammonium sulfate	[3] 583,418	[3] 122,518	490,349	102,973
Anhydrous ammonia and aqua (ammonia content)	54,750	45,005	71,802	59,021
Nitrogeneous chemical materials, not elsewhere classified	[3] 13,524	[3] 2,705	13,302	2,660
Sodium nitrate	[3] 954	[3] 153	2,384	381
Urea	[3] 86,742	[3] 39,034	32,725	14,726
Total	[3] 906,924	[3] 245,551	824,295	218,807

[1] Effective Sept. 1, 1963 classes were combined to become one class; August–December data reported 88,045 short tons, N content 22,011 short tons.
[2] Data not strictly comparable with other years.
[3] Revised figure.
[4] Not separately classified prior to Sept. 1, 1963; formerly part of synthetic nitrogeneous fertilizer materials

Source: Bureau of the Census

WORLD REVIEW [2]

NORTH AMERICA

Canada.—Consolidated Mining & Smelting Co. of Canada Ltd. was planning a major chemical fertilizer installation near Regina, Saskatchewan. Included in the project was an 83,000-ton-per-year ammonium phosphate plant. The company also expected to build a new urea plant in Calgary, Alberta, and to increase by 18,250 tons per year the ammonia capacity at Trail, British Columbia.[3] The ammonia capacity of the Sherritt Gordon Mines Ltd. plant at Fort Saskatchewan, Alberta, was increased from 185 to 225 tons per day.[4] A new

[2] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[3] Commercial Fertilizer. V. 107, No. 1, July 1963, p. 14.
[4] Engineering and Mining Journal Newsletter. V. 14, No. 1, January 1963, p. 5.

ammonium nitrate plant was built at the Beloeil works of Canadian Industries Ltd. in McMasterville, Quebec.[5]

TABLE 6.—World production and consumption of nitrogen compounds, years ended June 30, by principal countries

(Thousand short tons of contained nitrogen)

Country	Production [1]			Consumption [1]		
	1960-61	1961-62	1962-63	1960-61	1961-62	1962-63
Australia	23	25	30	37	44	55
Austria	187	200	204	61	67	73
Belgium	323	304	331	126	129	143
Brazil	18	13	24	66	72	83
British West Indies	22	29	29	18	25	27
Bulgaria	96	100	119	115	128	138
Canada	390	434	519	123	138	154
Ceylon	-----	-----	-----	30	34	39
Chile	160	192	187	22	25	29
China	386	408	441	672	694	838
Cuba	6	17	28	34	77	77
Czechoslovakia	159	165	177	197	206	215
Denmark	-----	-----	-----	141	152	162
Finland	43	53	49	73	69	73
France	844	965	1,010	748	834	898
Germany:						
East	408	422	438	299	325	320
West	1,561	1,504	1,617	908	927	1,108
Greece	-----	-----	-----	80	91	99
Hungary	63	75	83	104	119	121
India	129	176	234	277	416	507
Indonesia	-----	-----	-----	28	116	121
Ireland	-----	-----	-----	28	33	39
Israel	22	24	29	20	22	31
Italy	819	863	904	450	487	519
Japan	1,290	1,365	1,423	881	861	903
Korea:						
North	88	94	99	99	105	110
Republic of	22	37	44	193	198	204
Mexico	35	44	72	160	171	193
Netherlands	476	502	531	263	290	348
Norway	320	338	355	58	61	67
Pakistan	12	22	44	77	88	99
Peru	9	9	17	33	28	39
Philippines	15	20	24	56	80	72
Poland	311	335	347	321	335	342
Portugal	53	73	91	80	84	88
Rhodesia and Nyasaland, Federation of	-----	-----	-----	33	39	42
South Africa, Republic of	88	99	127	99	105	121
Spain	129	149	172	312	369	380
Sweden	58	66	69	127	134	143
Switzerland	35	33	39	26	29	31
Taiwan	55	68	77	122	138	149
U.S.S.R.	1,146	1,290	1,436	1,067	1,156	1,290
United Arab Republic (Egypt)	61	117	149	201	234	248
United Kingdom	678	700	750	690	735	758
United States	4,034	4,364	4,577	4,126	4,558	4,872
Yugoslavia	9	17	28	91	91	132
World total [2]	14,618	15,765	17,013	14,269	15,717	17,180

[1] Estimated.
[2] Includes quantities for minor producing and consuming countries not listed elsewhere.

Source: Nitrogen. No. 27, January 1964, pp. 11-13.

Costa Rica.—Fertilizantes de Centro America, S.A., a Costa Rican corporation wholly owned by Fertica, S.A., of Panama, completed construction on a $10 million chemical fertilizer plant near Puntarenas. The plant was designed to have an annual capacity of about

[5] Precambrian-Mining in Canada (Winnipeg). CIL Announces New Plant. V. 36, No. 6, June 1963, pp. 20–21.

100,000 tons of complex fertilizer and 80,000 tons of ammonium nitrate. Capacity production was expected by mid-1964.[6]

Mexico.—Complejo Industrial de Santa Rosalia, S.A., planned construction of an ammonia plant at Santa Rosalia, Baja California.[7] A new ammonium sulfate plant was in the planning stage for Coatzacoalcos, Veracruz, by Guanos y Fertilizantes de Mexico, S.A. Petroleos Mexicanos, a State-owned oil company, began construction on a 160,000-ton-per-year ammonia plant at Chihuahua, and planned another for the State of Campeche.[8] In Guadalajara, Fertilizantes de Occidente, S.A., was building an ammonium sulfate plant with an annual capacity of 36,000 tons.[9]

Netherlands Antilles.—Construction was completed on a $20 million group of chemical fertilizer plants in Aruba. The facility included a 360-ton-per-day ammonia plant operated by Antilles Chemical Co., a subsidiary of Standard Oil of New Jersey. The others of the group—a 225-ton-per-day urea plant, a 150-ton-per-day nitric acid plant, and a 400-ton-per-day complex fertilizer plant—were built for Aruba Chemical Industries, N.V. which is jointly owned by Standard Oil of New Jersey and International Development & Investment Co. Ltd.[10]

SOUTH AMERICA

Argentina.—The Argentine Government approved plans by Industrias Petroquimicas para el Argo to establish an ammonia and fertilizer complex at Puerto Madryn. The company expected to produce annually 100,000 tons of ammonia, 35,000 tons of ammonium nitrate, 35,000 tons of ammonium sulfate, and 40,000 tons of urea.[11]

Bolivia.—Plans were made by Yacimientos Petroliferos Fiscales Bolivianos to build a 60-ton-per-day ammonia plant and a 100-ton-per-day nitric acid plant near Santa Cruz.[12]

Brazil.—Petrobas, Brazilian Government oil monopoly, had a 200-ton-per-day ammonia plant under construction at Camacari, Bahia.[13]

Colombia.—In March, Industria Colombiana de Fertilizantes, largely Government owned, began producing ammonium nitrate, urea, and mixed fertilizers in its new facilities at Barrancabermeja. At about the same time, Amoniaco del Caribe, S.A., a subsidiary of International Petroleum (Colombia) Ltd., started producing ammonia and nitric acid at its new installation at Cartagena.[14]

Peru.—A plant to produce calcium ammonium nitrate was under construction in Cuzco. The owner of the plant, Cuzco Corp., expected production of 62,000 tons per year by 1965.[15] The Peruvian Government announced the formation of Corporatión Nacional de Fertil-

[6] U.S. Embassy, San Jose, Costa Rica. State Department Airgram A–97, Aug. 23, 1963, pp. 1, 2.
[7] Commercial Fertilizer. V. 106, No. 4, April 1963, p. 38.
[8] Nitrogen. No. 24, July 1963, p. 19.
[9] Chemical Week. V. 93, No. 10, Sept. 7, 1963, p. 42.
[10] Chemical & Engineering News. Fertilizer Plants Completed on Aruba. V. 41, No. 50, Dec. 16, 1963, p. 30.
[11] Work cited in footnote 8.
[12] Chemical Age (London). New Ammonia Nitric Acid Plant for Bolivia. V. 90, No. 2306, Sept. 21, 1963, p. 403.
[13] Commercial Fertilizer. V. 106, No. 3, March 1963, p. 52.
[14] Bureau of Mines. Mineral Trade Notes. V. 58, No. 1, January 1964, pp. 29–30.
[15] Foreign Trade (Ottawa, Canada). V. 120, No 12, Dec. 14, 1963, p. 32.

izantes to take over the Cía. Administradora del Guano. The corporation was authorized to produce and sell organic and inorganic fertilizers including exploiting guano deposits.[16]

TABLE 7.—Chile: Exports of nitrate in 1963, by countries[1]
(Thousand short tons)

Destination	Quantity	Destination	Quantity
Argentina	11	Mexico	12
Australia	9	Netherlands	41
Belgium	38	New Zealand	2
Brazil	55	Peru	8
Colombia	2	Portugal	7
Denmark	22	Spain	133
Ecuador	1	Sweden	12
France	53	United Kingdom	10
Germany, West	14	United States	462
Greece	2	Other countries [2]	7
India	24	In transit	41
Ireland	7		
Japan	30	Total	1,003

[1] Includes 101,567 tons of potassium nitrate.
[2] Includes El Salvador, Nicaragua, Panama, and Uruguay, and certain Middle Eastern Countries; each received less than 1,000 tons.

Venezuela.—Installation of an ammonia plant of 110-ton-per-day capacity was completed for Instituto Venezolano de Petroquimica near Puerto Cabella.[17]

EUROPE

Bulgaria.—A new plant consisting of 110 buildings, including a large power installation, began producing nitrogenous fertilizers at Stara Zagora. Capacity of the facility was stated to be 400,000 tons per year.[18] An order was placed with a London firm by the Government for an air-separation plant to produce high-purity liquid and gaseous nitrogen. Nitrogen capacity was to be 400 pounds per hour.[19] The 33,000-ton-per-year urea plant at Dimitrovgrad went into production.[20]

France.—The Air Liquide liquid nitrogen and oxygen plant at Pierrelatte, which was to supply the nearby atomic energy center, was due on stream by the end of the year.[21]

Germany, West.—A new 260-ton-per-day nitric acid plant was built for Ruhrchemie A–G.[22]

Greece.—The Government-owned nitrogenous fertilizer plant at Ptolemais made some test runs during the year and scheduled commercial-scale operation for the spring of 1964.[23] Plans were progressing for a $110 million oil, chemical, and steel project for Salonika. Included in the project was a 115-ton-per-year ammonia plant.[24]

[16] Chemical Age (London). New Firm to Exploit Peruvian Guano Deposits. V. 90, No. 2298, July 27, 1963, p. 144.
[17] Nitrogen. No. 23, May 1963, p. 42.
[18] Chemical Age (London). Bulgaria's Largest Fertiliser Plant Now on Stream. V. 90, No. 2303, Aug. 31, 1963, p. 298.
[19] Chemical Week. V. 93, No. 18, Nov. 2, 1963, p. 67.
[20] Page 41 of work cited in footnote 17.
[21] European Chemical News (London). Plant Nearing Completion. V. 4, No. 96, Nov. 15, 1963, p. 33.
[22] Chemical Trade Journal and Chemical Engineer (London). New Nitric Acid Plant. V. 153, No. 3981, Sept. 27, 1963, p. 472.
[23] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, p. 26.
[24] Chemical Age (London). Tender Out for Greek Petrochemicals Plant. V. 90, No. 2317, Dec. 7, 1963, p. 881.

Hungary.—The Hungarian State Co., Chemokomplex, awarded contracts for the design and construction of an ammonia and urea facility at Barcika. Completion date was scheduled for the beginning of 1966.[25]

Ireland.—A contract was awarded to Lurgi, A.G., of Frankfurt am Main, West Germany, by Nitrigin Eireann Teoranta (State owned), to construct a nitrogenous fertilizer plant at Arklow, County Wicklow. The plant, with an annual capacity of 150,000 long tons of ammonium sulfate and calcium ammonium nitrate, was scheduled for completion in 1965.[26]

Netherlands.—Power Gas Corp. Ltd., Stockton-on-Tees, England, was awarded a contract by Staatsmijnen (Dutch State Mines), in Limburg, to design and construct a 365-ton-per-day ammonia plant in Geleen. The plant was scheduled for operation in October 1964.[27]

Norway.—Norsk Hydro-Elektrisk Kvaelstof, A/S planned to raise the annual capacity of its ammonia plant at Herøya from 300,000 to 430,000 tons of nitrogen equivalent by 1965.[28]

Poland.—Construction was started on a 1,500-ton-per-day ammonia plant at Pulawy, near Warsaw. The output was to be used for the production of high-purity urea, and was scheduled for operation in 1968. Full production (670,000 tons of fertilizer annually) was expected in 1970.[29]

Rumania.—The ammonia, nitric acid, and ammonium nitrate units of the chemical complex under construction at Craiova were nearing completion at yearend. A 100,000-ton-per-year urea plant also was under construction.[30] Masinimport of Bucharest ordered an ammonia plant of 100,000 tons annual capacity to be built at Turnu Magurele.[31]

Spain.—The $33 million fertilizer plant of Refineria de Petroleos de Escombreras, S.A., was completed. The rated production capacities were 77,000 tons urea and 230,000 tons ammonium sulfate.[32] Sociedad Espanola de Fabricaciones Nitrogenados planned to expand its fertilizer works,[33] and Nitratos de Castilla, S.A., was enlarging its ammonia and ammonium nitrate plants at Valladolid.[34] Amoniaco Español, S.A., an affiliate of Esso Mediterranean, Inc., had under construction, at Malaga, a 300-ton-per-day ammonia plant and facilities for manufacturing ammonium sulfate, calcium ammonium nitrate, and nitrogen solutions. Production was scheduled for late in 1964.[35]

Sweden.—Aktiebolaget Svenska Saltpeterverken awarded a contract for the design, engineering, and construction of a recycle 75-ton-per-day urea plant at Koping.[36] A $4 million ammonium nitrate plant

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[25] Commercial Fertilizer. V. 107, No. 5, November 1963, p. 40.
[26] Bureau of Mines. Mineral Trade Notes. V. 56, No. 5, May 1963, p. 30.
[27] Nitrogen. No. 25, September 1963, p. 10.
[28] Bureau of Mines. Mineral Trade Notes. V. 57, No. 3, September 1963, pp. 38, 39.
[29] Chemical Age (London). Giant Ammonia Converters for Pulawy Complex. V. 90, No. 2317, Dec. 7, 1963, p. 882.
[30] Chemical Age (London). Crajova Complex Nears Completion. V. 90, Nos. 2319–2320, Dec. 21 and 28, 1963, p. 972.
[31] Work cited in footnote 27, p. 11.
[32] Nitrogen. No. 22, March 1963, p. 15.
[33] Nitrogen. No. 25, September 1963, pp. 10, 11.
[34] Nitrogen. No. 26, November 1963, p. 22.
[35] Farm Chemicals. Esso and Jersey Standard Looming Big in World Fertilizer. V. 126, No. 8, August 1963, pp. 12–13, 44, 52.
[36] Work cited in footnote 13.

was planned for operation in late 1965 at Landskrona, by Stockholms Superfosfat Fabriks AB.[37]

U.S.S.R.—The Soviet Union approached Japan late in the year for five urea plants, each having an annual capacity of from about 300,000 to 400,000 short tons.[38]

United Kingdom.—Agreements which allowed British Sulphate of Ammonia Federation Ltd. to impose restrictions on the acquisition and supply of sulfate, and Imperial Chemical Industries, Ltd. (ICI), to act as the sole selling agent for sulfate, were terminated.[39] ICI was involved in a multimillion dollar expansion program. A 100,000-ton-per-year ammonia plant was commissioned and an extension to provide another 180,000 tons was under construction at Severnside.[40] The Billingham installation was modernized and expanded, bringing annual ammonia capacity to over 400,000 tons.[41] ICI also had two 165-ton-per-day nitric acid plants start operations (one at Severnside and one at Heysham, Lancashire), and another acid plant of 520-ton-per-day capacity under construction at Severnside.[42] Fisons Fertilisers Ltd. had a new nitric acid plant under construction at Immingham,[43] and Scottish Agricultural Industries Ltd. announced plans for a 50,000-ton-per-year nitric acid plant to be built near Grangemouth.[44]

Yugoslavia.—A 400,000 ton fertilizer plant to produce ammonium sulfate and calcium ammonium nitrate was planned for Croatia.[45] Also, late in the year, tenders were put out for two new ammonia plants and a urea plant.[46]

ASIA

Burma.—Tenders for the construction of a fertilizer plant at Chauk were issued by Industrial Development Corp. The plant was expected to produce about 45,000 short tons of ammonia annually and was scheduled for operation in 1965.[47]

Ceylon.—The Ministry of Commerce and Industries of Ceylon proposed to establish a 66,000-ton-per-year ammonium sulfate fertilizer plant.[48]

China.—The first ammonium sulfate plant ever to be engineered and constructed entirely by Chinese personnel with all Chinese-manufactured equipment went on stream near Shanghai. An annual capacity of 27,500 short tons ammonia for conversion into 110,000 tons of am-

[37] Chemical Week. New Units Slated for Sweden, Czechoslovakia, South Africa. V. 93, No. 26, Dec. 28, 1963, p. 24.
[38] Oil, Paint and Drug Reporter. Urea: USSR Wants Huge Toyo Koatsu-Built Plants. V. 184, No. 27, Dec. 30, 1963, p. 3.
[39] Chemical Age (London). Restrictive Practices Court Ends Ammonium Sulphate Agreements. V. 89, No. 2292, June 15, 1963, p. 870.
[40] Chemical Age (London). Severnside Ammonia on Stream. V. 89, No. 2290, June 1, 1963, pp. 797–798.
[41] Chemical Trade Journal and Chemical Engineer (London). Ammonia and Fertiliser Plant Developments at ICI Severnside and Billingham Sites. V. 152, No. 3964, May 31, 1963, p. 861.
[42] Chemical & Engineering News. ICI Builds More Nitric Acid Capacity. V. 41, No. 30, July 29, 1963, pp. 28–29.
[43] Chemical Trade Journal and Chemical Engineer (London). Nitric Acid Plant for Immingham. V. 153, No. 3976, Aug. 23, 1963, p. 278.
[44] Commercial Fertiliser. V. 107, No. 3, September 1963, p. 30.
[45] Work cited in footnote 25.
[46] Chemical Age (London). Yugoslav Plans for Ammonia and Urea. V. 90, No. 2317, Dec. 7, 1963, p. 881.
[47] Work cited in footnote 23.
[48] Fertiliser and Feeding Stuffs Journal (London). V. 59, No. 4, Aug. 21, 1963, p. 150.

monium sulfate was claimed.[49] Continental Engineering Co., a subsidiary of Verenigde-Machine-Fabrieken, N.V., Stork-Werkspoor, of Holland, was awarded a contract to supply a urea plant with an annual capacity of about 193,000 tons. Also, China concluded a contract with a British firm, Humphreys & Glasgow Ltd., for a $5 to $8 million ammonia fertilizer plant.[50]

India.—The fertilizer plant of East India Distilleries-Parry Ltd. (EID), at Ennore, near Madras, went into production. The installation consisted of three main sections: One to produce ammonia, one for the production of sulfuric and phosphoric acids, and a granulation plant to form mixed fertilizers.[51] Contracts for building a large urea plant at Gorakhpur, Uttar Pradesh were awarded to a group of Japanese firms headed by Toyo Kogyo. The plant, with a daily capacity of 350 tons of ammonia and 544 tons of urea, was stated to become the world's largest.[52] Also, a contract was awarded by Fertiliser Corporation of India Ltd. (FCI) to a British firm for the erection of a fertilizer plant at Namrup in Assam, which included a 220-short-ton-per-day ammonia unit, a 275-ton-per-day sulfuric acid unit, and a urea plant with a daily capacity of 184 tons. FCI planned to design and install an ammonium sulfate plant to complete the complex.[53] A $27 million loan was made by Export-Import Bank to Coromandel Fertilizers, Ltd., a new company formed by California Chemical Co., a subsidiary of Standard Oil Co. of California, International Minerals and Chemicals Corp., and EID, to help in constructing a fertilizer plant at Vizakhapatnam, about 300 miles south of Calcutta on the east coast.[54]

Indonesia.—The urea plant at Palembang, Sumatra, which was financed by the Export-Import Bank, was completed.[55]

Iran.—The Shiraz fertilizer works was formally opened in October. It was a part of a $35 million project of the Petrochemical Corp., undertaken on behalf of the Iranian Government to produce fertilizer for the domestic market. The plant's rated annual capacity of 40,000 tons each of ammonium nitrate and urea, plus a substantial quantity of liquid ammonia, was expected to meet domestic needs.[56]

Kuwait.—A new company, Kuwait Chemical Fertilizers Co., was formed to build a 400-ton-per-day ammonia plant in the Shuaiba industrial area south of Ahmadi. The owners of the new company were listed as: Kuwait Petrochemical Industries Co. (60 percent), Gulf Oil Corp. (20 percent), and British Petroleum Co. Ltd. (20 percent).[57]

Philippines.—Esso Standard Chemical and Fertilizer Corp. planned to add a 77,000-ton-per-year urea plant to its installation in the Philip-

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[49] Chemical Age (London). First All-Chinese Fertiliser Plant. V. 90, No. 2310, Oct. 19, 1963, p. 594.
[50] Oil, Paint and Drug Reporter. Red China, UK Firm in Deal on Ammonia. V. 184, No. 20, Nov. 11, 1963, p. 4.
[51] Chemical Trade Journal and Chemical Engineer (London). EID-Parry Fertiliser Plant. V. 153, No. 3985, Oct. 25, 1963, p. 642.
[52] Commercial Fertilizer. V. 107, No. 2, August 1963, p. 44.
[53] Chemical Age (London). Chemico Gain Third Large Indian Fertiliser Contract. V. 89, No. 2290, June 1, 1963, p. 795.
[54] Chemical & Engineering News. V. 41, No. 44, Nov. 4, 1963, p. 145.
[55] Bureau of Mines. Mineral Trade Notes. V. 57, No. 1, July 1963, p. 36.
[56] Chemical Age (London). C.J.B.-Built Persian Refinery Opened. V. 90, No. 2312, Nov. 2, 1963, p. 679.
[57] European Chemical News (London). Ammonia Project for Kuwait. V. 4, No. 95, Nov. 8, 1963, p. 29.

pines. C. F. Braun and Co. of Alhambra, Calif., was selected for the construction job.[58]

Taiwan.—Kaohsiung Ammonium Sulphate Corp. put into operation a new anhydrous ammonia unit which increased output from 100 to 165 tons per day. Total production of about 500 tons of ammonium sulfate was made possible by the new ammonia unit.[59] A $23 million fertilizer plant, owned jointly by the Chinese Petroleum Corp. (30 percent), Socony Mobil Oil Co. and Allied Chemical Corp. (35 percent each), was officially opened. Annual production of 100,000 tons of urea and 106,000 tons of ammonia was expected.[60]

Thailand.—A consortium of West German firms led by Friedrich Uhde G.m.b.H., of Dortmund, was selected to build a fertilizer complex in North Thailand for Chemical Fertiliser Co. Ltd. (Thailand).[61]

AFRICA

Algeria.—A nitrogen fertilizer plant was planned for Arzew by SN Repal, a Saharan oil and natural gas company.[62]

Tunisia.—A project for a nitrogen fertilizer plant at La Skhirra was approved in principle by the Tunisian Government.[63]

United Arab Republic (Egypt).—Nasr Fertilizer & Chemical Industries Co. expected to begin operating a new 100,000-ton-per-year ammonium sulfate plant late in 1963. Projects for expansion were underway for the production of calcium nitrate and calcium ammonium nitrate.[64]

OCEANIA

Australia.—A $2 million contract was awarded to Humphreys & Glasgow Ltd. by Imperial Chemical Industries of Australia and New Zealand (ICIANZ) for Australia's first urea plant. The unit, which is an addition to the company's nitrogen complex at Botany, New South Wales, was scheduled for completion by March 1964. ICIANZ also expected to add units for ammonia and methanol.[65]

TECHNOLOGY

Synthetic lecontite, a sodium ammonium sulfate, was prepared and studied by X-ray diffraction techniques.[66] The diffraction data were compared with that for natural lecontite. The work supported the belief that synthetic $NaNH_4SO_4 \cdot 2H_2O$ is identical to the natural mineral lecontite.

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[58] European Chemical News (London). Two More Stamicarbon Urea Plants Sold. V. 4, No. 91, Oct. 11, 1963, p. 29.

[59] Chemical Fertilizer. V. 106, No. 6, June 1963, p. 32.

[60] European Chemical News. New Fertilizer Plant Starts Up in Formosa. V. 4, No. 101, Dec. 20, 1963, p. 19.

[61] Chemical Age (London). Uhde Fertiliser Complex for Thailand. V. 90, No. 2316, Nov. 30, 1963, p. 850.

[62] Oil, Paint and Drug Reporter. Nitrogen Fertilizer Unit To Be Built in Algeria. V. 184, No. 8, Aug. 19, 1963, p. 35.

[63] Chemical Trade Journal and Chemical Engineer (London). V. 153, No. 3987, Nov. 8, 1963, p. 714.

[64] Pages 30–32 of work cited in footnote 14.

[65] Chemical Engineering. V. 70, No. 4,Feb. 18, 1963, p. 202.

[66] Faust, Robert J., and F. Donald Bloss. X-Ray Study of Lecontite. Am. Mineralogist, v. 48, Nos. 1 and 2, January–February 1963, pp. 180–188.

The first International Symposium on Nitro Compounds was held September 18–20, 1963, in Warsaw, and was jointly sponsored by International Union of Pure and Applied Chemistry and the Polish Academy of Sciences. About 300 scientists from 20 countries were in attendance. Nine lectures and 96 papers were presented, many of which were later published.[67]

Results from investigations of ammoniation of triple superphosphate with ammonia gas and nitrogen solutions were published.[68]

Atomic Energy Commission studies indicated that the use of heat generated by a gas-cooled nuclear reactor to gasify North Dakota lignite and West Virginia coal may be economically feasible. The gas produced was suitable as a source for fuel or for ammonia.[69]

Design changes incorporating a new type of synthesis converter and making use of standard industrial parts were reported to have reduced substantially the operating costs of small ammonia plants.[70]

Details were published on the Norwegian "Odda process" for the manufacture of concentrated complex fertilizers. The process is based on the use of nitric acid with phosphate rock to produce nitrogen-phosphorus fertilizer and a byproduct of calcium nitrate.[71]

Manufacturing licenses for a process to produce high-purity nitric acid (not over one-millionth of 1 percent of impurities) were offered for sale by the Soviet foreign trade organization, Litsenzintorg.[72]

A computational investigation was made of a large-scale operational natural gas reforming plant to determine proper conditions necessary to insure freedom from carbon formation in the primary and secondary reformers. Also, the performance of the plant with increased throughput was predicted for various non-carbon-forming operating conditions. Results presented in an article[73] describing the investigation were derived from thermodynamic calculations based upon prior knowledge of the plant and process. All calculations were programed for machine computations.

Other articles discussing recent improvement in the manufacture of urea,[74] nitric acid,[75] calcium cyanamide,[76] ammonia and ammonium nitrate for fertilizers were published.[77]

A fast low-cost method for obtaining humic acids from oxidized lignite was developed by Bureau of Mines chemists.[78] The method

[67] Kamlet, Mortimer J. International Symposium on Nitro Compounds, Warsaw, 18–20 September 1963. Chem. and Ind. (London), No. 44, Nov. 2, 1963, pp. 1741–1748.

[68] Agricultural Chemicals. Ammoniation of Triple Superphosphate With Gaseous Ammonia and Nitrogen Solutions. V. 18, No. 11, November 1963, pp. 68, 70.

———. Fluidized Superphosphate Ammoniation. V. 18, No. 11, November 1963, pp. 70, 115.

[69] Oil, Paint and Drug Reporter. Nuclear-Coal Route to Ammonia, Methanol Seen Near. V. 184, No. 15, Oct. 7, 1963, p. 5.

[70] Chemical & Engineering News. Small NH_3 Plants May Compete With Large. V. 41, No. 52, Dec. 30, 1963, pp. 38–39.

[71] Chemical Trade Journal and Chemical Engineer (London). Fertilizers Manufacture by the Norwegian 'Odda Process'. V. 152, No. 3955, Mar. 29, 1963, pp. 508, 509.

[72] Chemical Trade Journal and Chemical Engineer (London). Soviet Press for Nitric Acid. V. 153, No. 3969, July 5, 1963, p. 8.

[73] Holland, D. R., and S. W. Wan. Gas Reforming Plant . . . A Computational Investigation. Chem. Eng. Prog., v. 59, No. 8, August 1963, pp. 69–74

[74] Nitrogen. Recent Developments in the Production of Urea. No. 25, September 1963, pp. 33–37.

[75] ———. Nitric Acid Processes. No. 21, January 1963, pp. 35–39.

[76] ———. Calcium Cyanamide. No. 22, March 1963, pp. 32–41.

[77] Strelzoff, S., and S. Vasan. Advances in the Technology of Fertilizers. Chem. Eng. Prog., v. 59, No. 11, November 1963, pp. 60–65.

[78] Chemical & Engineering News. Process Removes Humic Acids From Lignite. V. 41, No. 3, Jan. 21, 1963, p. 82.

showed some promise for producing a low-cost high nitrogen soil conditioner and fertilizer.

A new type of fertilizer was marketed using a base of soluble derivatives of humic, ulmic, and fulvic acids obtained from humus material from leonardite (a naturally oxidized lignite) deposits of Wyoming.[79]

New uses for nitrogen [80] and nitrogen compounds were added to the already very long list: Wood was plasticized with liquid ammonia; [81] underground fires were controlled with nitrogen gas; [82] ammonia was decomposed to generate hydrogen for fuel cells in submarines; [83] although not new the cryogenic uses of liquid nitrogen were increased; [84] ammonium nitrate and urea were experimently used to retard the melting of snow on ski slopes; [85] the possible use of ammonia for preserving fish was investigated; [86] and the potential use of anhydrous ammonia as a solvent was suggested.[87]

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[79] Agricultural Chemicals. New Humus Material Derived From Leonardite Deposit. V. 18, No. 6, June 1963, pp. 52, 121–122.

[80] Hartley, William D. Dozens of Uses Being Found for Nitrogen, a Cheap, Plentiful Gas That "Does Nothing". Wall Street J., v. 162, No. 96, Nov. 13, 1963, p. 32.

[81] Schuerch, Conrad. Plasticing Wood With Liquid Ammonia. Ind. and Eng. Chem., v. 55, No. 10, October 1963, p. 39.

[82] Steel & Coal (London). Use of Nitrogen in Controlling an Underground Fire. V. 187, No. 4974, Nov. 15, 1963, p. 961.

[83] American Cyanamid Co. Generation of Hydrogen for Fuel Cells in Submarine Propulsion. Processes Involving Decomposition of Ammonia. New York, October 1962; U.S. Dept. Commerce, OTS, AD 292246.

[84] Chemical Week. "Cold" Nitrogen Rides High. V. 93, No. 2, July 13, 1963, pp. 75–76, 80.

[85] Farm Chemicals. Snow Job. V. 126, No. 4, April 1963, p. 52.

[86] Science. Ammonia: Possible Use for Preserving Fish. V. 142, No. 3589, Oct. 11, 1963, pp. 233, 234.

[87] Chemical & Engineering News. Can You Use Liquid Anhydrous Ammonia as a Solvent? V. 41, No. 20, May 20, 1963, p. 83.

Perlite

By Timothy C. May [1]

PRODUCTION of crude perlite in the United States in 1963 was 1 percent less than in 1962 while expanded perlite output rose 14 percent.

DOMESTIC PRODUCTION

Crude Perlite.—Seventeen companies produced perlite from 18 mines in 7 States, compared with 16 companies, 17 mines, and 8 States in 1962. Producers used about the same quantity of crude perlite in their own expanding plants as in 1962, and sold other expanders 3 percent more than in 1962.

New Mexico was the leading producing State, followed by California, Arizona, Nevada, Colorado, Utah, and Idaho.

Expanded Perlite.—In 1963, perlite was expanded by 77 companies in 30 States at 90 plants. California had 14 expanding plants; Pennsylvania and Texas, 6 each; Illinois and New York, 5 each; and Colorado, Florida, Indiana, Iowa, and New Jersey, 3 each.

TABLE 1.—Crude and expanded perlite produced and sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Crude perlite						Expanded perlite		
	Quantity mined	Sold		Used at own plant to make expanded material		Total quantity sold and used	Quantity produced	Sold	
		Quantity	Value	Quantity	Value			Quantity	Value
1954–58 (average)	348	190	$1,690	92	$634	282	239	238	$12,174
1959	443	221	1,846	104	891	325	276	273	14,187
1960	385	214	1,847	98	818	312	248	244	13,046
1961	374	196	1,665	114	998	310	240	235	12,605
1962	408	198	1,611	122	1,052	320	238	234	[1] 12,536
1963	404	203	1,631	122	1,096	325	272	270	14,497

[1] Revised figure.

[1] Commodity specialist, Division of Minerals.

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TABLE 2.—Expanded perlite produced and sold by producers in the United States

(Thousand short tons and thousand dollars)

State	1962				1963			
	Quantity produced	Sold			Quantity produced	Sold		
		Quantity	Value	Average value per ton		Quantity	Value	Average value per ton
California	24	24	$1,421	$58.93	27	27	$1,654	$60.16
Florida	8	8	516	65.63	7	7	475	69.28
Kansas	1	1	42	64.05	(1)	(1)	(1)	(1)
Michigan	4	4	225	60.18	2	2	126	56.44
New Jersey	9	9	568	62.80	8	8	508	64.26
New York	12	12	628	53.62	10	10	524	51.78
Pennsylvania	14	14	936	65.14	14	14	847	60.31
Texas	27	27	1,599	58.15	26	26	1,512	57.73
Other Eastern States [2]	75	73	4,263	58.20	127	127	6,834	41.47
Other Western States [3]	64	62	2,338	37.64	51	49	2,017	54.11
Total	238	234	12,536	53.49	272	270	14,497	53.69

[1] Included with "Other Eastern States."
[2] Includes Illinois, Indiana, Kentucky, Maryland, Massachusetts, New Hampshire, North Carolina, Ohio, Tennessee, Virginia, and Wisconsin.
[3] Includes Arizona, Colorado, Idaho, Iowa, Louisiana, Minnesota, Missouri, Nebraska, Nevada, Oregon and Utah.

The Dallas plant of Texas Vermiculite Co. has a capacity of 32,000 bags of expanded perlite per month. The crude perlite is processed in a horizontal rotary furnace at 1,500° to 1,600° F. Quality-control tests on finished product include sieve analysis density checks, friability determinations, and examination for uniformity.[2]

CONSUMPTION AND USES

Producers reported the following end-use percentages for expanded perlite: building plaster aggregate, 39; insulation (other), 20; filter aids, 15; concrete aggregate, 12; oil well cement, 4; insulation (loose fill), 4; soil conditioning, 2; filler, 1; wallboard, 1; and miscellaneous uses, 2.

PRICES

The average value of crude perlite crushed, cleaned, and sized, f.o.b. producers' plants, sold to expanders was $8.05 per short ton, compared with $8.14 in 1962. The average value of crude perlite used by producers in their own expanding plants was $8.94, compared with $8.59 in 1962. A weighted average price of these two categories of crude perlite was $8.39, compared with $8.31 in 1962.

The average value of all expanded perlite sold in 1963 was $53.69 per ton, compared with $53.49 in 1962.

FOREIGN TRADE

Crude perlite may be imported duty-free under paragraph 1719 of the Tariff Act of 1930. Expanded perlite is dutiable at 15 percent ad valorem. During 1963 no crude or expanded perlite was imported.

[2] Levine, S. Production of Aggregates at Texas Vermiculite Co. Minerals Processing, v. 4, No. 8, August 1963, pp. 30–31.

WORLD REVIEW[3]

Canada.—Deposits of crude perlite in central and southern British Columbia have not been developed commercially. Raw material is imported from the United States for processing. The 10 plants operating during 1962 were in Calgary, Alberta (2); Vancouver and Richmond, British Columbia; Winnipeg, Manitoba; Caledonia and Hagersville, Ontario; and Ville St. Pierre, Beauport, and Charlesbourg West, Quebec. In 1962, about 97,000 cubic yards of expanded perlite valued at Can$737,000 was produced from the imported material. This represented a 5-percent increase in volume but a decrease of nearly 1 percent in value from 1961.

Plaster aggregate accounted for 86 percent of 1962 use of expanded perlite, compared with 91 percent in 1961. Nine percent was used in insulating concrete, compared with 4 percent in 1961. Horticulture, insulation, stucco, acoustic tile, and plaster uses were 5 percent, the same as in 1961.

Expanded perlite sold at 25 to 35 cents per cubic foot in bags of 3 and 4 cubic feet. All prices were f.o.b. plant.[4]

Midwest Expanded Ores Co., St. Boniface, Manitoba, planned to open a processing plant in Saskatoon, Saskatchewan.[5]

Germany, West.—It was reported that a Hungarian-designed perlite expansion plant will be delivered to Deutsche Perlite G.m.b.H. of Dormund, West Germany. The perlite is expanded by use of a special oil burner and various cyclone systems to ensure against dust. The plant will have a capacity of 21 cubic yards per hour.[6]

Mozambique.—An exclusive charter was granted to Bedaux, Lda., a French firm, for perlite exploration at Boane, District of Lourenco Marques.

TECHNOLOGY

Deposits of perlite potentially suitable for manufacturing lightweight insulating material occurring at Soledad Mountain and near Willow Springs Mountain in California were described.[7]

A comprehensive treatment of the perlite industry was given in papers at the Perlite Institute meeting in Washington, D.C., in April. Topics included the technical aspects of perlite insulating concrete, the advantages of perlite in engineering lightweight modern buildings, the role of perlite in texture paints, and the applications and advantages of silicone-treated perlite. The institute released technical data sheets covering specifications for silicone-treated perlite loose fill insulation and expanded perlite for low temperatures in atmospheric service.

A Hungarian-invented semiautomatic perlite-expanding machine was described. Raw perlite is discharged through a device at the

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[3] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

[4] Wilson, H. G. Lightweight Aggregates 1962 (Preliminary). Canada Dept. Mines and Tech. Surveys (Ottawa), June 1963, pp. 1–6.

[5] Rock Products. Lightweight Aggregates To Be Processed in Saskatoon. V. 66, No. 7, July 1963, p. 121.

[6] Mining Journal (London). Perlite Expansion Plant to West Germany. V. 261, No. 6676, Aug. 2, 1963, p. 114.

[7] Dibblee, Jr., T. W. Geology of the Willow Springs and Rosamond Quadrangles, California. Geol. Survey Bull. 1089–C, 1963, pp. 180, 242, 243.

bottom of a reinforced concrete storage tank and passes into the flame area of the expansion furnace through a pipe chute. The furnace, fired by crude diesel oil, is operated by a special type of oil burner. Primary and secondary air is supplied by a ventilator with a flexible pipeline connection. Under properly adjusted temperature and gas fume flow conditions, the granular perlite expands with a tenfold or twelvefold increase of volume and under the cooling effect of large quantities of cold air entering at the end of the furnace, it solidifies as spherical grains. The machine is operated totally free of dust.[8]

Some of the petrographic techniques used to characterize perlite were discussed. In addition to the conventional thin-section and immersion methods used in evaluating crude perlite, petrographic microscope techniques have contributed to the study of expanded perlite.[9]

A deposit of perlite in Idaho was described and reported to contain about 6.2 million tons of easily minable material.[10]

Investigations for perlite occurring at Sugar Mountain, Polychrome Pass, Calico Creek, and West Fork Calico Creek in the Alaska Range were described.[11]

A review with numerous maps was presented concerning the distribution of perlite in the U.S.S.R.[12] The Armenian S.S.R. has the largest deposits with 70 million tons of proved ore with excellent physical properties. Four main deposits were described.[13] Chemical composition, color, structure, and texture of perlite found in the Transcarpathian area were described.[14]

A patent was granted for a method of making moulded acoustical tile from a mixture of expanded perlite and other materials.[15]

Methods for substantially reducing cesspool odors[16] and for the disposal of radioactive wastes were patented.[17]

A process using expanded perlite as the preferred adsorptive material for a veratrine alkaloid insecticide was patented.[18]

A patent was granted on a vertical furnace for expanding perlite. Preheated crushed rock is introduced in a uniform pattern at the bottom of the furnace into an upwardly directed flame. The expanded perlite is conveyed to a cyclone separator.[19]

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[8] Chemical Trade Journal and Chemical Engineer (London). V. 152, No. 3965, June 7, 1963, p. 902.

[9] Kadey, Jr., F. L. Petrographic Techniques in Perlite Evaluation. Trans. AIME, v. 226 (Min. Eng.), No. 3, September 1963, pp. 332–336.

[10] Staley, W. W. Oneida Perlite Deposit. Idaho Bureau Mines and Geol., Miner. Res. Rept. 9, January 1962, 7 pp.

[11] U.S. Geological Survey. Contributions to Economic Geology of Alaska. Bull. 1155, 1963, pp. 49–66.

[12] Petrov, V. P., V. V. Nasedkin, and A. I. Polinkovskaya. (The Distribution of Perlites in the U.S.S.R., Their Geological Characteristics, and Their Technological Properties.) Sb. Tr. Resp. Nauchn-Issled. Inst. Mestnykh Stroit. Materialov, No. 25, 1962, pp. 6–18; Chem. Abs., v. 59, No. 1, July 8, 1963, p. 325.

[13] Sagatelyan, K. M. (Armenian Perlites.) Perlit i Vermikulit (Geol., Metodika Razvedki i Tekhnol.), Min. Geol. i Okhrany Nedr SSSR, 1962, pp. 29–37; Chem. Abs., v. 58, No. 12, June 10, 1963, p. 12310.

[14] Soloninko, I. S., and P. N. Chernyavskii. (The Transcarpathian Perlites.) Perlit i Vermikulit (Geol., Metodika Razvedki i Tekhnol.), Min. Geol. i Okhrany Nedr SSSR, 1962, pp. 21–29; Chem. Abs., v. 58, No. 10, May 13, 1963, p. 9977.

[15] Stedman, C. E. (assigned to U.S. Perlite Corp., Chicago, Ill.). U.S. Pat. 3,103,254, Sept. 10, 1963.

[16] Mendius, Jr., C. (assigned to Silbrico Corp., Chicago, Ill.). Process for Material Abatement of Odor Arising From Sewage Effluent. U.S. Pat. 3,113,924, Dec. 10, 1963.

[17] Beerman, H. P. (assigned to Victor Comptometer Corp., Chicago, Ill.). Method and Material for Disposing of Radioactive Waste. U.S. Pat. 3,116,131, Dec. 31, 1963.

[18] Allison, J. R. (assigned to Leffingwell Chemical Co., Whittier, Calif.). Sabadilla Seed Insecticide. U.S. Pat. 3,078,211, Feb. 19, 1963.

[19] Murdock, J. P., and H. A. Stein. Furnace for Expanding Perlite and Similar Substances. U.S. Pat. 3,097,832, July 16, 1963.

Phosphate Rock

By Richard W. Lewis [1]

FOR THE FIFTH consecutive year a new production record for marketable phosphate rock was set. There was a 2-percent increase over 1962 production. Over 10 million long tons was produced during the latter half of the year, upsetting early estimates of annual production based on the first 6-month period. Four percent more marketable rock was sold or used by producers than in 1962. World production also continued an upward trend, increasing by 6 percent.

TABLE 1.—Salient phosphate rock statistics

(Thousand long tons and thousand dollars)

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Mine production	45,875	49,249	54,338	60,535	56,746	61,578
P_2O_5 content	6,089	7,692	8,282	9,026	8,823	9,812
Marketable production	14,138	15,869	17,516	18,559	19,382	19,835
P_2O_5 content	4,446	4,939	5,443	5,804	6,004	6,215
Value	$88,270	$98,758	$117,041	$130,535	$134,304	$139,686
Average per ton	$6.24	$6.22	$6.68	$7.03	$6.93	$7.04
Sold or used by producers	13,939	16,065	17,202	17,842	19,060	19,860
P_2O_5 content	4,383	5,014	5,352	5,551	5,927	6,187
Value	$87,641	$99,657	$115,363	$125,593	$134,222	$140,642
Average per ton	$6.29	$6.20	$6.71	$7.04	$7.04	$7.08
Imports for consumption [1]	113	140	129	134	134	161
Value	$2,889	$3,421	$3,754	$3,629	$3,551	$3,651
Average per ton	$25.57	$24.45	$29.04	$27.08	$26.57	$22.68
Exports [2]	2,570	3,048	3,994	3,918	3,934	4,004
P_2O_5 content	842	956	1,290	1,261	1,269	1,302
Value	$16,604	$20,466	$26,632	$26,924	$27,567	$28,197
Average per ton	$6.46	$6.71	$6.67	$6.87	$7.01	$7.04
Consumption, apparent [3]	11,482	13,157	13,337	14,058	15,260	16,017
World: Production	32,160	37,800	41,240	44,770	47,450	50,400

[1] Data on P_2O_5 content not available.
[2] As reported to the Bureau of Mines by domestic producers.
[3] Measured by sold or used plus imports minus exports.

[1] Commodity specialist. Division of Minerals.

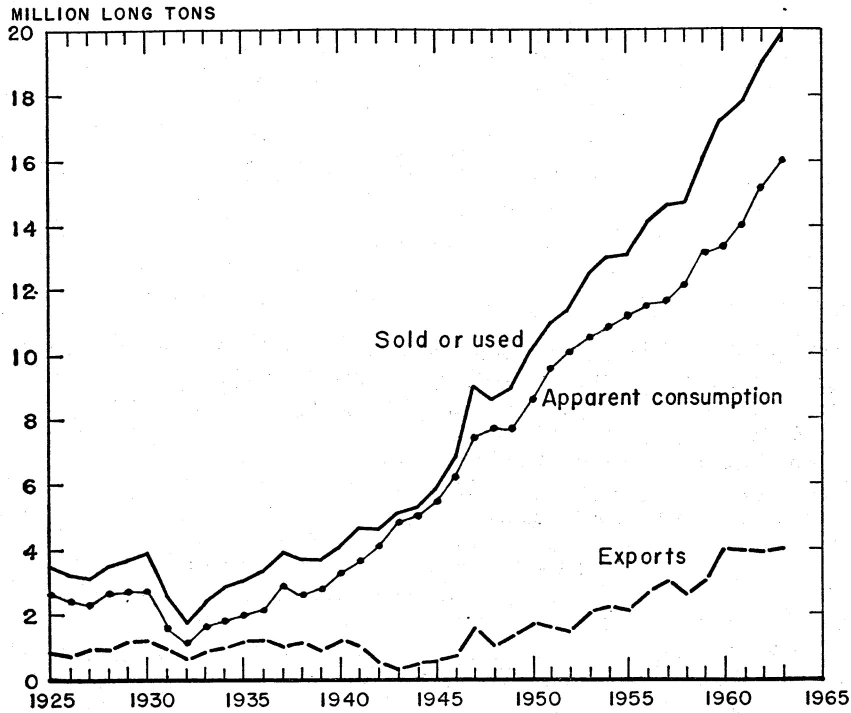

FIGURE 1.—Phosphate rock (sold or used), apparent consumption and exports, 1925–63.

DOMESTIC PRODUCTION

Florida phosphate rock producers exceeded the 1962 production of marketable rock by 5 percent, while in Tennessee and the Western States, production dropped 3 and 4 percent, respectively. Florida's production of marketable rock amounted to 74 percent of total domestic output; the Western States accounted for 14 percent; and Tennessee, for 12 percent.

There was substantial activity in the phosphate industry in 1963. New companies, as well as established phosphate producers, acquired new phosphate land. Some major expansion took place and some shutdowns occurred. Mergers were particularly prominent during the year.

Peyton Creek Mining Co. reported production and sales of phosphate rock from the long-known deposits of central Arkansas. Mississippi Chemical Co. announced plans to construct a $7 million phosphoric acid plant in the area, if results from test drillings and a survey of the deposits proved satisfactory. Monsanto Chemical Co., Olin Mathieson Chemical Corp., and Gulf Oil Corp. also were interested in these deposits.

Beaufort County, N.C., was the scene of much activity, with three major companies engaged in exploring and developing deposits of phosphate rock in the area. Texas Gulf Sulphur Co. conducted large-scale dredging operations near Aurora and struck phosphate late in December. The ore with water, sand, and clay was pumped through a 20-inch pipe to a pilot processing plant (completed during the year) where procedures for beneficiation were being studied. Pilot-plant studies were expected to be completed during the first quarter of 1964, when a decision to construct a multimillion-dollar processing plant would be made. Magnet Cove Barium Corp., Ltd., and Smith-Douglass Co. jointly acquired a 16,000-acre tract of bottom land of the Pungo River, a tributary of the Pamlico River, and conducted investigations of mining possibilities. North Carolina Phosphate Co., jointly owned by American Agricultural Chemical Co. and Kennecott Copper Corp., was exploring an area near Washington, N.C.

In the phosphorite region of the West, Kern County Land Co. exercised purchase options on 1,070 acres of land in the Sublette Ridge district of Lincoln County, about 5 miles north of Border, Wyo., and just east of the Idaho-Wyoming border. Duval Corp. joined Kern County Land Co. as a full partner in the project, and the two companies were investigating methods for beneficiating and processing the rock. Monsanto Chemical Co. successfully outbid competitors for Federal leases on 1,680 acres of phosphate land, 12 miles northeast of Soda Springs, Idaho, and on another 697 acres also near Soda Springs. Mountain Fuel Supply Co. (Salt Lake City, Utah) acquired several phosphate leases in the Georgetown Canyon area of Idaho, but no plans for development were announced. Susquehanna-Western, Inc., began exploration work on Federal phosphate land in Fremont County, Wyo.

TABLE 2.—Mine production of phosphate-rock ore in the United States, by States

(Thousand long tons)

Year	Florida		Tennessee [1]		Western States [2]		Total United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1954–58 (average)	40,928	4,943	2,766	565	2,181	581	45,875	6,089
1959	43,365	6,323	2,709	556	3,175	813	49,249	7,692
1960	48,007	6,753	2,931	636	3,400	893	54,338	8,282
1961	54,403	7,552	3,321	734	2,811	740	60,535	9,026
1962	49,600	7,093	3,812	855	3,334	875	56,746	8,823
1963	54,445	8,068	4,131	921	3,002	823	61,578	9,812

[1] Includes brown rock, white rock, and blue rock in 1954–58.
[2] Includes Arkansas (1963), Idaho, Montana, Utah, and Wyoming.

Several petroleum companies moved, or were negotiating moves, into the phosphate business. Cities Service Oil Co. completed a merger with Tennessee Corp., Socony Mobil Oil Co., Inc., effected a statutory merger with Virginia-Carolina Chemical Corp., and Continental Oil Co. purchased American Agricultural Chemical Co. Two oil companies were reported to be interested in purchasing Smith-Douglass Co., Inc. Kermac Nuclear Fuels Corp., mining subsidiary of Kerr-McGee Oil Industries, Inc., bought Baugh Chemical Co., not a phosphate producer but owner of approximately 2,000 acres of phosphate land south of Mulberry, Fla. Husky Oil Co. and International Minerals & Chemical Corp. (IMC) jointly were planning to build a major phosphate plant near Soda Springs, Idaho. The two companies had an agreement on the development of one of the largest surface-minable phosphate reserves known.

A large chemical plant to produce phosphoric acid and triple superphosphate was planned for Pierce, Fla., by American Agricultural Chemical Co. A new phosphoric acid plant with a daily production rate of 900 tons of acid as phosphorus pentoxide (P_2O_5) was officially opened at Bonnie, Fla., by IMC. In addition, IMC had under construction a large phosphate granulation plant at Bonnie which was scheduled for completion by the end of the year. This new facility was expected to produce 250,000 tons per year of finished materials—a 50-percent increase in the firm's capacity.

In December, IMC announced its intentions for closing, in 1964, its Prairie phosphate plant at Mulberry, Fla. The company officials stated that it was economically impossible to meet the demands of the State concerning the level of dust emitted by the plant. The Prairie plant was expected to be replaced with a larger and completely modern facility at an undesignated location.

Virginia-Carolina Chemical Corp. (V–C) expected delivery of a $2 million, 1,800-ton dragline before the end of the year. The new machine with bucket capacity of 35 cubic yards, the largest ever employed in phosphate mining, was ordered for use at the company's Peace River mine, 6 miles southeast of Bartow, Fla. V–C planned early in the year to spend $6 million on an expansion program in Mount Pleasant, Tenn. The program included modernization of existing facilities and a new 35,000-kva phosphorus furnace, construction of which was started later in the year. Citizens of Mount Pleasant voted a $5 million bond issue to construct industrial facilities which were to be offered to V–C on lease.

Hooker Chemical Corp. began construction on an installation on the Mississippi River, south of Davenport, Iowa, for manufacturing phosphate feed supplements. Initial production of dicalcium phosphate was scheduled for early 1964. Hooker, planning further expansion, announced in November its intention of acquiring National Phosphate Corp. of Marseilles, Ill., as a subsidiary, provided that the Government ruled favorably on the transaction.

Monsanto Chemical Co. had a new plant at Augusta, Ga., on stream early in the year. The plant initially produced fertilizer-grade phosphoric acid and sodium tripolyphosphate.

Kaiser Aluminum & Chemical Corp. was building a $2 million phosphoric acid plant at Gramercy, La. The plant was designed to use hydrochloric acid for the reaction with phosphate rock instead of the normally used sulfuric acid. The process was developed by Israel Mining Industries. Additional units to make phosphoric acid and various mixed fertilizers were planned by Lone Star Producing Co. for its new fertilizer complex under construction at Kerens, Tex. Construction was to start in the spring of 1964 with completion scheduled for March 1965.

J. R. Simplot Co. began a $10 million expansion program which was expected to double the fertilizer output of its plant at

Pocatello, Idaho. The program included at 700-ton-per-day sulfuric acid plant to be completed in November, and a new 1,000-ton-per-day phosphate rock calcining unit to be installed at a later date. Western Phosphates, Inc., planned an $8 million expansion at the Garfield, Utah, plant and later deferred the program because of changed market conditions for ammonium phosphate. Montana Phosphate Products Co., Garrison, Mont., was engaged in developing a new (Douglass) mine and flotation plant about 12 miles north of Philipsburg, Mont. The facility, scheduled for completion early in 1964, was engineered for an annual output of 300,000 tons of phosphate rock concentrate. The entire production was intended for the parent company's (Consolidated Mining & Smelting Co. of Canada, Ltd.) plants at Kimberley and Trail, British Columbia, Canada, for processing into fertilizers. Rocky Mountain Phosphates, Inc., began operating a new processing plant at Garrison, Mont. The new plant, including a large rotary kiln operating at 2,400° to 2,500° F, replaced the company's old plant at Butte, Mont., which was ordered closed by the Montana District Court because of complaints of excessive smoke and dust from the kiln. Central Farmers Fertilizer Co. shut down the elemental phosphorus furnace at its Georgetown, Idaho, plant. The company planned to continue producing triple superphosphate and other phosphatic fertilizers.

TABLE 3.—Marketable production of phosphate rock in the United States, by States

(Thousand long tons)

Year	Florida [1]		Tennessee [2]		Western States [3,4]		Total United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1954–58 (average)	10,410	3,448	1,700	443	2,028	555	14,138	4,446
1959	11,564	3,794	1,755	458	2,550	687	15,869	4,939
1960	12,321	4,052	1,939	506	3,256	885	17,516	5,443
1961	13,789	4,531	2,235	575	2,535	698	18,559	5,804
1962	13,949	4,543	2,418	638	3,015	823	19,382	6,004
1963	14,592	4,818	2,352	612	2,891	785	19,835	6,215

[1] Salable products from washers and concentrators of land pebble and hard rock, and drier production of soft rock (colloidal clay).
[2] Salable products from washers and concentrators of brown rock, brown-rock ore (matrix) used directly blue rock, and white rock in 1954–58.
[3] Mine production of ore (rock), plus a quantity of washer and drier production.
[4] Includes Arkansas (1963), Idaho, Montana, Utah, and Wyoming.

CONSUMPTION AND USES

According to reports from producers to the Bureau of Mines, 6,187,000 tons (P_2O_5 content) of phosphate rock was sold or used, 4 percent more than in 1962. Agricultural uses accounted for 60 percent of the total, while the chemical industry consumed 19 percent, and 21 percent was exported.

The U.S. Department of Agriculture reported a preliminary total of 3,092,070 short tons available P_2O_5 consumed as fertilizer during the year ending June 30, 1963. This was 10 percent more than in the preceding fiscal year.

TABLE 4.—Phosphate rock sold or used by producers and apparent consumption in the United States

(Thousand long tons and thousand dollars)

Year	Sold or used		Apparent consumption
	Quantity	Value	Quantity
1954–58 (average)	13,939	$87,641	11,482
1959	16,065	99,657	13,157
1960	17,202	115,363	13,337
1961	17,842	125,593	14,058
1962	19,060	134,222	15,260
1963	19,860	140,642	16,017

TABLE 5.—Florida phosphate rock sold or used by producers, by kinds

(Thousand long tons and thousand dollars)

Year	Hard rock				Soft rock [1]			
	Rock	P_2O_5 content	Value		Rock	P_2O_5 content	Value	
			Total	Average per ton			Total	Average per ton
1954–58 (average)	85	30	$704	$8.28	66	13	$440	$6.67
1959	76	27	649	8.54	56	11	443	7.91
1960	74	26	639	8.64	45	9	372	8.33
1961	73	26	672	9.16	39	8	303	7.87
1962	70	25	659	9.34	33	6	275	8.39
1963	76	27	723	9.48	33	7	269	8.11
	Land pebble				**Total**			
	Rock	P_2O_5 content	Value		Rock	P_2O_5 content	Value	
			Total	Average per ton			Total	Average per ton
1954–58 (average)	10,057	3,339	$62,878	$6.25	10,208	3,382	$64,022	$6.27
1959	11,628	3,837	71,771	6.17	11,760	3,875	72,863	6.20
1960	12,132	3,984	80,905	6.67	12,251	4,019	81,916	6.69
1961	12,667	4,168	88,395	6.98	12,779	4,202	89,370	6.99
1962	13,624	4,460	93,669	6.88	13,727	4,491	94,603	6.89
1963	14,377	4,722	100,749	7.01	14,486	4,756	101,741	7.02

[1] Includes material from waste-pond operations.

TABLE 6.—Tennessee phosphate rock[1] sold or used by producers

(Thousand long tons and thousand dollars)

Year	Rock	P_2O_5 content	Value: Total	Value: Average per ton	Year	Rock	P_2O_5 content	Value: Total	Value: Average per ton
1954-58 (average)	1,753	456	$12,480	$7.12	1961	2,291	592	$19,099	$8.34
1959	1,775	462	13,266	7.47	1962	2,476	654	20,173	8.15
1960	1,927	502	15,319	7.95	1963	2,395	625	18,303	7.64

[1] Includes small quantity of Tennessee blue rock and white rock in 1954-58.

TABLE 7.—Western States phosphate rock sold or used by producers

(Thousand long tons and thousand dollars)

Year	Idaho				Montana[1]				Total			
	Rock	P_2O_5 content	Value: Total	Value: Average per ton	Rock	P_2O_5 content	Value: Total	Value: Average per ton	Rock	P_2O_5 content	Value: Total	Value: Average per ton
1954-58 (average)	1,212	317	$5,771	$4.76	766	228	$5,368	$7.01	1,978	545	$11,139	$5.63
1959	1,590	400	6,625	4.17	940	277	6,903	7.34	2,530	677	13,528	5.35
1960	1,973	520	10,269	5.21	1,051	311	7,859	7.47	3,024	831	18,128	5.99
1961	1,687	434	8,913	5.28	1,085	323	8,211	7.57	2,772	757	17,124	6.18
1962	1,744	444	10,164	5.83	1,113	338	9,282	8.35	2,857	782	19,446	6.81
1963	1,739	432	10,015	5.76	1,240	374	10,583	8.53	2,979	806	20,598	6.91

[1] Includes Arkansas in 1963, Utah in 1954-55 and 1961-63, and Wyoming in 1954-63.

TABLE 8.—Phosphate rock sold or used by producers in the United States, by grades and States

(Thousand long tons)

Year and grade—B.P.L.[1] content (percent)	Florida: Quantity	Florida: Percent of total	Tennessee: Quantity	Tennessee: Percent of total	Western States: Quantity	Western States: Percent of total	Total United States: Quantity	Total United States: Percent of total
1962:								
Below 60	69	1	1,984	80	1,609	56	3,662	19
60 to 66	2,820	20	[2] 459	[2] 19			704	4
66 to 68			33	1	[2] 1,248	[2] 44	2,541	13
68 to 70	1,509	11	(2)	(2)			2,779	15
70 to 72	3,103	23	(2)	(2)	-----	-----	[3] 3,148	[3] 17
72 to 75	4,047	29	-----	-----	(3)	(3)	4,047	21
75 to 77	[4] 2,179	16	-----	-----	-----	-----	2,179	11
Total	13,727	100	2,476	100	2,857	100	19,060	100
1963:								
Below 60	57	(5)	2,099	88	1,695	57	3,851	19
60 to 66	1,735	12					601	3
66 to 68			296	12	1,284	43	1,390	7
68 to 70	3,120	22					4,444	22
70 to 72	2,958	20	-----	-----	-----	-----	2,958	15
72 to 75	3,854	27	-----	-----	-----	-----	3,854	20
75 to 77	[4] 2,762	19	-----	-----	-----	-----	2,762	14
Total	14,486	100	2,395	100	2,979	100	19,860	100

[1] Bone phosphate of lime, $Ca_3(PO_4)_2$.
[2] Figures combined to avoid disclosing individual company confidential data.
[3] Includes 72-75 grade rock in Western States.
[4] Includes some higher grade rock.
[5] Less than 1 percent.

TABLE 9.—Phosphate rock sold or used by producers in the United States, by uses and States [1]

(Thousand long tons)

State and use	1954–58 (average)		1959		1960		1961		1962		1963	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
Florida:												
Agricultural	7,230	2,402	8,753	2,937	8,385	2,774	9,006	2,990	9,746	3,210	10,585	3,483
Industrial	749	245	341	102	387	116	377	114	592	183	471	151
Exports	2,229	735	2,666	836	3,479	1,129	3,396	1,098	3,389	1,098	3,430	1,122
Total	10,208	3,382	11,760	3,875	12,251	4,019	12,779	4,202	13,727	4,491	14,486	4,756
Tennessee: [2]												
Agricultural	370	100	172	52	184	56	148	46	103	32	127	39
Industrial	1,383	356	1,603	410	1,743	446	2,143	546	2,373	622	2,268	586
Total	1,753	456	1,775	462	1,927	502	2,291	592	2,476	654	2,395	625
Western States:												
Agricultural	461	146	476	152	823	260	664	207	686	215	668	209
Industrial	1,176	292	1,672	405	1,686	410	1,586	387	1,626	396	1,736	417
Exports	341	107	382	120	515	161	522	163	545	171	575	180
Total	1,978	545	2,530	677	3,024	831	2,772	757	2,857	782	2,979	806
Total United States:												
Agricultural	8,061	2,648	9,401	3,141	9,392	3,090	9,818	3,243	10,535	3,457	11,380	3,731
Industrial	3,308	893	3,616	917	3,816	972	4,106	1,047	4,591	1,201	4,475	1,154
Exports	2,570	842	3,048	956	3,994	1,290	3,918	1,261	3,934	1,269	4,005	1,302
Total	13,939	4,383	16,065	5,014	17,202	5,352	17,842	5,551	19,060	5,927	19,860	6,187

[1] It was necessary to change the composition of this table in order to avoid disclosure of individual company confidential data.
[2] No exports reported.

STOCKS

Producers' yearend stocks were 4 percent less than at the end of 1962.

TABLE 10.—Producer stocks of phosphate rock, Dec. 31 [1]

(Thousand long tons)

Source	1962		1963	
	Rock	P_2O_5 content	Rock	P_2O_5 content
Florida	3,716	[2] 1,201	3,822	1,263
Tennessee [3]	[2] 143	41	100	28
Western States	[2] 735	[2] 189	667	174
Total	[2] 4,594	[2] 1,431	4,589	1,465

[1] As reported to the Bureau of Mines by domestic producers.
[2] Revised figure.
[3] Includes a quantity of washer-grade ore (matrix).

PRICES

After an increase at the beginning of the year, prices of Florida land-pebble phosphate rock remained unchanged. A rise in labor cost during the year was not reflected in a price rise for phosphate rock.

TABLE 11.—Prices of Florida land pebble, unground, washed, and dried phosphate rock, in bulk, carlots, at mine, in 1963

(Per short ton)

Grade (percent B.P.L.[1])	Jan. 7	Dec. 30
66 to 68	$5.385	$5.38
68 to 70	6.245	6.24
70 to 72	6.825	6.82
74 to 75	7.725	7.72
76 to 78 [2]	8.615	8.61

[1] Bone phosphate of lime, $Ca_3(PO_4)_2$.
[2] Percent changed to "76 to 77" July 15, 1963.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE

Imports.—Crude phosphates and superphosphates imports increased 20 and 11 percent, respectively, from 1962. Decreases were in evidence, however, for ammonium phosphates (20 percent) and dicalcium phosphates (52 percent).

TABLE 12.—U.S. imports for consumption of phosphate rock and phosphatic fertilizers

Fertilizer	1962		1963	
	Long tons	Value	Long tons	Value
Phosphates, crude, not elsewhere specified	133,628	$3,550,900	160,708	$3,651,105
Superphosphates (acid phosphate):				
Normal (standard)	13,860	325,260	[1] 64,144	[1] 3,302,069
Concentrated (treble)	44,352	2,692,284		
Ammoniated	954	48,455	[2] 1,592	[2] 45,699
Total superphosphates	59,166	3,065,999	65,736	3,347,768
Ammonium phosphates, used as fertilizer	144,722	9,642,213	115,812	7,244,711
Bone dust, or animal carbon and bone ash, fit only for fertilizer	9,577	578,166	[3] 19,148	[3] 1,065,553
Guano	3,946	395,724	4,594	381,404
Slag, basic, ground or unground	2,012	156,516	527	39,073
Dicalcium phosphate (precipitated bone phosphate), all grades	9,193	433,720	4,326	210,530

[1] Not separately classified beginning Sept. 1, 1963; Jan.–Aug., normal (standard), 15,804 long tons ($397,574); concentrated (treble), 34,141 long tons ($2,066,330).
[2] Beginning Sept. 1, 1963, not separately classified.
[3] Data known to be not strictly comparable with those of other years.

Source: Bureau of the Census.

Exports.—The tonnage of phosphate rock exported increased 9 percent over that of 1962. Shipments from Florida accounted for 87 percent of the total. Canada received 97 percent of the "Other phosphate rock" exported and over 500,000 long tons of the Florida rock. Japan continued to be the leading customer with Canada next, receiving 33 percent and 24 percent, respectively. Shipments to Japan increased 25 percent for a record high. The Republic of Korea was the major recipient of superphosphates (42 percent), followed by Canada (20 percent) and Chile (14 percent).

TABLE 13.—U.S. exports of phosphate rock, by grades and countries

Grade and destination	1962		1963	
	Long tons	Value	Long tons	Value
Florida phosphate rock:				
North America:				
Canada	457,901	$4,412,134	524,998	$5,253,504
Costa Rica	397	4,628	7,243	73,343
El Salvador			3,539	32,616
Mexico	124,757	1,007,446	191,571	1,535,401
Netherlands Antilles			1,787	14,698
South America:				
Brazil	60,059	627,027	102,726	1,025,440
Chile	202	3,312	494	10,025
Colombia	4,418	59,789	16,609	182,791
Peru	15,890	152,003	14,987	147,042
Uruguay	737	17,948		
Venezuela	855	16,138	89	2,116
Europe:				
Belgium-Luxembourg	2,484	22,977	26,121	225,024
Denmark	17,082	164,674	27,858	253,265
France	23,510	223,283	22,329	218,442
Finland			5,297	49,000
Germany, West	364,616	3,065,579	370,456	3,008,294
Italy	724,568	6,013,433	642,704	5,286,076
Netherlands	135,574	1,311,839	86,905	803,829
Norway			6,652	61,517
Spain	157,099	1,458,299	61,766	529,962
Sweden	49,361	485,343	51,923	527,350
Switzerland	2,184	22,386		
United Kingdom	280,924	2,318,557	264,579	2,352,353
Asia:				
Israel			1,696	11,868
Japan	1,200,036	9,752,186	1,502,333	12,372,072
Malaya, Federation of			15,960	244,261
Philippines	18,833	182,010	18,979	190,505
Singapore	904	21,000	3,000	53,100
Taiwan	19,397	178,943	10,312	95,527
Vietnam	[1] 17,153	[1] 315,140	23,487	364,196
Africa: British East Africa	300	4,583		
Oceania: Australia			26,631	231,280
Total	[1] 3,679,241	[1] 31,840,657	4,033,031	35,154,897
Other phosphate rock: [2]				
North America:				
Bahamas	27	638		
British Honduras	63	587		
Canada	543,220	6,805,295	562,033	5,420,543
El Salvador			45	803
Mexico			4,700	34,449
South America:				
Brazil	5,503	51,839		
Venezuela	567	7,260	722	14,645
Europe:				
Belgium-Luxembourg	1,500	19,125	5,546	43,804
Germany, West	63	533	6,098	55,837
Italy	9,845	90,027	62	621
United Kingdom	16	254		
Asia: Vietnam	1,950	69,140		
Africa:				
Mozambique			62	542
South Africa, Republic of	62	636		
Total	562,816	7,045,334	579,268	5,571,244
Grand total	[1] 4,242,057	[1] 38,885,991	4,612,299	40,726,141

[1] Revised figure.
[2] Includes colloidal matrix, sintered matrix, soft phosphate rock, and Tennessee, Idaho, and Montana rock.

Source: Bureau of the Census.

TABLE 14.—U.S. exports of superphosphates (acid phosphates), by countries

Destination	1962		1963	
	Long tons	Value	Long tons	Value
North America:				
Bahamas	467	$19,613	390	$16,460
British Honduras	94	7,160		
Canada	138,292	4,294,965	118,508	3,836,506
Canal Zone			134	7,620
Costa Rica	2,390	145,669	2,475	146,227
Dominican Republic	4,340	257,449	1,860	69,787
El Salvador			110	7,177
Guatemala	13	1,440	38	1,920
Honduras	193	13,416	17	1,031
Jamaica	30	2,125	350	23,411
Mexico	5,210	382,972	6,255	420,941
Nicaragua	45	1,200	531	34,114
Panama	93	5,417	178	13,342
Other	4	280	9	874
South America:				
Argentina	1,313	71,879	778	49,070
Brazil	40,227	1,937,807	46,258	2,494,054
Chile	70,149	4,109,446	81,931	4,660,721
Colombia	12,800	744,744	30,618	1,528,870
Ecuador	596	40,945	420	32,812
Peru	149	12,893	37	3,400
Venezuela	6,995	310,274	3,042	153,693
Other	4	316	14	880
Europe:				
Belgium-Luxembourg	8,911	81,333		
Denmark	33	700	29	1,000
France			2,003	79,176
Netherlands	39,871	1,719,500	45,005	1,891,235
Sweden	201	4,150		
United Kingdom	46	987	46	997
Asia:				
Indonesia	21,221	1,497,608		
Korea, Republic of	198,171	11,618,869	255,262	13,486,061
Nansei and Nanpo Islands	3,750	254,282	1,012	69,800
Philippines	34	2,211	196	13,400
Thailand	9	960	880	44,697
Vietnam	[1] 1,512	[1] 87,882	1,606	30,241
Other	32	2,022	104	7,916
Africa:				
Ghana	67	3,650		
South Africa, Republic of			1,787	92,060
Other			4	400
Oceania: Australia	22	1,547		
Total	[1] 557,284	[1] 27,635,711	601,887	29,219,893

[1] Revised figure.

Source: Bureau of the Census.

WORLD REVIEW [2]

NORTH AMERICA

Canada.—Dow Chemical of Canada, Ltd., was planning a 35-ton-per-day pilot plant for Sarnia, Ontario, to test its new phosphoric acid process which uses hydrochloric acid with phophate rock. The firm expected to have the plant in operation by fall of 1965.[3] Consolidated Mining & Smelting Co. of Canada, Ltd., planned to commence building a new 75,000-ton-per-year 54-percent phosphoric acid unit at its chemical plant at Kimberley, British Columbia. The new unit was scheduled for completion early in 1965.[4]

[2] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[3] Chemical & Engineering News. Dow To Test Phosphoric Acid Process in Canada. V. 41, No. 41, Oct. 14, 1963, p. 35.
[4] Oil, Paint and Drug Reporter. Cominco Is Planning Major Building Moves. V. 184, No. 27, Dec. 30, 1963, pp. 3, 42.

Mexico.—Plans for expansion of phosphoric acid facilities at Lecheria were announced by Hooker Chemical Corp.[5]

TABLE 15.—World production of phosphate rock by countries [1] [2]

(Thousand long tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
United States	14,138	15,869	17,516	18,559	19,382	19,835
Mexico	[3] 24	29	27	29	[4] 30	[4] 30
Netherlands Antilles (exports)	105	97	113	141	127	[4] 110
Total [1]	14,267	15,995	17,656	18,729	19,539	19,975
South America:						
Argentina	[5] 1	1	(6)	(6)	(6)	(6)
Brazil:						
Apatite	59	131	200	240	305	[4] 305
Phosphate rock	167	860	666	409	251	[4] 250
Chile:						
Apatite	41	19	17	14	12	14
Guano	35	21	18	19	16	22
Peru (guano)	270	125	155	157	203	189
Venezuela	[5] 59	----	----	----	----	----
Total	632	1,157	1,056	839	787	[4] 780
Europe:						
Belgium	18	13	8	14	12	[4] 12
France	100	76	57	80	[4] 80	[4] 80
Poland	45	40	40	46	55	[4] 55
Spain	11	(6)	3	----	----	----
U.S.S.R.:						
Apatite [4]	3,620	4,040	4,720	5,610	6,400	7,280
Sedimentary rock [4]	1,600	1,970	2,260	3,050	3,450	3,640
Total [4]	5,390	6,140	7,090	8,800	10,000	11,070
Asia:						
China [4]	190	500	600	500	600	700
Christmas Island (Indian Ocean) (exports)	358	494	503	694	521	651
India (apatite)	8	16	15	20	29	13
Indonesia	2	10	7	10	6	[4] 6
Israel	120	201	221	222	226	295
Jordan	197	332	356	416	450	[4] 400
Korea, North (apatite) [4]	24	50	100	150	200	200
Philippines:						
Guano	3	(6)	10	(6)	(6)	1
Phosphate rock	(6)	----	(6)	----	4	1
Viet-Nam, North:						
Apatite	(7)	256	480	555	667	[4] 740
Phosphate rock	(7)	50	50	57	33	[4] 50
Total [1] [4]	980	1,910	2,340	2,620	2,740	3,060
Africa:						
Algeria	651	563	554	433	384	244
Malagasy Republic	3	7	5	----	----	----
Morocco	5,470	7,050	7,354	7,824	8,033	8,413
Mozambique (guano)	[8] 1	(6)	(6)	----	----	----
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	----	2	3	(6)	----	----
Senegal:						
Aluminum phosphate	88	94	104	137	139	124
Calcium phosphate	2	----	106	401	489	462
Seychelles Islands (guano)	8	6	7	8	5	[4] 5
South Africa, Republic of	152	228	263	292	302	448
South-West Africa (guano)	1	1	----	1	1	1
Togo	----	----	----	116	190	578
Tunisia	2,056	2,150	2,063	1,950	2,064	2,330
Uganda	3	3	4	(6)	1	[4] 1
United Arab Republic (Egypt)	579	619	557	617	592	602
Total [1]	9,014	10,723	11,020	11,779	12,200	13,208

See footnotes at end of table.

[5] Commercial Fertilizer. V. 107, No. 2, August 1963, p. 44.

TABLE 15.—World production of phosphate rock by countries [1] [2]—Continued

(Thousand long tons)

Country [1]	1954-58 (average)	1959	1960	1961	1962	1963
Oceania:						
Angaur Island (exports)	52					
Australia	8	5	2	5	4	[4] 4
Makatea Island (French Oceania)	266	362	407	375	407	[4] 400
Nauru Island (exports)	1,250	1,192	1,351	1,282	1,516	1,547
Ocean Island (exports)	303	314	320	338	257	356
Total	1,879	1,873	2,080	2,000	2,184	2,307
World total (estimate) [1] [4]	32,160	37,800	41,240	44,770	47,450	50,400

[1] A negligible amount of phosphate rock is produced in Jamaica, Japan, Sarawak, Somali Republic, and Tanganyika.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Average annual production 1957-58.
[4] Estimate.
[5] Average annual production 1956-58.
[6] Less than 500 tons.
[7] Data not available; estimate by author of chapter included in the total.
[8] Average annual production 1955-58.

SOUTH AMERICA

Brazil.—A $15 million nitrophosphate fertilizer plant, having a daily capacity of 250 tons, was to be constructed in the State of Rio Grande do Sul.[6]

Peru.—Homestake Mining Co. of San Francisco, Calif., relinquished its option with Midepsa Industries, Ltd. (Montreal), whereby Homestake would have acquired a 46-percent interest in the Sechura Desert phosphate deposits held by Minerales Industriales del Peru, S.A., a subsidiary of Midepsa.[7] A similar agreement was made between Midepsa and Texada Mines, Ltd., another Canadian firm, in a further attempt to develop and exploit the property.[8]

Venezuela.—In January, the phosphorite mining industry in the Lobatera area, Táchira State, was formally dedicated. Known reserves amounted to only 250,000 tons, but exploration was in progress to find additional ore.[9]

EUROPE

Austria.—Donau Chemie A.-G. began an expansion program into the fertilizer industry at its plantsite at Moosbierbaum. The firm planned to invest about $2.7 million over an 18-month period on the project which would include extending the capacity of its sulfuric acid plant from 80 to 135 tons per day and constructing new facilities to produce annually 20,000 tons of wet-process phosphoric acid, 30,000 to 35,000 tons of triple superphosphate, and 100,000 tons of compound fertilizers. Fisons Fertilizers, Ltd., Great Britain, was to supply the necessary technical aid.[10]

[6] Chemical Week. V. 92, No. 24, June 15, 1963, p. 61.
[7] Bureau of Mines. Mineral Trade Notes. V. 56, No. 5, May 1963, p. 31.
[8] Engineering and Mining Journal. Midepsa, Texada To Work Peru's Sechura Phosphate. V. 164, No. 10, October 1964, p. 114.
[9] Bureau of Mines. Mineral Trade Notes. V. 56, No. 6, June 1963, p. 30.
[10] Chemical Trade Journal and Chemical Engineer (London). New Fertiliser Plant for Austria. V. 153, No. 3979, Sept. 13, 1963, p. 378.

Finland.—The first phosphoric acid plant in Finland was under construction in Usikaupunki. The plant, with an annual capacity of 13,500 to 16,500 tons, was planned as the first of a group for making triple superphosphate, diammonium phosphate, and compound fertilizers. The entire project was not scheduled for production before 1966.[11]

France.—A new chemical company, Sté. Atlantique d'Engrais Chimiques, was formed to manufacture concentrated (50 to 54 percent P_2O_5) phosphoric acid, triple superphosphate, ammonium phosphate, and complex fertilizers at new facilities to be constructed in Boucau, an industrial area of Bayonne. Davison Chemical Division, W. R. Grace & Co. (Baltimore, Md.), majority owner of the new company, had as participating partners Société Nationale de Pétrolés d'Aquitaine, Société des Produits Azotés, and Banque Louis Dreyfus et Cie. First production from the new plant was expected in the spring of 1965. Phosphate rock for the operation was to be supplied from high-grade deposits in Togo, West Africa, where W. R. Grace & Co. has a minority interest.[12]

Germany, East.—A new superphosphate plant went into operation at VEB Fahlbert List chemical works at Magdeburg. The plant was claimed to have an annual output of 270,000 tons of phosphatic fertilizers and to be one of the most modern of its kind in the world.[13]

Germany, West.—Knapsack-Griesheim, A.G., a subsidiary of Farbwerke Hoechst, A.G., installed a new elemental phosphorous furnace at its Knapsack plant near Cologne. Total annual capacity for phosphorus was brought to 70,000 tons with the additional furnace.[14] Knapsack started production of phosphorus pentasulfide later in the year and began erecting a dicalcium phosphate plant of 8,000-ton-per-year capacity, due on stream by the end of 1964.[15]

Hungary.—A 120,000-ton-per-year sulfuric acid plant and a 200,000-ton-per-year superphosphate plant were completed and officially opened at the Tisza River Chemical Works at Szolnok.[16]

U.S.S.R.—A large, highly mechanized superphosphate plant was under construction in Kedainay, Lithuania. The plant, scheduled for completion in 1965, was to fully cover Lithuania's agricultural requirements with some surplus for export.[17] Contracts were concluded with Société pour l'Equipement des Industries Chimiques (France) for two wet phosphoric acid process plants to be engineered and equipped to utilize the Prayon process.[18] Techmashimport also awarded a contract to Humphreys & Glasgow, Ltd., to engineer and supply equipment for a phosphorus pentasulfide plant.[19]

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[11] Chemical Trade Journal and Chemical Engineer (London). Compound Fertilisers To Be Made. V. 153, No. 3970, July 12, 1963, p. 59.
[12] European Chemical News (London). New Grace Subsidiary in France. V. 4, No. 84, Aug. 23, 1963, p. 20.
[13] Chemical Age (London). New Superphosphate Plant at East German Works. V. 90, No. 2295, July 6, 1963, p. 20.
[14] Chemical Trade Journal and Chemical Engineer (London). Phosphorus Plant Extension. V. 153, No. 3970, July 12, 1963, p. 59.
[15] Chemical Age (London). Knapsack Produce Phosphorus Pentasulphide. V. 90, No. 2317, Dec. 7, 1963, p. 881.
[16] Chemical Trade Journal and Chemical Engineer (London). New Acid and Fertiliser Plants. V. 153, No. 3992, Dec. 13, 1963, p. 906.
[17] Chemical Trade Journal and Chemical Engineer (London). Lithuania Superphosphate Plant. V. 152, No. 3966, June 14, 1963, p. 956.
[18] Chemical Age (London). Soviet Phosphoric Acid Contracts for Speichim. V. 90, No. 2313, Nov. 9, 1963, p. 728.
[19] Phosphorus & Potassium (London). No. 6, June 1963, p. 8.

United Kingdom.—Fisons Fertilizers, Ltd., was constructing a new 50,00-ton-per-year phosphoric acid plant at its complex in Immingham. The plant was scheduled for completion late in 1964.[20]

Yugoslavia.—A new sulfuric acid and superphosphate plant was completed and put on stream at Kosovska Mitrovica in southwestern Serbia. The plant, valued at $16 million, had annual capacities of 245,000 tons of superphosphate and 120,000 tons of sulpuric acid.[21]

ASIA

China.—The first phase of construction at the Hsinhsiang phosphate mine on the Han River in Hupeh Province was nearly completed and a mine was being developed in Kweichow Province. An annual production rate of 600,000 tons was claimed possible for the Hsinhsiang mine.[22]

India.—Phosphate rock deposits were discovered in one of the islands off the Kerala coast. Plans were formulated to explore the deposits.[23] The first major chemical plant in Assam started production. The designed daily capacity of the plan, on the Keelong River at Chadrapur, was 15 tons of sulfuric acid, 100 tons of superphosphate, and 200 tons of mixed fertilizers.[24]

Indonesia.—A superphosphate plant with an annual capacity of of 100,000 tons was being constructed in southern Java at Tjilajap.[25]

Israel.—Chemicals and Phosphates, Ltd. (C&P), was formed by a merger of Negev Phosphate Co., Ltd., which mines the Oron deposits, and Fertilizers and Chemicals, Ltd. (F&C), a Haifa firm. C&P expected to increase production at Oron to 400,000 tons of 38 percent P_2O_5 rock and 250,000 tons of 29 percent P_2O_5 rock by early 1964, using a new chemical process developed by F&C. Exploitation of the phosphate rock in the Arad area, which has an established reserve of 30 million tons, also was to be undertaken by C&P.[26] A phosphate rock deposit estimated to contain 15 million tons was discovered at Zefa-Afah in the Negev Desert. It was thought that the area may contain an additional 100 million tons.[27] One of the largest calcining kilns ever built was being assembled at the Oron plant. The kiln was manufactured in the United States, involved 16 ships for its transportation to Israel. The calcining plant was scheduled for operation in the fall of 1964 with an annual capacity of 500,000 tons.[28] Israel-American Phosphates Co. discovered a deposit of high-quality phosphate in the desert near Kibbutz Ein-Yahav, between Sodom and Eilat. The phosphates were near the surface, easily accessible, and of quality comparable to those of the Arad region. The company

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[20] Phosphorus & Potassium (London). No. 7, September 1963, p. 21.
[21] Chemical Week. V. 93, No. 8, Aug. 24, 1963, p. 35.
[22] Phosphorus & Potassium (London). No. 8, December 1963, p. 7.
[23] Fertiliser and Feeding Stuffs Journal (London). Deposits of Rock Phosphate. V. 58, No. 12, June 12, 1963, p. 559.
[24] Chemical Trade Journal and Chemical Engineer (London). Chemical Plant Starts Production. V. 153, No. 3992, Dec. 13, 1963, p. 906.
[25] Commercial Fertilizer. V. 107, No. 1, July 1963, p. 14.
[26] Bureau of Mines. Mineral Trade Notes. V. 57, No. 1, July 1963, p. 36.
[27] Chemical Age (London). Big New Phosphate Find in Israel. V. 89, No. 2282, Apr. 6, 1963, p. 499.
[28] Chemical Trade Journal and Chemical Engineer (London). Phosphate Production: Calcination Plant. V. 153, No. 3978, Sept. 6, 1963, p. 358.

formulated plans for developing the deposit and ordered heavy excavating equipment.[29]

Jordan.—The investigation of the Al Hasa phosphate rock deposits by Ralph M. Parsons Co. was completed. A reserve of about 30 million tons was proved, and it was reported that the deposits could be exploited at a cost of $6.30 to $7 per ton, f.o.b. Aqaba. The Jordan Development Board allocated $8.4 million from the Kuwait Development Loan to exploit the Al Hasa deposits.[30]

Pakistan.—The Government of Pakistan approved an East Pakistan Industrial Development Corp. proposal for an 80,000-ton-per-year superphosphate plant to be built at Chittagong.[31]

Syrian Arab Republic.—Tentative plans were made to exploit the Khneifess phosphate deposits at an annual rate of 500,000 tons for local consumption.[32]

Viet-Nam, North.—The Government of North Viet-Nam was being assisted by the Soviet Union in the construction of a 100,000-ton-per-year superphosphate plant and a 40,000-ton-per-year sulfuric acid plant in Lam-Tschao Province.[33]

AFRICA

Rhodesia and Nyasaland, Federation of.—An agreement was reached between the Southern Rhodesian Government and African Explosives & Chemical Industries, Ltd., whereby the company will exploit the phosphate deposits at Dorowa.[34]

South Africa, Republic of.—Phalaborwa Mining Co. was building a plant in the Phalaborwa area near Kruger National Park for producing phosphoric acid and superphosphates. The Phalaborwa Mining Co. was newly formed, with major stockholders being The Rio Tinto-Zinc Corp., Ltd. (England), Newmount Mining Corp. (U.S.), Rio Algom Mines (Canada), and American Climax Metal Inc. (U.S.).[35] Fisons Fertilizers, Ltd., was planning to build a phosphoric acid plant at Phalaborwa in conjunction with Federale Volksbeleggings.[36] Phosphate Development Corp., Ltd. (FOSKOR), completed its new phosphate plant at Phalaborwa. The output of the plant, having an annual capacity of 350,000 tons of phosphate concentrate, was expected to nearly eliminate phosphate rock imports. It was proposed that the old plant would be expanded to produce 240,000 tons of concentrate per year and would be used to treat the large reserve of pyroxenite ore which averages 6 to 8 percent P_2O_5.[37] African Metals Corp., Ltd., concluded beneficiation and recovery testing of samples of low-grade phosphate ore from its extensive Langebaan deposits near

[29] Chemical Age (London). Large Phosphate Field Discovery in Israel. V. 90, No. 2311, Oct. 26, 1963, p. 654.
[30] Bureau of Mines. Mineral Trade Notes. V. 58, No. 1, January 1964, p. 33.
[31] Bureau of Mines. Mineral Trade Notes. V. 56, No. 6, June 1963, p. 29.
[32] Bureau of Mines. Mineral Trade Notes. V. 57, No. 3, September 1963, pp. 40–42.
[33] Work cited in footnote 19.
[34] Fertiliser and Feeding Stuffs Journal (London). S. Rhodesia Phosphate Deposits. V. 59, No. 6, Sept. 18, 1963, p. 219.
[35] Phosphorus & Potassium (London). Phosphate Fertiliser Plant for South Africa. No. 7, September 1963, p. 28.
[36] Chemical Trade Journal and Chemical Engineer (London). Fisons Fertiliser Factory for N. Transvaal. V. 153, No. 3981, Sept. 27, 1963, p. 466.
[37] Bureau of Mines. Mineral Trade Notes. V. 57, No. 6, December 1963, p. 36.

Saldanha Bay, and proceeded with the erection of a milling and concentrating plant.[38]

TABLE 16.—Selected African countries: Exports of phosphate rock in 1963, by countries

(Long tons)

Destination	Algeria	Morocco	Senegal	Togo	Tunisia	Total
North America:						
Canada		20,373				20,373
Cuba		51,144				51,144
United States				39,164		39,164
South America:						
Brazil		8,188	3,248	99,206		110,642
Chile			7,570	10,334	2,953	20,857
Uruguay		5,861			4,921	10,782
Europe:						
Austria		168,552				168,552
Belgium		905,543		19,133		924,676
Bulgaria		20,111			48,128	68,239
Czechoslovakia		110,283			105,682	215,965
Denmark		236,653	4,872		29,305	270,830
Finland		94,950				94,950
France	97,124	1,394,766	142,165	71,358	488,941	2,194,354
Germany:						
East		21,549				21,549
West	2,562	725,031	162,926	32,521	80,268	1,003,308
Greece		120,871			62,806	183,677
Hungary		60,661				60,661
Ireland		225,834				225,834
Italy	25,535	276,012		102,204	457,314	861,065
Netherlands		396,640	43,931	11,958	168,647	621,176
Norway		55,585		1,516		57,101
Poland		394,032			51,130	445,162
Portugal		266,180				266,180
Spain	178,334	704,286		3	50,839	933,462
Sweden		276,301	6,496		15,698	298,495
Switzerland		21,105		315	1,033	22,453
United Kingdom		790,223	39,239	6,300	27,858	863,620
Yugoslavia	24,598	5,033			127,364	156,995
Asia:						
China		266,969				266,969
India		111,983			157,326	269,309
Indonesia	5,206					5,206
Japan		160,891	64,682	57,750	36,692	320,015
Taiwan		79,254				79,254
Turkey		105,814			12,598	118,412
Africa:						
Canary Islands		15,584				15,584
Dahomey				4		4
Rhodesia and Nyasaland, Federation of		32,081				32,081
South Africa, Republic of		191,071		16,780		207,851
Togo			66,994			66,994
Oceania:						
Australia			11,868			11,868
New Zealand			1,968			1,968
Total	333,359	8,319,414	555,959	468,546	1,929,503	11,606,781

United Arab Republic (Egypt).—Plans were being carried forward to more than double the 1963 output of superphosphates by mid-1964 and to attain an annual production capacity of 500,000 tons in 1965. Abu Zaabal Fertiliser and Chemical Co. was adding 50,000 tons to its annual 70,000-ton output. Soc. Financière et Industrielle d'Egypte expected to double its 1963 production capacity by June 1964 and to have a new 200,000-ton-per-year plant on stream in 1965. The new plant, under construction at Assiut (costing $8 million), was being supplied with German equipment. The companies engaged in mining

[38] Mining Magazine (London). V. 108, No. 4, April 1963, p. 229.

phosphates during the year were Nasr Phosphate Co., Safaga Phosphate Co., and Egyptian Phosphate Extracting and Trading Co.[39]

OCEANIA

Australia.—The first wet-process phosphoric acid plant in Australia was being built by Humphreys & Glasgow, Ltd., for Australian Fertilisers, Ltd., at Port Kembla. Production was to have started in November.[40] An agreement was signed by the State Premier with three fertilizer firms—Cuming Smith and Mount Lyell Farmers Fertilisers, Ltd., Cresco Fertilisers Ltd., and Albany Superphosphate Co. Pty., Ltd.—where a new company was formed to build and operate a superphosphate plant. An 88-acre site was secured at Esperance, Western Australia, and the Government made special financial arrangements to get the facility started.[41] Imperial Chemicals Industries of Australia and New Zealand, Ltd. (ICIANZ), had its fertilizer complex at Botany near completion.[42] Also, ICIANZ awarded a contract to Simon-Carves, Ltd., to design, build, and commission a 200-ton-per-day phosphoric acid plant at Yarraville, a suburb of Melbourne.[43]

TECHNOLOGY

Eight mining companies in the Florida pebble phosphate area were engaged in a mutual program of strip mining with a definite plan for simultaneous land reclamation. A complete report giving details of the new mining methods being used was published.[44] Details of the pumping methods used in connection with the hydraulic transportation of ore and materials in the Florida pebble phosphate industry were described.[45]

Several technological advances were made in the processing of phosphate rock to produce wet-process phosphoric acid. A new plant at Bonnie, Fla., incorporating many of these improvements, completed late in 1962 for International Minerals & Chemical Corp., was in full operation by the first of 1963. Two 300-ton-per-day processing trains were being used. Each train consisted of attack and filtration sections using the Prayon process, followed by Swenson forced-circulation evaporators. Only five men were required for the operation of both trains. An air-conditioned control room on the reaction floor close to all major process control points was equipped with a semigraphic control panel, start and stop switches for all plant motors, alarms, off-lights, an autowriter for transmitting analytical data from the laboratory, and closed-circuit television for monitoring the filter

[39] Chemical Age (London). Big Boost for Egyptian Superphosphate Capacity. V. 90, No. 2316, Nov. 30, 1963, p. 844.
[40] Chemical Trade Journal and Chemical Engineer (London). Some New Plants at Port Kembla. V. 153, No. 3969, July 5, 1963, p. 24.
[41] Fertiliser and Feeding Stuffs Journal (London). Super Works Agreement Signed. V. 58, No. 5, Mar. 6, 1963, p. 218.
[42] European Chemical News (London). Complete Range of Fertilisers From ICIANZ. V. 4, No. 90, Oct. 4, 1963, p. 24.
[43] European Chemical News (London). Phosphoric Acid Plant Contract. V. 4c, No. 99, Dec. 6, 1963, p. 23.
[44] Custred, U. K. New Mining Methods Rehabilitate Florida's Strip Mines. Min. Eng., v. 15, No. 4, April 1963, pp. 50–52, 60.
[45] Bowen, Floyd B. Pumping of Phosphate Slurries. Canadian Min. and Met. Bull. (Montreal), v. 56, No. 618, October 1963, pp. 768–772.

operations. The entire plant was designed for a minimum of maintenance, automatic operation, high efficiency, and a minimum of air pollution.[46]

A new rendition of the wet process for making phosphoric acid was developed and offered for licensing by Struthers Scientific & International Corp., New York.[47] The process covered by U.S. Patent 2,897,-053, was reported to produce acid containing up to 50 percent P_2O_5 without scale forming on the equipment. It was also claimed that by careful control of temperature and feed rate, large, easy-to-separate calcium sulfate crystals would form in the new crystallizer.

Davison Chemical Division of W. R. Grace & Co. studied a new process for making 50 percent P_2O_5 phosphoric acid. In the process, phosphate rock is reacted with 98 percent sulfuric acid after which it is heated at 400° to 500°F to form a clinker. The clinker subsequently is leached with hot water to give the 50 percent P_2O_5 acid. Tennessee Valley Authority, at Wilson Dam, Ala., studied a new method for producing phosphoric acid using fuming sulfuric acid (oleum). The use of such highly concentrated acid resulted in a high reaction temperature, so that no heating step was needed.[48]

A method for producing phosphoric acid from Canadian iron ore was being developed by Chemical Research Associates, Inc., Bernardsville, N.J., for Multi-Minerals, Ltd., Toronto, Ontario, Canada. The method under study consisted of dissolving the apatite from the ore concentrate in constant-boiling hydrochloric acid and removing calcium chloride by ion exchange or electrodialysis techniques. Sixty-five to 70 percent phosphoric acid was produced.[49] The Dow Chemical Co. patented a new process for the production of phosphoric acid and planned to test the new process in a pilot plant to be constructed in 1964. The new process used hydrochloric acid to digest the phosphate rock followed by solvent extraction to separate phosphoric acid from calcium chloride.[50]

Collier Carbon & Chemical Corp. developed a submerged combustion process for making 69 to 70 percent polyphosphoric acid, referred to as anhydrous liquid phosphate (ALP), from 52 to 54 percent wet-process phosphoric acid.[51] Four important advantages of ALP over the conventional 52 to 54 percent wet-process acid were cited: The higher concentration of P_2O_5 results in freight savings; ALP when shipped in properly designed tank cars will drain clean, eliminating car cleanout; ALP produces clear ammoinated solutions free of gels and precipates, where as with the majority of 52 percent wet acids the converse is true; and ALP's performance in granulating plants is superior to that of the 52 percent wet process acid.

Scottish Agricultural Industries, Ltd., Edinburgh, Scotland, tested a new process for making potassium metaphosphate in a 100-pound-per-hour pilot plant to obtain scaleup data. The product was said

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[46] Palm, G. F. Improvements in Phosphoric Acid Technology. Chem. Eng. Prog., v. 59, No. 12, December 1963, pp. 76–84.

[47] Chemical Engineering. Key to Strong Phosphoric Acid: Controlled Crystallization. V. 70, No. 14, July 8, 1963, p. 76.

[48] Mining Magazine (London). V. 109, No. 1, July 1963, p. 30.

[49] Chemical & Engineering News. V. 41, No. 13, Apr. 1, 1963, p. 43.

[50] Farm Chemicals. V. 126, No. 12, December 1963, p. 66.

[51] Young, D. C., and C. B. Scott. Wet-Process Polyphosphoric Acid. Chem. Eng. Prog., v. 59, No. 12, December 1963, pp. 80–84.

to cost more per ton to produce than triple superhosphate but to approximate the same cost per unit of plant food.[52] The success of the new process was due to the operation of a specially designed rotary kiln. The process was licensed exclusively to Chemical Construction Corp. of New York, for design and construction work in North America.

A new process, was developed by Israel Mining Industries, Ltd., for making magnesium phosphate fertilizer. The process, which was based on novel technology, required reltaively low temperatures. The available phosphate in the compound would be similar to that in monocalcium phosphate. Magnesium, which is beneficial to some soils, also would be available. Field tests were made in various parts of the world.[53]

Soil research personnel of the University of Wisconsin worked with mixtures of molten sulfur and phosphate rock in an attempt to produce a cheap fertilizer material that would be as effective as triple superphosphate. Experiments in the field gave fairly good results.[54]

Fire-resistant plastics and foams incorporating a new series of chemicals, mainly phosphorus- and halogen-containing compounds, were investigated by several firms.[55] Although a number of problems remained unresolved, indications were strong that an increasing number of nonflammable plastics would be marketed soon.

The University of Wisconsin, with the use of polyphosphates, perfected a process for making a milk concentrate which resembles the flavor and color of fresh milk more closely than does conventional evaporated milk.[56] The process was developed several years ago by the U.S. Department of Agriculture (USDA), but was not recommended because the milk tended to gel in storage. The addition of polyphosphates before sterilization corrected this fault. Several matters would need attention, including approval by the Food and Drug Administration, before the process could become commercial, USDA pointed out.

A new method for producing corrosion-protective coatings on metals, covered by British Patent 802,276, was made available.[57] The method, using a solution of tannin in the presence of phosphoric acid, was stated to produce coatings on either rusty or bright iron or steel surfaces superior to any other known treatment.

Results of a number of research studies on phosphorus and its compounds were published. Crystal and structure transitions of black phosphorus at high pressures were studied by X-ray diffraction techniques.[58] The phosphate minerals, richellite[59] and stewartite,[60]

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[52] Chemical Engineering. Rotary Kiln May Make Metaphosphate Marketable. V. 70, No. 9, Apr. 29, 1963, pp. 62, 64.
[53] Chemical Week. V. 93, No. 14, Oct. 5, 1963, p. 69.
[54] Chemical & Engineering News. V. 41, No. 28, July 15, 1963, p. 61.
[55] Chemical Week. Plastics' Trial by Fire. V. 92, No. 8, Feb. 23, 1963, pp. 105, 106, 108, 110.
[56] Chemical & Engineering News. V. 41, No. 51, Dec. 23, 1963, p. 27.
[57] Chemical Trade Journal and Chemical Engineer (London). Tannin-Phosphorus Coatings for Metals. V. 153, No. 3990, Nov. 29, 1963, p. 809.
[58] Science. Crystal Structures Adopted by Black Phosphorous at High Pressures. v. 139, No. 3561, Mar. 29, 1963, pp. 1291, 1292.
[59] McConnell, Duncan. Thermocrystallization of Richellite To Produce a Lazulite Structure (Calcium Lipscombite). Am. Mineralogist, v. 48, Nos. 3–4, March–April 1963, pp. 300–307.
[60] Peacor, Donald R. The Unit Cell and Space Group of Stewartite. Am. Mineralogist, v. 48, Nos. 7–8, July–August 1963, pp. 913–914.

were investigated, and crystallographic data were obtained by X-ray diffraction methods.

Potassium dihydrogen phosphate-sodium succinate buffer mixtures were investigated. Equimolal mixtures were used successfully for determining dissociation constants of 2-nitro-4-chlorophenol and 2,6-dichlorophenol.[61] The reaction of trialkyl phosphate-complexed sulfur trioxide with high-molecular-weight alpha-olefins was studied, and the techniques used for separation, recovery, and identification of the products were described.[62] Additional reports on research studies within the specialized areas of organophosphorus chemistry were published.[63] Thorium phosphate phosphors[64] and cadmium chlorophosphate phosphor[65] were prepared, and their structures as well as some physical properties were determined.

New advances in the science of chemical analysis included a method for determining beta-activity of phosphorus 32 in the sulfur disk of a radiation dosimeter,[66] the use of a benzoate in quantitative analysis of phosphate rock,[67] a rapid control method for determining calcium in wet-process phosphoric acid,[68] a method for eliminating interference from phosphorus in the flame-spectrophotometric determination of calcium,[69] a technique for determining boron in natural phosphates using methyl borate,[70] and an automatic potometric method for determining phosphorus in fertilizers.[71]

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[61] Paabo, Maya, Roger G. Bates, and Robert A. Robinson. Buffer Solutions of Potassium Dihydrogen Phosphate and Sodium Succinate at 25° C. NBS J. Res., v. 67A (Phys. and Chem.), No. 6, November–December 1963, pp. 573–576.

[62] Turbak, Albin F., and Joel R. Livingston, Jr. Reaction of Phosphate-Complexed Sulfur Trioxide With Alpha-Olefins. I&EC Product Res. and Devel., v. 2, No. 3, September 1963, pp. 229–231.

[63] Driscoll, J. S., and C. N. Matthews. A Phosphonium Borohydride Reducing Agent. Chem. and Ind. (London), No. 31, Aug. 3, 1963, p. 1282.

Grayson, Martin. Synthesis of Organophosphorus Compounds. Chem. & Eng. News, v. 40, No. 49, Dec. 3, 1962, pp. 90–100.

Holtschmidt, H., and G. Oertel. Isocyanates of Esters of Some Acids of Phosphorus and Silicon. Angew. Chem. (Internat. Ed.), v. 1, No. 12, December 1962, pp. 617–621.

Hudson, R. F., and M. Green. Stereochemistry of Displacement Reactions at Phosphorus Atoms. Angew. Chem. (Internat. Ed.), v. 2, No. 1, January 1963, pp. 11–20.

Lapidot, A. D. Samuel, and B. Silver. Criteria for beta-Elimination in Organic Phosphates. Chem. and Ind. (London), No. 12, Mar. 23, 1963, pp. 468–471.

[64] Ranby, P. W., and Doreen Y. Hobbs. Thorium Phosphate Phosphors. J. Electrochem. Soc., v. 110, No. 4, April 1963, pp. 280–284.

[65] Ropp, R. C. A Study of Cadmium Chlorophosphate Phosphor. J. Electrochem. Soc., v. 110, No. 2, February 1963, pp. 113–117.

[66] Chemistry and Industry (London). No. 3, Jan. 19, 1963, p. 114.

[67] Building Science Abstracts (London). V. 36, No. 6, June 1963, p. 191.

[68] Chemical & Engineering News. U.S.I. Research Develops Rapid Control Method for Phosphoric Acid Plants. V. 41, No. 3, Jan. 21, 1963, pp. 9, 10.

[69] Building Science Abstracts (London). V. 35, No. 10, October 1962, p. 301.

[70] Building Science Abstracts (London). V. 36, No. 6, June 1963, p. 191.

[71] Ferretti, R. J., and W. M. Hoffman. Automatic Photometric Determination of Phosphorus as Molybdovanadophosphoric Acid. Commercial Fertilizer, v. 106, No. 1, January 1963, pp. 24–25.

Patents were granted for new methods and techniques for beneficiating[72] and processing phosphate rock[73] and for the recovery of byproducts.[74]

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[72] Baarson, R. E., H. B. Treweek, C. W. Jonaitis, and C. L. Ray (assigned to Armour & Co., Chicago, Ill.). Phosphate Ore Flotation Process. U.S. Pat. 3,098,817, July 23, 1963.
Fagnant, J. A. (assigned to The Kemmerer Coal Co., Frontier, Wyo.). Calcining and Ore Reduction Oven. U.S. Pat. 3,084,922, Apr. 9, 1963.

[73] Barber, J. C., G. H. Megar, and T. S. Sloan (assigned to Tennessee Valley Authority). Recovery of Phosphorus From Sludge. U.S. Pats. 3,084,029 and 3,113,839, Apr. 2 and Dec. 10, 1963.
Beetz, P. (assigned to Panmetals & Processes, Inc., Panama, Panama). Process for the Preparation of Mineral Phosphates Intended for the Manufacture of Phosphoric Acid by the Wet Method. U.S. Pat. 3,097,922, July 16, 1963.
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Facer, L. H. (assigned to Glen E. Cooley, Schenectady, N.Y.). Process for Producing Fertilizers and Products Thereof. U.S. Pat. 3,098,737, July 23, 1963.
Higuchi, K. M., Tsuyuguchi, T. Osa, K. Ando, and S. Yonemoto (assigned to Hokkaido Tanko K.K.K., Tokyo, Japan). Preventing Reversion by the Addition of Nitro-Humic Acid or Alkali Salts Thereof. U.S. Pat. 3,114,625, Dec. 17, 1963.
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Hrishikesan, K. G., and F. E. Adkins, Jr. (assigned to Reynolds Metals Co., Richmond, Va.). Method for the Concurrent Production of Alkali Metal Aluminate and Hydrogen Fluoride. U.S. Pat. 3,116,971, Jan. 7, 1964.
Jadot, E. (assigned to Panmetals & Processes, Inc., Panama, Panama). Method for Preparing Diammonium Phosphate, Starting From Phosphoric Acid Produced by the Wet Process. U.S. Pat. 3,115,390, Dec. 24, 1963.
Karcher, J. C., and C. L. Canfield (assigned to Concho Petroleum Co., Dallas, Tex.). Method of Forming a Granular Humate Ammonium Fertilizer. U.S. Pat. 3,111,404, Nov. 19, 1963.
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Platinum-Group Metals

By Glen C. Ware[1]

SALES of platinum-group metals to consuming industries were high throughout the year and aggregated 1,003,000 troy ounces, 16-percent more than in 1962. However, the prices of platinum and palladium declined in April under the pressure of heavy offerings from the U.S.S.R. and did not regain their losses until August. In November a second rise in the price of platinum brought it to its high for the year.

Canada reported lower production of platinum-group metals in 1963. No reports of Soviet production are available, but reports of mine development and the market activity of the U.S.S.R. indicate that production was the same as that of 1962. Judged by U.S. imports, Colombian production increased in 1963, but did not significantly affect world output.

Reports of production by Rustenburg Platinum Mines, Ltd., are not available, but a 4-percent increase in dividends from recurring income indicates that this producer in the Republic of South Africa continued to recover from its 1961 slump.[2]

World production is estimated to have decreased slightly.

TABLE 1.—Salient platinum-group metals statistics

(Troy ounces)

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Mine production [1]	20,339	15,485	23,609	43,248	28,742	49,750
Value	$1,539,196	$913,736	$1,485,439	$2,256,432	$1,591,463	$2,442,840
Refinery production:						
New metal	54,463	49,321	51,243	79,453	54,775	80,208
Secondary metal	81,068	135,996	76,857	85,971	132,102	117,099
Imports for consumption	800,541	1,010,333	680,646	884,463	720,352	1,318,961
Exports (except manufactures)	37,443	31,405	65,149	61,845	60,591	63,012
Stocks, Dec. 31: Refiner, importer, dealer	494,023	495,851	515,750	555,445	598,102	699,575
Consumption	745,077	896,403	775,214	823,226	866,459	1,003,194
World: Production	1,075,000	1,055,000	1,275,000	[2] 1,355,000	[2] 1,630,000	1,530,000

[1] From crude platinum placers and byproduct platinum-group metals recovered largely from domestic gold and copper ores.
[2] Revised.

[1] Commodity specialist, Division of Minerals.
[2] Potgietersrust Platinums Ltd. Reports and Accounts, year ended Oct. 31, 1963. 16 pp.

LEGISLATION AND GOVERNMENT PROGRAMS

The regulations which govern the flow of raw materials to defense agencies were established under the Defense Materials System by the Business and Defense Services Administration of the U.S. Department of Commerce. Those affecting platinum-group metals remained in effect during the year. Purchase orders for materials needed in national defense continued to have priority over unrated commercial orders.

All platinum-group metals through the semifabricated stage required a validated license for export to Soviet-bloc countries. The export of all commodities to North Korea, China, and Viet-Nam was prohibited.

Platinum-group metals continued to be included in the list of commodities eligible for Government financial assistance under the program administered by the Office of Minerals Exploration; no projects were active in 1963.

DOMESTIC PRODUCTION

The domestic sources of primary platinum-group metals remained unchanged. The Goodnews Bay Mining Co. was the only producer from placer deposits, and American Metals Climax, Inc., was the major producer from sludges and residues from the electrolytic refining of copper. Other refiners of copper residues were American Smelting and Refining Company and International Smelting & Refining Company. A small quantity of crude platinum was recovered from the gold placer operations of Yuba Consolidated Industries, Inc.

The amount of new platinum-group metals refined from these sources was 52,000 troy ounces, a 74-percent increase. Domestic refining of foreign crude material raised the total to 80,000 ounces, compared with 54,800 ounces in 1962.

TABLE 2.—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
1954–58 (average)	44,493	5,012	2,529	953	725	751	54,463
1959	37,296	7,525	1,700	491	930	1,379	49,321
1960	35,131	9,636	2,675	1,003	2,457	341	51,243
1961	46,113	28,988	1,903	148	1,993	308	79,453
1962:							
From domestic sources:							
Crude platinum; Gold and copper refining	14,244	14,141	739	95	439	146	29,804
From foreign crude platinum	22,218	2,003	166	5	577	2	24,971
Total	36,462	16,144	905	100	1,016	148	54,775
1963:							
From domestic sources:							
Crude platinum; Gold and copper refining	20,818	28,099	1,381	189	1,073	398	51,958
From foreign crude platinum	19,472	4,700	889		2,348	841	28,250
Total	40,290	32,799	2,270	189	3,421	1,239	80,208

The recovery of secondary metal was 117,000 ounces compared with 132,000 ounces produced in 1962, a 11-percent decrease. Toll refining returned 931,000 ounces of metal, chiefly platinum and palladium, to industrial consumers, 5 percent over the 1962 amount. Toll refiners receive worn laboratory ware and plant equipment and materials such as platinum-clad melting pots, dies, spinnerets, and poisoned catalysts. They return refined metal to the user.

TABLE 3.—Secondary platinum-group metals recovered in the United States

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1954–58 (average)	42,119	33,053	1,322	334	2,364	1,876	81,068
1959	58,945	68,279	1,188	361	5,631	1,592	135,996
1960	38,861	35,465	914	279	953	385	76,857
1961	51,218	32,451	193	6	1,836	267	85,971
1962	71,817	56,273	767	99	2,570	576	132,102
1963	54,084	59,993	440	273	1,990	319	117,099

CONSUMPTION AND USES

Consumption of platinum-group metals in 1963 was the largest amount in history and was 16 percent higher than 1962 consumption. Of the 1,003,000 troy ounces of platinum-group metals consumed in the United States in 1963, 871,000 ounces went into industrial categories and 58,000 ounces was used for jewelry and decorative uses. Chemical industries, the greatest consumers of platinum, increased consumption of that metal 78 percent and virtually doubled the use of iridium. The increased use of rhodium and iridium indicates a change in the pattern of use of the platinum-group metals in the chemical industries. Data are not taken relative to specific uses, and it cannot be stated with certainty what operations within the industry demanded greater quantities of them, but at least two developments made new demands. The need for highly refractive material for melting pots and molds in the preparation of lasers made demands upon platinum-iridium alloys. About 500,000 tons per year was added to the Nation's nitric acid production capacity during 1963, making a corresponding demand for platinum-rhodium alloy catalyst.

The electrical industry, second greatest consumer of platinum-group metals, took 3 percent more platinum and 1 percent more palladium than in 1962. However, its consumption of iridium dropped 32 percent to near the 1961 level. This may reflect a change in pattern of use in 1962 when working stocks were acquired, rather than a decrease in use in 1963 when stocks were only maintained.

The reclamation of platinum and rhodium from the nitric acid industry illustrates reclamation in general. Ammonia is oxidized on a gauze of a platinum-rhodium alloy containing 10 percent rhodium. The gauze becomes generally contaminated and disintegrates in places. About 75,000 to 100,000 ounces of this material is reclaimed each year at a cost of about $9 an ounce. About 0.008 ounce per ton of acid is unreclaimable, amounting to an estimated 30,000 ounces in 1963.

The uses of platinum-group metals are based primarily upon two properties, chemical inertness and the ability to catalyze chemical reactions. The refractory character and the hardness of certain platinum-group alloys promote their use in chemical ware, in melting pots, and in durable electrical contacts for use in switch gear in communication systems.

TABLE 4.—Platinum-group metals sold to consuming industries in the United States

(Troy ounces)

Year and industry	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1954–58 (average)	365,918	349,716	5,542	977	17,333	5,591	745,077
1959	363,490	488,071	7,508	779	30,813	5,742	896,403
1960	324,583	414,225	6,168	788	24,615	4,835	775,214
1961	283,088	508,040	6,547	805	19,174	5,572	823,226
1962:							
Chemical	87,822	110,518	1,973	774	8,276	903	210,266
Petroleum	13,160	961			152		14,273
Glass	45,530	124			5,111		50,765
Electrical	100,569	327,788	3,468	174	5,265	1,875	439,139
Dental and medical	22,601	54,899	263		44	966	78,773
Jewelry and decorative	28,573	12,975	3,123		6,546	546	51,763
Miscellaneous	6,017	12,595	424	177	669	1,598	21,480
Total	304,272	519,860	9,251	1,125	26,063	5,888	866,459
1963:							
Chemical	156,427	118,757	3,860	930	9,537	1,068	290,579
Petroleum	40,721	16,008			188	1	56,918
Glass	57,919	20	50		13,191	2	71,182
Electrical	110,576	331,868	2,364	19	6,676	888	452,391
Dental and medical	18,894	42,940	102		10	469	62,415
Jewelry and decorative	32,963	13,880	3,302		7,044	492	57,681
Miscellaneous	6,844	3,054	154	107	422	1,447	12,028
Total	424,344	526,527	9,832	1,056	37,068	4,367	1,003,194

STOCKS

Domestic refiners, importers, and dealers reported 699,600 ounces of platinum-group metals in stock December 31, 1963, 17 percent above the figure for 1962. This gain is not remarkable in view of a 16-percent gain in consumption and substantial offerings of metal at shaded prices. Stocks of all the metals of the group increased, except that of osmium which decreased 45 percent. Stocks of platinum, palladium, iridium, rhodium, and ruthenium increased 25, 11, 36, 7, and 12 percent, respectively.

TABLE 5.—Government inventory of platinum-group metals, December 31, 1963

(Thousand troy ounces)

Metal	National (strategic) stockpile	Supplemental stockpile	Total
Iridium	14		14
Palladium	90	648	738
Platinum	716	50	766
Rhodium	1		1
Ruthenium		15	15
Total	821	713	1,534

No platinum-group metals were added to the Government inventories during the year, but 7,884 ounces of palladium was disposed of, clearing the Defense Production Act inventory of all metal. During 1962, the Commodity Credit Corporation inventory was transferred to the supplemental stockpile. All the platinum-group metals on Government inventory was in the national stockpile and the supplemental stockpile. These stockpiles contained 1,534,000 ounces of metal at yearend.

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
1959	290,691	158,706	11,127	4,218	20,720	10,389	495,851
1960	260,916	204,345	11,473	4,225	26,547	8,244	515,750
1961	255,654	244,910	12,250	3,058	29,258	10,315	555,445
1962	256,755	285,173	13,871	2,762	30,692	8,849	598,102
1963	320,601	315,756	18,907	1,531	32,900	9,880	699,575

PRICES

Prices of platinum and palladium declined owing to offerings from the U.S.S.R. during the second quarter. In April the price of platinum fell $5 per troy ounce to $75 to $80, and the price of palladium fell $2 to $22 to $24 per ounce. The price ranges quoted by E&MJ Metal and Mineral Markets for the four minor metals follow: Iridium, $70 to $75; osmium, $60 to $70; rhodium, $137 to $140; and ruthenium at $55 to $60. These prices were unchanged since 1961 and held throughout the year. Despite heavy imports and increasing stocks in the hands of dealers, prices firmed again; after a second price rise, platinum was quoted at $82 to $85 per ounce in November, the highest price range of the year. Palladium returned to $24 to $26 in August and remained steady. Near yearend, trading in futures resumed on the New York Mercantile Exchange, and January 1965 platinum futures rose to $102 per troy ounce.

FOREIGN TRADE

Imports.—Imports of platinum-group metals aggregated 1,319,000 troy ounces, 83 percent more than in 1962 and 31 percent more than the previous high set in 1959. Shipments from Canada, Switzerland, United Kingdom, and the U.S.S.R. accounted for the increase. Trade with other countries declined. Unrefined material and all refined metals except ruthenium contributed to the increase. Unrefined material increased 97 percent; platinum, 234 percent, palladium, 17 percent; iridium, 45 percent; osmium, 97 percent; and rhodium, 21 percent. Ruthenium decreased 54 percent.

Exports.—Exports of platinum-group metals increased to 63,000 ounces. The United Kingdom continued to take the major portion of U.S. exports.

TABLE 7.—U.S. imports for consumption of platinum-group metals

Year	Troy ounces	Value (thousands)	Year	Troy ounces	Value (thousands)
1954–58 (average)	800,541	[1] $40,392	1961	884,463	$36,840
1959	1,010,333	36,912	1962	720,352	32,699
1960	680,646	34,131	1963	1,318,961	48,775

[1] Data known to be not comparable with other years.

Source: Bureau of the Census.

TABLE 8.—U.S. imports for consumption of platinum-group metals (unmanufactured), by countries[1]

(Troy ounces)

Year and country	Unrefined material[2]		Refined metals						Total
	Platinum grain nuggets (including crude, dust and residues)	Platinum sponge and scrap	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	
1962:									
North America:									
Canada	14		80,365	85,249	5,325		10,145	2,250	183,348
Mexico		173		4,721					4,894
Total	14	173	80,365	89,970	5,325		10,145	2,250	188,242
South America:									
Colombia	22,052	616	975						23,643
Venezuela			312						312
Total	22,052	616	1,287						23,955
Europe:									
Austria				3,215					3,215
France		3	913	5,976					6,892
Germany, West			2,200		209				2,409
Italy		2,212	775						2,987
Netherlands			1,172	46,447					47,619
Norway	1,300		4,420	5,990					11,710
Switzerland			8,212	122,422					130,634
U.S.S.R.			14,378	91,245			8,366		113,989
United Kingdom[3]			96,498	66,559	3,467	1,062	11,492	6,249	185,351
Total	1,300	2,215	128,568	341,854	3,676	1,062	19,858	6,249	504,806
Asia:									
Japan		2,213							2,213
Taiwan				48					48
Total		2,213		48					2,261
Oceania: Australia		968					120		1,088
Grand total:									
Troy ounces	23,366	6,185	210,220	431,872	9,001	1,062	30,123	8,499	720,352
Value	$1,610,406	$683,952	$16,097,273	$9,369,755	$577,761	$54,937	$3,965,449	$338,500	$32,699,488

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1963:									
North America:									
Canada	29	-----	398,527	33,482	9,625	-----	5,625	800	448,088
Mexico	-----	1,764	-----	3,582	-----	-----	5	-----	5,351
Netherlands Antilles	350	-----	-----	-----	-----	-----	-----	-----	350
Panama	1,037	-----	-----	-----	-----	-----	-----	-----	1,037
Total	1,416	1,764	398,527	37,064	9,625	-----	5,630	800	454,826
South America: Colombia	[4] 28,592	-----	-----	-----	-----	-----	-----	-----	28,592
Europe:									
Belgium-Luxembourg	-----	-----	249	5,700	-----	-----	-----	-----	5,949
France	-----	-----	35	4,297	-----	-----	-----	-----	4,332
Germany, West	-----	-----	354	-----	-----	-----	129	-----	483
Italy	-----	-----	1,738	-----	-----	-----	30	-----	1,768
Netherlands	-----	-----	1,606	9,223	-----	-----	-----	-----	10,829
Norway	1,200	-----	2,975	4,075	-----	-----	-----	-----	8,250
Spain	-----	-----	85	-----	-----	-----	-----	-----	85
Sweden	-----	-----	1,203	-----	-----	-----	-----	-----	1,203
Switzerland	-----	-----	39,217	128,717	-----	-----	1,648	-----	169,582
U.S.S.R	3,468	-----	28,930	185,897	-----	-----	12,560	-----	230,855
United Kingdom	15,891	-----	225,447	127,064	3,434	2,091	16,503	3,117	393,547
Total	20,559	-----	301,839	464,973	3,434	2,091	30,870	3,117	826,883
Asia:									
Japan	64	4,512	-----	1,711	-----	-----	-----	-----	6,287
Jordan	-----	-----	51	-----	-----	-----	-----	-----	51
Lebanon	60	-----	121	-----	-----	-----	-----	-----	181
Taiwan	-----	-----	-----	95	-----	-----	-----	-----	95
Total	124	4,512	172	1,806	-----	-----	-----	-----	6,614
Africa:									
Mozambique		-----	675	-----	-----	-----	-----	-----	675
South Africa, Republic of	-----	900	-----	-----	-----	-----	-----	-----	900
Total	-----	900	675	-----	-----	-----	-----	-----	1,575
Oceania: Australia	-----	471	-----	-----	-----	-----	-----	-----	471
Grand total:									
Troy ounces	50,691	7,647	701,213	503,843	13,059	2,091	36,500	3,917	1,318,961
Value	$3,696,442	$560,096	$27,491,286	$11,052,155	$958,930	$49,715	$4,801,038	$165,700	$48,775,362

[1] On the basis of detailed information received by the Bureau of Mines from importers, certain items reported by the Bureau of the Census as "sponge and scrap" have been reclassified and included with "platinum refined metal" in this table.

[2] Bureau of the Census categories are in terms of metal content. It is believed, however, that in many instances gross weight is actually reported.

[3] In addition, 24 troy ounces ($1,455) of osmiridium was imported.

[4] Adjusted by the Bureau of Mines.

Source: Bureau of the Census.

TABLE 9.—U.S. exports of platinum-group metals, by countries [1]

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)
	Troy ounces	Value	Troy ounces	Value	
1954–58 (average) [2]	22,036	$1,494,394	15,407	$428,914	$1,898,260
1959	18,560	1,146,795	12,845	389,988	2,305,855
1960	49,497	3,211,538	15,652	503,914	2,978,436
1961	41,385	2,088,753	20,460	819,882	2,983,447
1962:					
North America:					
Canada	392	60,952	2,002	71,701	2,274,242
Mexico	177	34,076	3,119	83,274	313,453
Other			185	4,594	6,550
Total	569	95,028	5,306	159,569	2,594,245
South America:					
Argentina	19	8,545			17,949
Brazil	389	50,620	365	10,566	8,511
Chile	2	1,122	206	7,911	3,911
Colombia	1	512	900	22,530	87,541
Venezuela	18	3,582	60	1,440	99,154
Other			503	16,943	5,722
Total	429	64,381	2,034	59,390	222,788
Europe:					
Belgium-Luxembourg	449	14,650	224	7,100	28,197
France	406	10,317	326	41,107	25,149
Germany, West	377	28,925	1,502	128,247	122,403
Italy	135	7,758	96	4,042	84,787
Switzerland	2,953	169,149	100	8,000	35,482
United Kingdom	43,044	1,052,577	357	17,342	197,438
Other	29	4,443	60	1,748	2,572
Total	47,393	1,287,819	2,665	207,586	496,028
Asia:					
Japan	1,211	61,735	935	32,379	4,732
Other	40	4,669			124,955
Total	1,251	66,404	935	32,379	129,687
Africa					54,069
Oceania	9	450			608,917
Grand total	49,651	1,514,082	10,940	458,924	4,105,734
1963:					
North America:					
Canada	338	54,912	1,200	50,373	1,507,270
Mexico	142	15,300	3,857	105,891	299,715
Netherlands Antilles	1,285	99,190			80,914
Other	2	298	257	5,941	47,107
Total	1,767	169,700	5,314	162,205	1,935,006
South America:					
Brazil	1,647	175,960	545	15,411	2,478
Chile	41	4,112	15	2,436	1,241
Colombia	14	2,021	64	1,376	3,955
Other			12	1,489	6,490
Total	1,702	182,093	636	20,712	14,164
Europe:					
Belgium-Luxembourg	345	32,318	321	14,480	29,297
France	6,472	532,428	1	258	14,484
Germany, West	6,882	576,758	3,080	100,111	28,240
Italy	377	30,821	446	55,262	7,434
Switzerland	2,783	248,879	146	7,033	6,232
United Kingdom	26,684	1,517,262	313	26,554	74,206
Other	1,243	97,414	72	1,989	5,172
Total	44,786	3,035,880	4,379	205,687	165,065
Asia:					
India	321	24,000			5,002
Japan	2,564	227,311	1,447	118,890	56,301
Other	94	9,930			32,720
Total	2,979	261,241	1,447	118,890	94,023
Africa					31,934
Oceania	2	1,440			15,409
Grand total	51,236	3,650,354	11,776	507,494	2,255,601

[1] Quantities are gross weight.
[2] Owing to changes in classification, data not strictly comparable with years before 1955.
Source: Bureau of the Census.

WORLD REVIEW

World production of platinum-group metals was estimated to be 1,530,000 ounces, 6 percent less than in 1962. Canada reported 23 percent of the total and the United States, 3 percent. Seventy four percent of production was estimated. To U.S.S.R., Africa, and Colombia were attributed 52, 20, and 2 percent, respectively. Owing to the paucity of data upon which these estimates were made, especially that for the U.S.S.R., the 6-percent decrease is not significant.

Sales of petroleum reforming catalysts continued to expand both in the United States and in Europe. Engelhard Industries Inc. reported the highest sales of this catalyst since it was introduced in 1954.

The U.S.S.R. disrupted the orderly marketing of platinum-group metals in 1963. It made large offerings at below market prices in the spring but curtailed its offerings later in the year. Prices dropped, but by yearend they had regained their earlier losses. A looming shortage touched off activity in the futures market as the year closed. Both Canada and the Republic of South Africa drew upon reserves to meet sales demand.

Canada.—Output of platinum-group metals was 344,736 ounces valued at Can$21.8 million. The output was 27 percent less than in 1962 and 23 percent less than exports to the United States in 1963. The decrease in output reflects the decrease in the production of nickel, the primary product with which platinum-group metals are associated. Nickel ores from the Sudbury district of Ontario continued to account for the bulk of Canada's production of platinum-group metals. Although the deliveries of nickel reached an alltime high, the production of nickel and platinum-group metals was not affected; reserves had accumulated in the interim following the cessation of deliveries of nickel to the U.S. stockpile.

Colombia.—International Mining Corp., the surviving organization after a merger with South American Gold & Platinum Co., reported the production of 13,000 ounces of platinum in 1963, the same amount as in 1962. The entire production was sold at prices equivalent to those prevalent in 1962. Production was placed at 28,592 ounces, the amount of U.S. imports. This amount may be low because some metal may have reached the market through circuitous channels.

The company operated four dredges in the Choco district and one in the Narino area. Dwindling reserves in the developed areas in the Choco district point to curtailed production, but additional reserves were developed at both Narino and Choco.

South Africa, Republic of.—The production of platinum-group metals in the Republic of South Africa was estimated to be 300,000 ounces, the same as in 1962. An additional 5,500 ounces of osmiridium was produced from gold ores. Sales were up despite low demand in the first 8 months. Rustenburg Platinum Mines, Ltd., in its annual report for the period ending August 31, 1963, reported a 10-percent increase in sales. Its principal outlets were the United States, the United Kingdom, and Japan.

Mine production remained at its 1962 level, and stocks decreased. Lesser amounts of byproduct metals were available for sale. However, during the third quarter of the calendar year production was increased to rebuild reserves and to enable them to profit by the continuing strong demand which is in prospect for the future.

U.S.S.R.—The U.S.S.R. does not release any data about its platinum-metal industry; consequently its production must be estimated based largely on inference. There is reason to believe that the U.S.S.R. is the largest producer of these metals and probably accounts for about half of the world's production. Over the past 6 years Soviet shipments, direct plus estimated reexports from other importers, to the United States have averaged 374,000 ounces per year. Consumption of Soviet metal in Communist countries was estimated at 460,000 ounces, and that in the free world was estimated at 380,000 ounces. The total of these amounts, 1,214,000 ounces, was reduced to 800,000 ounces in the interest of conservatism and because some of the deliveries may have come from accumulated stocks rather than current production.

TABLE 10.—World production of platinum-group metals [1]

(Troy ounces)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada:						
Platinum: Placer and from refining nickel-copper matte	164,373	150,382				
Other platinum-group metals: From refining nickel-copper matte	187,600	177,713	483,604	418,278	470,787	344,736
United States: Placer platinum and from domestic gold and copper refining	20,339	15,485	23,609	43,248	28,742	49,750
Total	372,312	343,580	507,213	461,526	499,529	394,486
South America: Colombia: Placer platinum (U.S. imports)	31,780	31,498	28,855	29,844	22,052	28,592
Europe: U.S.S.R.: Placer platinum and from refining nickel-copper ores [2]	240,000	300,000	330,000	500,000	800,000	800,000
Asia:						
Japan:						
Palladium from refineries	232	341	563	1,550	1,372	1,326
Platinum from refineries	651	470	1,396	2,247	1,872	1,714
Iridium from refineries	[3] 776	-	-	-	-	-
Philippines:						
Platinum from refining nickel-platinum concentrates	-	-	-	177	172	-
Palladium from refining nickel-platinum concentrates	-	-	-	215	141	-
Total	1,659	811	1,959	4,189	3,557	3,040
Africa:						
Congo, Republic of the (formerly Belgian): Palladium from refineries [4]	164	-	-	-	-	-
Ethiopia: Placer platinum	230	68	189	180	180	[2] 180
South Africa, Republic of:						
Platinum-group metals from platinum ores	421,634	[2] 375,000	[2] 400,000	[2] 350,000	[2] 300,000	[2] 300,000
Osmiridium from gold ores	6,043	5,352	[5] 6,334	[2] 7,000	[2] 6,000	[2] 5,500
Total	428,071	380,420	406,523	357,180	306,180	305,680
Oceania:						
Australia:						
Placer platinum	17	-	4	2	-	-
Placer osmiridium	34	3	-	-	-	-
New Guinea	14	18	4	5	7	5
Total	65	21	8	7	7	5
World total (estimate) [1]	1,075,000	1,055,000	1,275,000	1,355,000	1,630,000	1,530,000

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] Annual average production, 1955–58.
[4] Includes platinum.
[5] Sales.

TECHNOLOGY

Coatings of platinum-group metals on other materials to impart corrosion resistance or ease in bonding contributed to the greatest number of technological advances reported during the year.

Research results on protective coatings suggest that individual group metals are not suitable above 2,000° C because their oxides are volatile. Alloys of these metals have possibilities, but they were not tested.[3] Oxidation rates and the losses by volatilization have been determined for the metals of the group.[4] To a certain extent the need for absolute reliability in space exploration has relieved technology of cost restrictions, leading to new applications of palladium and to an increase in the use of platinum and rhodium as electroplated coatings.[5]

Palladium has been applied successfully by chemical replacement. The coats are tarnish resistant and can be soldered easily even after prolonged storage. Waste through excessive deposit is avoided because deposition is arrested when the substrate is covered to a thickness of 5 to 14 microinches.[6] Platinum coats on molybdenum wire have resolved the troublesome fracture of the seals between the metal grid and the quartz container of lamps. The coat protects the wire from oxidation and promotes the formation of a sound joint with the quartz.[7]

Platinum coats on metal whiskers enable them to be fused into a matrix which retains an amazing degree of its strength at temperatures near their melting point. Silver has been used as the matrix metal, but nickel and other metals are being tested. The whiskers may be of any metal from which they can be grown. Sapphire whiskers also can be coated with plantium to wet them and form a strong bond with the matrix material.[8] Silver and platinum form a continuous series of solid solutions, thereby promoting the formation of a bond between the plantium coat and the silver matrix.[9]

The addition of 2 percent platinum and 8 percent iron to molybdenum disulfide enables this conventional dry lubricant to be used in evacuated systems.[10]

Since the introduction of catalytic cracking in petroleum refining, platinum has been the chief representative of its group, but palladium catalysts have been developed. A series of supported palladium catalysts to hydrogenate hydrocarbon streams prior to refining them promotes the reaction of carbon monoxide with hydrogen. The concentration of palladium in the catalyst ranges from 0.05 to 0.4 percent.[11] The total amount these metals used is much larger than the new supply that is required because the metal is recovered and

[3] Dickinson, C. D., M. G. Nicholas, A. L. Pranatis, and C. I. Whitman. Protective Coatings for Tungsten. J. Metals, v. 15, No. 10, October 1963, pp. 787–792.

[4] Krier, C. A., and R. I. Jaffee. Oxidation of the Platinum-Group Metals. J. Less-Common Metals, v. 5, No. 5, October 1963, pp. 411–431.

[5] Foulke, D. G. Engineering Applications for Precious Metal Plating. Metal Prog., v. 84, No. 6, December 1963, pp. 107–111, 132, 134, 136.

[6] Mining Journal (London). Immersion Palladium Plating. V. 260, No. 6658, Mar. 29, 1963, p. 302.

[7] Metal Progress. Heat Problem Solved With Engelhard Platinum Clad Molybdenum Wire. V. 84, No. 3, September 1963, p. 158.

[8] Steel. The Startling Promise of a Whisker: Take a Giant Step Forward. V. 153, No. 17, Oct. 21, 1963, p. 106.

[9] Klement, W., Jr., and H. L. Luo. Metastable Solid Solutions in Silver-Platinum Alloys. Trans. AIME, v. 227 (Met. Soc.), No. 5, October 1963, pp. 1253–1254.

[10] U.S. Department of Commerce, Office of Technical Services Public Information Office. Breakthrough Achieved in Bearing Systems Using High-Temperature Dry Lubricants. OTS 63–715, Oct. 24, 1963, 1 p.

[11] Chemical Engineering. Palladium Catalysts. V. 70, No. 19, Sept. 16, 1963, p. 100.

reused. Hydroforming continued to gain in use. Because the process does not use platinum-group metal catalysts, it threatens to displace them in part. Counter to this trend has been the development of cheaper methods to reclaim spent catalyst, enabling it to be used less sparingly to crack portions of the crude which contain enough metal residues to make catcracking unprofitable at the present cost of catalysts.[12]

Because they are cheaper, catalysts based on other metals, the oxides of nickel and cobalt for example, compete with platinum-group metals. The looming market for catalysts to activate the combustion of smog-forming constituents in motor vehicle exhaust is the prize for the most effective material at a given cost. Nickel boride catalysts also contended with the platinum-group metals in fuel-cell technology.[13]

Thermocouples using rhodium are not suitable in irradiated environments because the rhodium atoms capture neutrons and ultimately decay into palladium. This creates a drift in the calibrated value. Molybdenum-platinum alloy thermocouples are stable under a high neutron flux and function reliably up to 3,090° F in nonoxidizing atmospheres.[14] Above 2,200° F platinum alloy thermoelements must be sheathed.[15]

Palladium-containing brazing alloys have good wetting capacity, good ductility, and freedom from erosive tendencies. They are finding use in gas turbines, jet engines, and airframes, and in missile, nuclear, and electronic applications.[16] Pure rhodium foil has given better results as a brazing medium than titanium, palladium, and vanadium. Rhodium-joined sheets of porous and of fully dense tungsten have been used successfully in ion engines for periods of 100 hours.[17]

Several new uses for palladium have been developed. A precious metal paste with powdered glass and palladium is applied to a ceramic base and fired to make resistors. Application of leads completes the fabrication.[18] A storage cell has been devised which has electrodes of palladium alloys whose function depends solely upon the transfer of hydrogen from one to the other. The utility of such cells will depend upon special uses.[19] A palladium alloy has been used to purify hydrogen from furnaces used to reduce metal oxides. At 3,000 standard cubic feet per hour, the purifier can return 80 percent of the hydrogen to the furnace with an impurity content of less than 10 parts per billion.[20]

A platinum-cobalt, magnetic alloy with a minimum of size and weight per unit of flux has been developed. It is ductile and can be fabricated into rods and fine wire. The alloy is suitable for watches

[12] Burke, D. P. Catalysts for the Petroleum Industry. Chem. Week, v. 93, No. 7, Aug. 17, 1963, pp. 51–59.
[13] Chemical and Engineering News. Anode Systems May Lower H_2–O_2 Fuel Cell Cost. V. 41, No. 38, Sept. 23, 1963, pp. 60–62.
[14] Materials in Design Engineering. V. 58, No. 7, December 1963, p. 9.
[15] Steel. High Temperature Sensors. V. 153, No. 15, Oct. 7, 1963, p. 19.
[16] Cross, A. S., Jr., and F. B. Adamec. New Era Brazing Turns to Filler Metals With Palladium. The International Nickel Co., Inc. (Pamphlet), 1963, 7 pp.
[17] Metalworking News. Use for Rhodium Told at Refractory Meeting. V. 4, No. 173, Dec. 16, 1963, p. 24.
[18] Hoffman, L. C. Precision Glaze Resistors. Am. Cream. Soc. Bull., v. 42, No. 9, September 1963, pp. 490–493.
[19] Mining Journal (London). Novel Method of Storage. V. 261, No. 6678, Aug. 16, 1963, p. 153.
[20] Metalworking News. Fansteel Instals Palladium Alloy Hydrogen Purifier. V. 4, No. 149, July 15, 1963, p. 8.

and for magnets in space age equipment such as relays, X-band helix traveling-wave tubes, and gyrotorquers.[21]

Multiple oxide crystals for masers and lasers are produced from melts in crucibles of rhodium and iridium. These metals are used because of their high melting points and resistance to chemical attack.[22]

A novel electrode structure using platinum in a special configuration and a liquid electrolyte led to a 40- to 50-percent power efficiency at 250 to 400° F in fuel cells that operate on a variety of inexpensive hydrocarbons. Output reached 25 watts per square foot at 0.5 volt.[23]

In a patented platinum reforming process, the number of barrels of feedstock processed per pound of catalyst was increased by treating a higher boiling fraction of the reformed distillate with a nickel catalyst.[24] Platinum and palladium were used to prepare cyclopentadiene.[25] The preparation and the regeneration of supported catalysts were the subject of two patents.[26]

Supported palladium or ruthenium catalysts were applied to removing gaseous contaminants from a gas containing hydrogen and carbon monoxide.[27] The platinum-group metals were used as gamma-phase precipitants to produce a monocrystalline structure in magnets.[28]

Hydrogen-permeable diaphragms were used to supply atomic hydrogen to be emitted at a surface where it may react with hydrogenatable material.[29]

Thermoelectricity was generated in cells using the oxides, borides, carbides, and nitrides of rhodium.[30] A patent was issued for a way to fabricate ruthenium powder to wrought metal.[31] Platinum was used in a direct current electric circuit to protect metallic structures from corrosion by sea water.[32] A patent covering a nickel-chromium-palladium alloy gives a range of compositions suitable for brazing.[33]

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[21] American Metal Market. Placovar New Magnet for Miniaturization. V. 70, No. 188, Sept. 30, 1963, p. 24.

[22] Metallurgia. V. 68, No. 407, September 1963, p. 141.

[23] Chemical Engineering. Novel Electrode Structure Is Key to New Low-Temperature Fuel Cell. V. 70, No. 10, May 13, 1963, p. 86.

[24] Porter, F. W. B., and P. T. White (assigned to The British Petroleum Co., Ltd., London). Catalytic Reforming of Petroleum Hydrocarbons. U.S. Pat. 3,071,537, Jan. 1, 1963.
——. Catalytic Reforming of Petroleum Hydrocarbons. U.S. Pat. 3,071,539, Jan. 1, 1963.

[25] Wollensak, J. C. (assigned to Ethyl Corp., New York). Preparation of Cyclopentadiene Metal Compounds. U.S. Pat. 3,088,960, May 7, 1963.

[26] Laporte Chemicals Ltd. Palladium Catalysts for OA Peroxide. British Pat. 922,022, July 26, 1963.
Robinson, R. M., and L. R. McKeage (assigned to Abbott Laboratories, Chicago, Ill.). High Temperature Regeneration of Rhodium Catalyst. U.S. Pat. 3,071,551, Jan. 1, 1963.

[27] Andersen, H. C., P. L. Romeo, Sr., and D. R. Steele (assigned to Engelhard Industries, Inc., Newark, N.J.). Treatment of Gases. U.S. Pat. 3,084,023, Apr. 2, 1963.

[28] Steinort, E. (assigned to Centro Magneti Permanenti, Milan, Italy). Monocrystalline Permanent Magnets and Method of Making Them. U.S. Pat. 3,085,036, Apr. 9, 1963.

[29] Andrus, O. E. (assigned to A. O. Smith Corp, Milwaukee, Wis.). Continuous Decontamination of the Hydrogen Acquiring Surface of a Palladium Diaphragm Used for the Transfer of Atomic Hydrogen. U.S. Pat. 3,113,080, Dec. 3, 1963.

[30] Henderson, C. M., and D. M. Harris (assigned to Monsanto Chemical Co., St. Louis, Mo.). Thermoelectricity. U.S. Pat. 3,081,363, Mar. 12, 1963.

[31] Cope, R. G. (assigned to The International Nickel Co., Ltd., New York). Ruthenium Fabrication. U.S. Pat. 3,108,000, Oct. 22, 1963.

[32] Sabins, R. C. Platinum Plug-Valve Metal Anode for Cathodic Protection. U.S. Pat. 3,108,939, Oct. 29, 1963.

[33] Huschke, E. R., Jr., P. R. Mobley, and W. R. Blackham (assigned to General Electric Co., New York). Nickel-Chromium-Palladium Brazing Alloy. U.S. Pat. 3,089,769, May 14, 1963.

Potash

By Richard W. Lewis [1]

WORLD DEMAND for potash was high in 1963, and producers supplied a total output of 12 million short tons of potassium monoxide (K_2O) equivalent. In the United States the apparent consumption increased 13 percent to a record 2.9 million tons K_2O equivalent. Potash would have been in limited supply had it not been for large shipments from Canada.

DOMESTIC PRODUCTION

The output of marketable potassium salts increased 5 percent over the previous record set in 1961. Approximately 90 percent of the domestic production came from mines in the Carlsbad, N. Mex. area with California and Utah furnishing the bulk of the remainder. Small quantities also were marketed from Michigan and Maryland.

The calculated average grade of crude salts mined in New Mexico was 18.78 percent K_2O equivalent, compared with 18.55 percent in 1962.

Approximately 11,000 short tons of manure salts containing 2,650 tons K_2O equivalent was produced and sold.[2]

There was considerable activity in potash exploration. Midwest Oil Corp. leased 3,200 acres of State-owned potash lands north of Moab, Utah. The potash was known to be much deeper in this area than the Texas Gulf Sulfur Co. deposit at Cane Creek. However, Midwest was reported as being interested in controlled solution mining. Tenneco Oil Company, a subsidiary of Tennessee Gas Transmission Co., discovered potash at a depth of about 3,000 feet while drilling for oil near La Sal, San Juan County, Utah. Soon after, Tenneco acquired leases on more than 50,000 acres to the south, west, and east of the La Sal Mountains. Continental Oil Co., Richfield Oil Corp., Superior Oil Company of California, and San Jacinto Petroleum Corp. continued their interest in Utah potash but little activity by them was reported.

Several firms were interested in the geothermal brine deposits of the Salton Sea area in the Imperial Valley of California. Shell Oil Co., O'Neill, Ashmun & Hilliard Co., Earth Energy, Inc. (a joint subsidiary of Magma Power Co. and Pure Oil Co.), and Western Geothermal, Inc. (a subsidiary of Natomas Co.) were drilling wells in the area. Five

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[1] Commodity specialist, Division of Minerals.

[2] American Potash Institute, Inc. North American Deliveries of Potash Salts. E-173, Mar. 3, 1964 p. 2.

TABLE 1.—Salient potash statistics

(Thousand short tons and thousand dollars)

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Production of potassium salts (marketable)..........quantity..	3,599	4,033	4,472	4,629	4,167	4,867
Approximate equivalent K_2O quantity..	2,120	2,383	2,638	2,732	2,452	2,865
Value [1]............	$78,654	$80,393	$89,676	$104,464	$94,859	$109,276
Sales of potassium salts by producers quantity..	3,565	4,191	4,412	4,226	4,615	4,588
Approximate equivalent K_2O quantity..	2,100	2,476	2,602	2,487	2,722	2,713
Value at plant............	$77,794	$83,903	$88,417	$95,388	$105,608	$103,152
Average value per ton............	$21.82	$20.02	$20.04	$22.57	$22.89	$22.48
Imports for consumption of potash materials..........quantity..	319	432	415	465	[2] 617	1,041
Approximate equivalent K_2O quantity..	172	234	226	262	[2] 341	594
Value............	$11,374	$15,737	$15,370	$17,315	[2] $21,765	$31,137
Exports of potash materials..quantity..	344	572	833	803	[2] 859	722
Approximate equivalent K_2O quantity..	182	337	491	473	[2] 506	425
Value............	$13,077	$18,496	$25,926	$32,477	[2] $30,731	$25,519
Apparent consumption of potassium salts [3]..........quantity..	3,540	4,051	3,994	3,888	[2] 4,373	4,907
Approximate equivalent K_2O quantity..	2,090	2,373	2,337	2,276	[2] 2,557	2,882
World: Production (marketable):						
Approximate equivalent K_2O...do..	8,300	9,400	10,000	10,700	[2] 10,800	12,000

[1] Derived from reported value of "Sold or used."
[2] Revised figure.
[3] Measured by sold or used plus imports minus exports.

TABLE 2.—Production and sales of marketable potassium salts in the United States, in 1963, 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............	2,281	1,395	$48,300	2,257	1,381	$47,849
Coarse............	1,550	946	35,528	1,403	856	32,380
Granular............	444	268	10,367	409	247	9,618
Total............	4,275	2,609	94,195	4,069	2,484	89,847
Other potassium salts [2] [3]............	592	256	15,081	519	229	13,305
Grand total............	4,867	2,865	109,276	4,588	2,713	103,152

[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 the sulfate manufactured from captive production of muriate.

wells were drilled, the deepest being about 6,000 feet. The principal interest in the chemical-rich superheated brine appeared to be development of power; however, representative samples of the brine showed a high mineral content especially in potassium and lithium. It was estimated that 1,000 tons per day of potash might be available from one of the wells. No chemical company had definite plans for recovering the brine minerals, although several showed considerable interest.

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
1954–58 (average)	11, 598	2, 238	3, 299	1, 943	$71, 760	3, 272	1, 928	$71, 079
1959	13, 932	2, 588	3, 707	2, 189	74, 117	3, 821	2, 258	76, 725
1960	15, 071	2, 841	4, 138	2, 440	82, 645	4, 092	2, 412	81, 653
1961	15, 653	2, 934	4, 281	2, 523	96, 380	3, 882	2, 281	87, 415
1962	14, 115	2, 619	3, 758	2, 208	85, 124	4, 206	2, 476	95, 851
1963	16, 414	3, 083	4, 500	2, 644	100, 570	4, 214	2, 488	94, 249

[1] Sylvite and langbeinite.
[2] Derived from reported value of "Sold or used."

A new area was being explored for potash by several firms north and west of St. Johns, Ariz., in Navajo and Apache Counties. At least three companies, Duval Corp., United States Borax & Chemical Corp., and Kern County Land Co., obtained leases and prospecting permits in the area. Five or six core-drilling rigs were in operation, and tests indicated potash at depths ranging from 800 to 1,300 feet. Neither the grade of the deposit nor its size was reported.

Lithium Corporation of America planned to build an $8 to $9 million plant near Promontory Point on the Great Salt Lake, Utah, to extract minerals from the lake brine. The firm obtained a long-term option on about 23,000 acres of land to carry out feasibility studies. Potassium and lithium compounds, sodium sulfate, and bromine would be major products after completion of the facility.

On August 27, an underground gas explosion near Moab, Utah, took the lives of 18 men. A new potash mine was being developed under contract by Harrison International, Inc. for Texas Gulf Sulphur Co., and was nearing completion when the accident occurred. Upon investigation it was concluded that gas was liberated after blasting at the face of one of the development drifts and was carried by a return ventilating current to the underground workshop where it was ignited. An air sample collected at the face after the explosion was reported to contain 6.7 percent combustible hydrocarbons, of which 4.74 percent was methane. First among the recommendations arising from the investigation was that the mine "should be operated as a gassy mine."[3] Due to the disaster, initial production, which had been planned for late 1963, was rescheduled for mid-1964.

Duval Corp. was sinking two shafts at its Nash Draw mine site in the Carlsbad Basin, N. Mex. The property contains two ore bodies, sylvite at a depth of 900 feet and langbeinite at 1,075 feet. The firm planned to begin mining the langbeinite during the second half of 1964 and leave the sylvite in place until 1969, at which time the ore would be exhausted at the company's Saunders mine 13 miles to the north. A plant for processing the Nash Draw langbeinite ore

[3] U.S. Department of the Interior News Release. Bureau of Mines Investigation Reveals Cause of Utah Potash Mine Disaster. BuMines, Oct. 4, 1963, 2 pp.

was under construction at the Saunders mine adjacent to the present floatation plant.

Kermac Potash Co. completed a second shaft to the firm's potash ore body in the Carlsbad Basin and construction was started early in the year on a 1,500-ton-per-day processing plant. First production from the facility was scheduled for the fall of 1964.

National Potash Co. began sinking two 700-foot shafts to open a new ore body about 17 miles west of its refinery near Carlsbad. Ore production by mid-1964 would supplement the firm's established mine output.

Bonneville, Ltd., Wendover, Utah, was sold to Standard Magnesium Corp., of Tulsa, Okla., and the company name was changed to Standard Magnesium & Chemical Co., Bonneville Division, in May. The firm announced plans to double the output of potash and to construct a pilot plant to produce a 48-percent magnesium chloride byproduct. The company acquired leases on an additional 57,000 acres of Federal land around the original operations.

CONSUMPTION AND USES

The apparent consumption of potassium salts in the United States continued to increase. Deliveries of potash for agricultural use gained 13 percent, whereas chemical potash deliveries rose only 6 percent.

Illinois, with 288,964 tons (K_2O equivalent), again was the leading State for deliveries. Indiana, Ohio, Georgia, and Florida followed in order, as in 1962. 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 1963, by States of destination

(Short tons of K_2O)

State	Agricultural potash	Chemical potash	State	Agricultural potash	Chemical potash
Alabama	90,923	19,815	Nebraska	7,517	24
Alaska	------	------	Nevada	14	599
Arizona	866	109	New Hampshire	193	20
Arkansas	58,883	332	New Jersey	36,956	2,121
California	23,131	8,351	New Mexico	377	100
Colorado	1,915	(1)	New York	48,552	69,745
Connecticut	4,523	158	North Carolina	117,092	375
Delaware	11,051	576	North Dakota	3,820	------
District of Columbia	638	------	Ohio	201,433	6,053
Florida	153,242	1,542	Oklahoma	12,157	167
Georgia	174,589	197	Oregon	7,352	607
Hawaii	22,860	------	Pennsylvania	44,274	2,896
Idaho	1,775	------	Rhode Island	1,813	313
Illinois	288,964	17,577	South Carolina	70,171	------
Indiana	231,054	2,867	South Dakota	1,162	------
Iowa	122,538	263	Tennessee	98,673	------
Kansas	6,809	898	Texas	96,316	6,830
Kentucky	54,557	7,725	Utah	81	76
Louisiana	28,542	589	Vermont	2,879	------
Maine	10,026	------	Virginia	116,905	542
Maryland	77,835	1,519	Washington	10,065	1,060
Massachusetts	14,363	224	West Virginia	2,838	11,090
Michigan	90,920	1,270	Wisconsin	86,062	126
Minnesota	87,883	------	Wyoming	263	------
Mississippi	66,612	------			
Missouri	85,753	1,490	Total	2,677,302	168,247
Montana	85	1			

[1] Less than 1 ton.

Source: American Potash Institute, Inc.

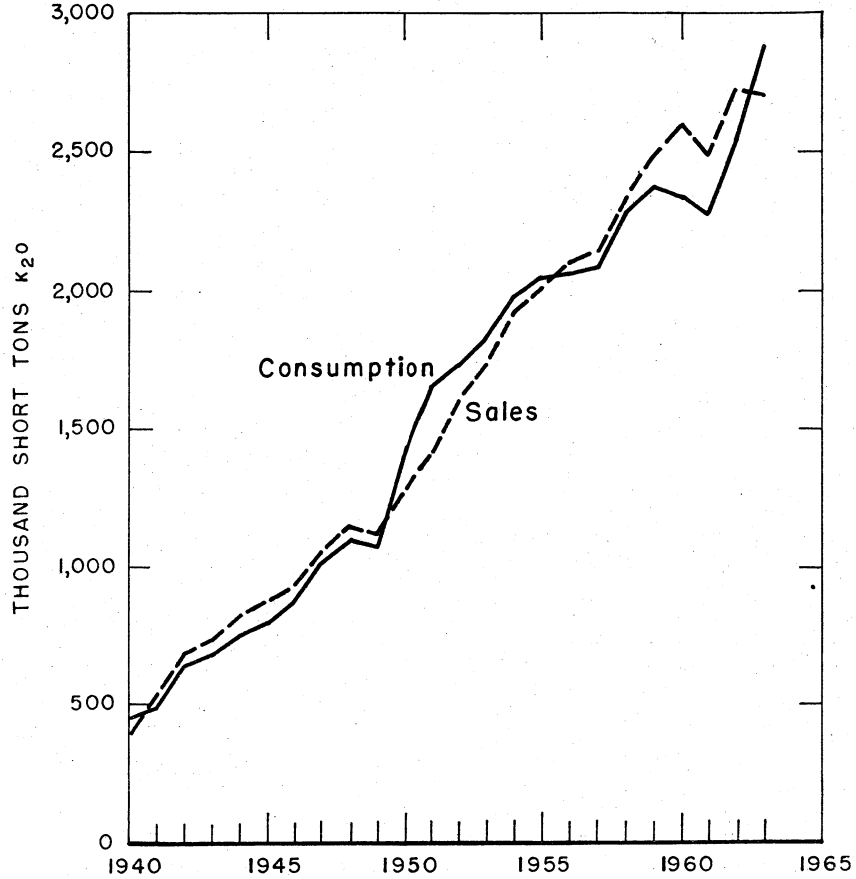

FIGURE 1.—Comparison of apparent domestic consumption of potash (K_2O) and sales by domestic producers of potash in the United States, 1940–63.

STOCKS

Stocks of potassium salts held by producers were increased 59 percent. Stocks on hand at yearend included material sold for delivery during the 1964 spring planting season.

TABLE 5.—Stocks of potassium salts in the United States

(Thousand short tons)

Year	Number of producers	Stocks, Dec. 31	
		Potassium salts	Equivalent potash (K_2O)
954–58 (average)	11	692	411
1959	11	464	277
1960	11	521	311
1961	11	927	558
1962	11	[1] 475	[1] 286
1963	10	754	438

Revised figure.

PRICES

The 1963–64 bulk prices for muriate of potash remained steady Both the muriate and the sulfate of potash increased 1 cent per unit for deliveries in the first half of 1964. The producers' published price-lists were for shipments during the months indicated against contracts made before July 1. An additional 2 cents per unit was charged by most companies for contracts made after July 1. All companies reserved the right to adjust prices to meet competition.

TABLE 6.—Bulk prices for New Mexico potash [1]

(Cents per unit K_2O)

Product	1963			1964	
	July–Aug.	Sept.–Oct.	Nov.–Dec.	Jan.	Feb.–June
Standard muriate, 60-percent-K_2O minimum	35	36	37	37	40
Coarse, 60-percent-K_2O minimum	36	37	38.5	38.5	41.5
Granular, 60-percent-K_2O minimum	37	38.5	40	40	44
Sulfate of potash, 50-percent-K_2O minimum	67	70	73	73	76
Manure salts (run of mine), 20-percent-K_2O minimum	17.65	17.65	17.65	17.65	17.65

[1] Quoted by producers, f.o.b. Carlsbad, in minimum 40-ton carlots.

TABLE 7.—Bulk prices for California potash [1]

(Cents per unit K_2O)

Product	1963			1964	
	July–Aug.	Sept.–Oct.	Nov.–Dec.	Jan.	Feb.–June
Standard muriate, 60-percent-K_2O minimum	44	45	46	46	48.5
Granular muriate, 60-percent-K_2O minimum	45	46	47	47	49.5
Sulfate of potash, 52-percent-K_2O minimum	79	81.5	84	84	87

[1] Quoted by American Potash & Chemical Corp., carlots, f.o.b., Trona, Calif.

FOREIGN TRADE

Imports.—Total imports of muriate of potash were 93 percent greater than in 1962 because of a sevenfold increase in shipments from the recently opened Canadian deposit. Shipments from France remained steady but deliveries from West Germany and Spain were reduced 27 and 31 percent, respectively. About 9 percent less crude potassium sulfate was imported during the year.

Exports.—Total exports of potash fertilizers decreased about 16 percent. For the third consecutive year, exports to Japan decreased and shipments were 11 percent less than in 1962.

TABLE 8.—U.S. imports for consumption of potash materials

Material	Approximate equivalent as potash (K_2O) (percent)	1962				1963			
		Short tons	Approximate equivalent as potash (K_2O)		Value	Short tons	Approximate equivalent as potash (K_2O)		Value
			Short tons	Percent of total			Short tons	Percent of total	
Used chiefly in fertilizers:									
Muriate (chloride) [1]	60	456,568	272,993	[2] 80.0	$13,012,264	882,731	529,663	89.2	$22,559,966
Potassium nitrate, crude	40	[2] 3,187	[2] 1,275	[2] .4	[2] 192,807	4,446	1,778	.3	228,239
Potassium sodium nitrate mixtures, crude	14	[2] 27,301	[2] 3,822	[2] 1.1	[2] 1,134,103	38,080	5,331	.9	1,578,601
Potassium sulfate, crude [1]	50	114,471	57,466	16.9	4,408,189	103,704	52,096	8.8	3,978,900
Other potash fertilizer materials	6	4,576	275	.1	171,633	1,933	116	.0	54,921
Total		[2] 606,103	[2] 335,831	98.5	[2] 18,918,996	1,030,894	588,984	99.2	28,400,627
Used chiefly in chemical industries:									
Bicarbonate	46	681	313		79,514	558	257		60,645
Bitartrate: Cream of tartar	25	1,420	355		669,657	1,253	313		548,616
Carbonate	61	116	71		14,935	323	197		41,292
Caustic	80	1,260	1,008		233,641	1,044	835		184,537
Chlorate and perchlorate	36	673	242		140,925	789	284		163,072
Cyanide	70	[2] 961	[2] 673	1.5	[2] 507,874	867	607	.8	444,676
Ferricyanide	42	[2] 381	160		[2] 231,658	381	160		227,499
Ferrocyanide	44	723	318		[2] 261,881	700	308		244,517
Nitrate	46	3,136	1,443		365,392	3,517	1,618		425,738
Rochelle salts	22	211	46		83,497	291	64		113,996
All other	(3)	1,019	503		255,839	759	372		281,770
Total		[2] 10,581	[2] 5,132	1.5	[2] 2,844,813	10,482	5,015	.8	2,736,358
Grand total		[2] 616,684	[2] 340,963	100.0	[2] 21,763,809	1,041,376	593,999	100.0	31,136,985

[1] Quantities furnished by American Potash Institute, Inc., except imports of muriate from Canada. Values adjusted by Bureau of Mines, except muriate from Canada; and sulfate from Italy and Israel in 1963.
[2] Revised figure.
[3] Approximate equivalent as potash (K_2O): 1962, 39 percent; 1963, 40 percent.

Source: Bureau of the Census.

TABLE 9.—U.S. imports for consumption of potash materials, by countries

(Short tons)

Year and country	Bitartrate—cream of tartar (25)[1]	Caustic (hydroxide) (80)[1]	Chlorate and perchlorate (36)[1]	Cyanide (70)[1]	Muriate (chloride)[2] (60)[1]	Potassium nitrate, crude (40)[1]	Potassium sodium nitrate mixtures, crude (14)[1]	Potassium nitrate (saltpeter), refined (46)[1]	Potassium sulfate, crude[2] (50)[1]	All others[3]	Total	
											Quantity	Value
1962:												
Belgium-Luxembourg										213	213	$131,789
Canada		71		[4] 52	76,395	([5])	2			162	[4] 76,682	[4] 1,678,615
Chile						2,204	[4] 27,269				[4] 29,473	[4] 1,220,294
France		21	22	234	173,972	227			37,567	3,052	215,095	7,431,300
Germany:												
East			22					487		57	566	84,337
West		884	27	475	150,810	756	30	1,641	37,472	[4] 1,536	[4] 193,631	[4] 6,507,914
Italy	303			16				874	31,793	1,198	34,184	1,611,024
Spain	233		133		46,958			122	7,639	49	55,134	1,716,005
Sweden		283	356								639	188,700
U.S.S.R.					8,433					6	8,439	257,276
United Kingdom	884			134						530	1,548	580,868
Other countries		1	113	50				12		904	1,080	355,687
Total	1,420	1,260	673	[4] 961	456,568	[4] 3,187	[4] 27,301	3,136	114,471	[4] 7,707	[4] 616,684	[4] 21,763,809
1963:												
Belgium-Luxembourg		11		15				130		205	361	152,663
Canada				42	563,344		662			733	564,781	13,030,628
Chile						3,858	36,696				40,554	1,670,994
France		29		115	176,479	181	45		46,262	1,730	224,841	7,602,353
Germany:												
East								240		88	328	70,508
West		812	11	406	110,671	396	677	1,895	34,711	803	150,382	5,241,963
Italy	775			81		11		891	18,270	88	20,116	1,295,428
Netherlands		4		5				12		967	988	303,229
Spain	200		193		32,237			332	4,351	77	37,390	1,253,697
Sweden		188	369								557	155,758
United Kingdom	250			186						208	644	246,233
Other countries	28		216	17				17	110	46	434	113,531
Total	1,253	1,044	789	867	882,731	4,446	38,080	3,517	103,704	4,945	1,041,376	31,136,985

[1] Figures in parentheses indicate, in percent, approximate equivalent as potash (K_2O).
[2] Quantities furnished by American Potash Institute, Inc., except imports of muriate for Canada. Values adjusted by Bureau of Mines, except muriate from Canada; and sulfate from Italy and Israel in 1963.
[3] Approximate equivalent as potash (K_2O): 1962, 38 percent, 1963, 39 percent.
[4] Revised figure.
[5] Revised to none.

Source: Bureau of the Census.

TABLE 10.—U.S. exports of potash materials, by countries [1]

Destination	Fertilizer				Chemical			
	1962		1963		1962		1963	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
North America:								
Canada	90,163	$3,685,855	51,698	$2,179,073	5,942	$1,101,612	6,743	$1,335,108
Costa Rica	333	15,500	14,013	403,681	3	1,224	7	2,058
Dominican Republic	3,612	141,130	1,750	62,563	6	2,286	12	3,516
Mexico	27,444	746,064	26,459	707,322	950	184,966	1,093	233,066
Other	3,389	144,564	1,898	83,150	78	12,141	74	23,622
Total	124,941	4,733,113	95,818	3,435,789	6,979	1,302,229	7,929	1,597,370
South America:								
Argentina	110	3,757	1,753	48,120	118	38,912	193	73,080
Brazil	32,740	1,014,068	23,425	741,055	733	155,224	903	204,249
Chile	7,036	226,530	8,105	193,404	63	15,526	211	36,400
Colombia	5,700	205,416	15,195	498,875	97	25,682	114	31,135
Peru	105	5,187	116	4,646	70	17,654	47	13,283
Venezuela	3,425	102,494	1,109	38,000	178	48,582	207	55,369
Other	1,960	80,298	24	924	106	19,941	14	4,301
Total	51,076	1,637,750	49,727	1,525,024	1,365	321,521	1,689	417,817
Europe:								
Belgium-Luxembourg	2,352	74,296	-------	-------	17	9,386	139	41,348
Germany, West	-------	-------	-------	-------	236	99,747	730	248,046
Ireland	15,[illegible]20	441,335	12,768	356,237	99	10,815	103	27,803
Italy	44,847	1,234,585	-------	-------	226	35,008	483	105,150
Netherlands	1,120	31,360	-------	-------	242	100,915	298	129,459
Sweden	2,205	61,791	2,205	58,267	807	43,608	873	58,237
United Kingdom	3,877	124,860	735	35,862	433	111,848	846	220,767
Other	-------	-------	-------	-------	120	38,277	331	132,630
Total	69,521	1,968,227	15,708	450,366	2,180	449,604	3,803	963,440
Asia:								
India	-------	-------	-------	-------	231	35,656	42	6,320
Japan	[2]395,362	[2]13,397,869	351,500	11,108,771	92	18,206	35	23,002
Korea, Republic of	40,019	1,317,943	74,725	2,209,107	-------	-------	10	3,035
Pakistan	-------	-------	-------	-------	50	13,887	227	53,640
Philippines	21,365	661,229	12,261	404,199	118	27,564	151	34,163
Taiwan	16,926	465,756	15,792	427,475	8	2,496	94	16,990
Viet-Nam	11,767	550,878	3,735	136,719	31	8,033	75	19,689
Other	91	3,305	183	7,756	201	33,578	164	39,538
Total	[2]485,530	[2]16,396,980	458,196	14,294,027	731	139,420	798	196,377
Africa:								
South Africa, Republic of	15,521	446,406	41,806	1,164,375	89	31,294	81	19,339
Other	-------	-------	851	37,488	98	18,939	21	5,093
Total	15,521	446,406	42,657	1,201,863	187	50,233	102	24,432
Oceania:								
Australia	41,145	1,277,213	16,062	446,079	1,695	164,892	372	112,446
New Zealand	58,010	1,836,583	28,871	848,738	34	6,950	10	5,250
Total	99,155	3,113,796	44,933	1,294,817	1,729	171,842	382	117,696
Grand total	[2]845,744	[2]28,296,272	707,039	22,201,886	13,171	2,434,849	14,703	3,317,132

[1] Revisions in Minerals Yearbook 1962, p. 1007, table 10, 1961, should read as follows: Fertilizer—Taiwan, 36,362 tons, $1,196,262; grand total, 784,384 tons, $29,770,447. Chemical—Taiwan, 60 tons, $12,133; grand total, 18,766 tons, $2,706,301.

[2] Revised figure.

Source: Bureau of the Census.

WORLD REVIEW[4]

Canada.—Alwinsal Potash of Canada Ltd. announced plans to develop potash deposits in the Lanigan-Guernsey area, 75 miles east of Saskatoon, Saskatchewan. The company expected to start sinking a shaft to the ore body (3,200 feet below the surface) early in 1964 and to begin building a refinery in 1966. The cost of the venture was estimated at $50 million. The predicted annual output of the facility would be 1 million tons of refined potash, initial production being scheduled for 1968.[5]

TABLE 11.—World production of potash (marketable, unless otherwise stated), by countries [1]

(Short tons, K_2O equivalent)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada		46,500			[2] 150,000	[2] 600,000
United States	2,120,233	2,383,259	2,638,574	2,732,602	2,452,921	2,865,560
Crude (including brines) [3]	2,414,382	2,781,960	3,039,309	3,143,569	2,863,335	3,304,211
South America: Chile (nitrate)	9,759	15,482	[2] 16,500	15,504	19,541	[2] 20,500
Europe:						
France	1,427,904	1,611,466	1,688,635	1,884,791	1,898,178	[2] 1,900,000
Crude [3]	1,615,579	1,828,804	1,909,791	2,098,603	2,118,919	2,116,435
Germany:						
East [2]	1,605,000	1,764,000	1,836,000	1,846,000	1,930,000	[2] 1,984,000
Crude [2] [3]	1,850,000	2,028,000	2,111,000	2,122,000	2,183,000	[2] 2,280,000
West	1,845,000	2,022,697	2,181,206	2,253,122	2,138,637	[2] 2,115,000
Crude [3]	2,188,500	2,363,842	2,553,158	2,646,000	2,495,331	[2] 2,500,000
Italy	(4)	10,698	54,338	149,187	170,142	[2] 210,000
Spain	252,660	269,790	291,356	289,037	259,156	274,863
U.S.S.R. [2]	917,600	1,160,000	1,212,500	1,455,000	1,650,000	1,875,000
Asia:						
Israel	34,320	[5] 76,000	[5] 91,000	[5] 93,600	[5] 100,200	124,560
Japan: (alunite) [2]	475	210	190	130		
Africa: Eritrea	90					
World total (marketable) (estimate) [1]	8,300,000	9,400,000	10,000,000	10,700,000	10,800,000	12,000,000

[1] This table incorporates some revisions. Data do not add exactly to total shown because of rounding where estimated figures are included in the detail.
[2] Estimate.
[3] To avoid duplication of figures, data on crude potash are not included in the total.
[4] Data not available, estimate by author of chapter included in total.
[5] Year ended Mar. 31 of year following that stated.

International Minerals & Chemical Corp. (Canada), Ltd. launched a $2.8 million expansion program at its refinery near Esterhazy, Saskatchewan. The program included the installation of five new compactors to increase the output of granular potash and new drying facilities to produce white potash crystals for the Japanese market. Upon completion in February 1964, the total annual plant output of refined potash was expected to reach 1.2 million tons.[6] The firm also started sinking a second shaft about 6 miles southeast of the original opening. The cost of the new shaft was expected to be $9.5 million and its completion was scheduled for the 1967–68 fiscal year. Capacity of the two shafts was estimated to be 4 million tons of product per year.

[4] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[5] Western Miner and Oil Review (Vancouver). Two Giant Projects. V. 36, No. 7, July 1963, p. 27.
[6] Northern Miner (Toronto). Expand Refinery At Inter. M. & C. No. 39, Dec. 19, 1963, p. 13.

Kalium Chemicals Ltd., a jointly owned subsidiary of Armour & Co. and Pittsburgh Plate Glass Co., began construction of a refinery and other facilities required for bringing into production its potash reserves, 25 miles west of Regina near Belle Plaine, Saskatchewan. The facilities were designed to use solution-mining methods which have been under study by the company for several years. Initial production from the property was scheduled for late 1964.[7]

Potash Company of America was engaged in redesigning and installing machinery to remodel the mining and refining facilities at its potash property about 15 miles east of Saskatoon, Saskatchewan. Completion of the project was scheduled for December 1964, at which time production would be resumed.[8]

United States Borax & Chemical Corp. was reexamining the possibilities for developing its potash property in Canada.[9] Homestake Mining Co. appeared interested in becoming a partner in the venture again, but no final decisions were announced.

Both Duval Corp. and Southwest Potash Corp. continued to study solution-mining techniques at their respective Canadian potash holdings.

Congo, Republic of the.—Plans were formulated to exploit potash from deposits of sylvinite in the Hollé area near Pointe-Noire. Mining rights were assigned by the Government to Société des Potasse de Hollé. The plans called for underground mining to begin about 1968 with an annual output of 2 million tons of potassium salts. The salts would be refined at the mine site, producing about 600,000 tons of product per year for overseas markets. The ore reserves were estimated to be sufficient to maintain mining operations for 15 to 20 years.[10]

Ethiopia.—Exploration continued on the potash deposits in the Dallol Depression adjoining the Red Sea, and Ralph M. Parsons Co. planned to invest $20 million in developing the property. An estimated 300,000-ton-per-year initial production rate was scheduled for export in 1965. At least 50 million tons of marketable sylvite and other potash minerals was estimated for the area.[11]

Germany, East.—Herr Werner Lange, Chairman and Director-General of Bergbau-Handel, stated that East Germany's output of potash was being increased, and an annual production of 2.2 million tons of K_2O was expected by 1970.[12]

India.—A plant designed to produce 2 to 3 tons of potassium chloride and 10 tons of magnesium sulfate per day from mixed salts, after the removal of common salt, was completed at Kandla in Gujarat. This was the first commercial-scale potash plant in India.[13]

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[7] Northern Miner (Toronto). Plan 1964 Start Kalium Project. No. 29, Oct. 10, 1963, pp. 13, 20.
Precambrian-Mining in Canada (Winnipeg). New Multi-Million-Dollar Potash Project for Saskatchewan. V. 36, No. 5, May 1963, pp. 10–11.
Western Miner and Oil Review (Vancouver). Kalium Chemicals to Employ Solution-Mining Methods. V. 36, No. 7, July 1963, p. 36.

[8] Commercial Fertilizer. V. 107, No. 4, October 1963, p. 34.

[9] Northern Miner (Toronto). New Potash Project May Be Shaping Up. No. 40, Dec. 26, 1964, p. 9.

[10] Bureau of Mines. Mineral Trade Notes. V. 56, No. 6, June 1963, p. 30; v. 57, No. 2, August 1963, p. 50.

[11] Engineering and Mining Journal. V. 164, No. 12, December 1963, p. 168.

[12] European Chemical News (London). Potash Output In East Germany. V. 3, No. 69, May 10, 1963, p. 6.

[13] European Chemical News (London). New Plant Will Boost Indian Fertilizer Production. V. 3, No. 59, Mar. 1, 1963, p. 21.

TABLE 12.—France: Exports of potash materials,[1] by countries [2]

(Short tons)

Destination	1961	1962	Destination	1961	1962
North America:			Asia:		
Canada	33,013	29,201	Ceylon	37,404	37,541
Cuba	3,333	----------	India	6,025	11,198
Martinique	8,284	6,592	Japan	173,706	122,223
United States	177,888	179,466	Malaya	4,193	4,016
South America:			Philippines	14,240	1,901
Brazil	8,773	27,776	Taiwan	11,023	11,170
Chile	6,714	4,382	Africa:		
Colombia	7,330	4,409	Algeria	13,491	1,412
Venezuela	5,657	2,792	Ivory Coast	6,693	5,964
Europe:			Morocco: Southern Zone	12,423	6,236
Austria	21,367	30,081	Rhodesia and Nyasaland, Federation of	20,441	8,588
Belgium-Luxembourg	171,344	149,690	Senegal	5,864	2,381
Denmark	52,751	41,454	South Africa, Republic of	19,276	26,171
Finland	8,789	1,666	Tunisia	1,102	4,162
Germany, West	31,307	39,090	Zanzibar	----------	5,081
Greece	5,465	3,790	Oceania:		
Ireland	79,254	67,718	Australia	16,429	8,386
Italy	64,629	53,723	New Zealand	61,592	26,767
Netherlands	121,125	77,632	Other countries	41,991	30,701
Norway	17,471	9,377			
Sweden	45,986	33,630			
Switzerland	79,879	87,010	Total	1,677,504	1,416,111
United Kingdom	281,252	252,734			

[1] Figures include salts, carbonate, chloride, and nitrate of potash.
[2] This table incorporates some revisions.

TABLE 13.—West Germany: Exports of potash materials,[1] by countries [2]

(Short tons)

Distination	1962	1963	Destination	1962	1963
North America:			Europe—Continued		
Canada	26,291	9,593	Switzerland	27,703	36,957
United States	177,497	199,175	United Kingdom	222,432	225,686
South America:			Yugoslavia	1,103	22,047
Brazil	30,774	44,030	Asia:		
Chile	6,239	3,056	Ceylon	5,453	13,029
Colombia	7,140	10,391	India	15,010	13,907
Uruguay	3,913	1,754	Japan	31,878	106,597
Europe:			Malaya	8,439	11,806
Austria	52,926	----------	Philippines	2,909	6,107
Belgium-Luxembourg	153,880	126,610	Taiwan	11,321	38,917
Czechoslovakia	----------	4,433	Africa:		
Denmark	188,536	148,911	Morocco	4,409	2,841
Finland	12,716	17,214	Rhodesia and Nyasaland, Federation of	10,938	15,350
France	110,906	33,119	South Africa, Republic of	40,801	44,266
Germany, East	----------	71,325	Oceania:		
Greece	11,310	8,392	Australia	13,366	52,926
Ireland	49,378	50,589	New Zealand	25,576	45,554
Italy	27,516	30,562	Other countries	30,067	40,772
Netherlands	151,825	187,263			
Norway	4,830	11,296			
Sweden	37,793	53,395	Total	1,504,875	1,687,870

[1] Data include crude salts, chloride, sulfate, magnesium sulfate, and beet ash.
[2] This table incorporates some revisions.

Israel.—The expansion program of the Dead Sea Works, Ltd., progressed according to plan. The large dike across the southern part of the Dead Sea was nearly completed, and the first evaporation pan was in use.[14] The new potash plant under construction at Sodom was expected to begin operating in April 1964.[15]

[14] Chemical Trade Journal and Chemical Engineer (London). Israeli Potash and Bromine. V. 153, No. 3990, Nov. 29, 1963, p. 809.
[15] Chemical Age (London). Dead Sea Works Potash Plant to Start in April. V. 90, No. 2318, Dec. 14, 1963, p. 933.

Spain.—Cia. Potasas de Navarra, S.A., controlled by Institute National de Industrias, began producing from its new mines in Navarra Province. Production was planned to reach the rate of 150,000 tons per year in 1964 and 300,000 tons by 1968.[16]

TABLE 14.—Spain: Exports of potash materials by countries [1]

(Short tons)

Destination	1962	1963	Destination	1962	1963
North America: United States	46,959	39,129	Norway	61,694	73,883
South America: Chile	3,307	16,535	Portugal	13,735	22,694
Europe:			United Kingdom	61,059	54,547
Belgium-Luxembourg	29,928	28,765	Africa: Algeria		1,234
Denmark	6,630	6,118	Other countries		220
Italy	11,067	25,179			
Netherlands	17,747	15,695	Total	252,126	283,999

[1] This table incorporates some revisions.

United Arab Republic (Egypt).—By means of radioactive isotopes, sizable deposits of potassium salts were discovered in petroleum-prospect areas on the Red Sea coast.[17]

United Kingdom.—Shale deposits containing up to 11 percent potash were discovered in Scotland, stretching from near Cape Wrath in the north to Loch Carron in the south.[18]

U.S.S.R.—An agreement was signed with Poland on February 18, 1963, whereby Poland would extend $6.3 million in credit to the U.S.S.R. to be repaid by deliveries of potassium salts from the deposits in Bielorussia. Much of the credit would be used for the purchase of Polish machinery and equipment to aid in the development of potash deposits near Soligorsk in Bielorussia. It was reported that the cost of producing potash from the Bielorussian deposits is about one-quarter that estimated for the Polish deposits.[19]

TECHNOLOGY

Pilot-plant solution-mining methods were developed and apparently proved feasible for mining potassium salts in Saskatchewan, Canada, by Standard Chemical Ltd.[20] Kalium Chemicals, Ltd., a company jointly owned by Pittsburgh Plate Glass Co. (PPG) and Armour & Co., acquired the potash operations of Standard Chemical Co. and began constructing a plant to treat the brine pumped from the deposit. The mining and refining techniques to be used were not disclosed; however, Canadian Patent 672,308,[21] granted to PPG employees, described a

[16] Mining Journal (London). Cia. Potasas De Navarra. V. 261, No. 6697, Dec. 27, 1963, p. 618.
[17] Bureau of Mines. Mineral Trade Notes. V. 58, No. 3, March 1964, p. 33.
[18] European Chemical News (London). Scottish Shale Rich In Potash. V. 4, No. 96, Nov. 15, 1963, p. 33.
[19] Bureau of Mines. Mineral Trade Notes. V. 56, No. 6, June 1963, p. 32.
[20] Mining Journal (London). Solution Mining of Potash. V. 260, No. 6670, June 21, 1963, p. 617.
[21] Dahms, J. B., and B. P. Edmonds (assigned to Pittsburgh Plate Glass Co., Pittsburgh, Pa.). Canadian Pat. 672,308, Oct. 15, 1963.

cyclic process of removing an aqueous solution of potassium chloride (KCl) and sodium chloride (NaCl) from a subterranean cavity, cooling the brine to crystallize the KCl, separating the solids from the mother liquor, and returning the liquor to the cavity to dissolve additional salt.[22] Imperial Oil Ltd. and Duval Corp. were also investigating solution mining for their deposits in the Saskatchewan, Canada, potash district.[23]

Reports were published on improved mining methods and equipment used in the Carlsbad, N. Mex. deposits.[24] Also, comprehensive reports were published concerning the International Minerals & Chemical Corp. (Canada), Ltd. potash operation in Saskatchewan, Canada [25] and the Montecatini potash mine at San Cataldo, Sicily.[26]

The results of a preliminary investigation of compressive strength versus length-diameter ratios of potash specimens and a statistical treatment of the data were summarized.[27]

A new chemical process for treating dilute brines and end liquors to recover potassium sulfate, sodium sulfate, and borax was put into practice by American Potash & Chemical Corp. at its Trona, Calif., plant.[28] The unique method, which used an undisclosed chelating agent, made it commercially possible to recover sulfate and borate values that were previously lost.

The All Union Halurgy Scientific Research Institute, Poland, developed and tested a high-speed method for drying industrial quantities of potassium chloride based on a fluidized-bed technique used in the Soviet Union.[29] Moisture removal of 174 to 205 pounds per square foot per hour was claimed for the process.

Laboratory test work on separating sylvite from halite using heavy liquids was reported.[30] A study indicated that a 70-percent KCl product could be obtained on a 90-percent-recovery basis. For an acceptable final product, however, further processing would be necessary either by a second separation using heavy liquids or by conventional froth flotation.

A new flotation process, which separates sylvinite from langbeinite, was developed by International Minerals & Chemical Corp. (IMC).[31]

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[22] Chemical Engineering. Chementator. V. 70, No. 23, Nov. 11, 1963, p. 122.
[23] Northern Miner (Toronto). Testing New Method for Mining Potash. No. 41, Jan. 3, 1963, p. 19.
[24] Mining Congress Journal. Longwall Mining of Potash With Borer Type Continuous Miners. V. 49, No. 7, July 1963, pp. 21–25.
Mining Engineering. Rail-Belt Haulage System at IMC's Carlsbad Operation. V. 15, No. 3, March 1963, pp. 39–41.
Pit and Quarry. Longwall Mining System Used in U.S. Borax Potash Operation. V. 56, No. 3, September 1963, pp. 104–105.
[25] Precambrian-Mining in Canada (Winnipeg). IMC's Esterhazy Potash Project. V. 36, No. 1, January 1963, pp. 10–44.
[26] Grindrod, J. Sicilian Potash Mine Operations. Pit and Quarry, v. 55, No. 9, March 1963, pp. 144–145, 148.
[27] Beckman, Robert T. Compressive Strength Versus Length-Diameter Ratios of Potash Specimens. BuMines Rept. of Inv. 6339, 1963, 15 pp.
[28] Phosphorus and Potassium (London). Potassium Sulphate From Brines Using a Chelating Agent. No. 8, December 1963, p. 42.
[29] Phosphorus and Potassium (London). Fluidized-bed for Drying Potassium Chloride. No. 8, December 1963, p. 41.
[30] Adams, Albert, and William B. Dancy. Heavy Liquid Separation of Halite and Sylvite. Trans. Soc. Min. Eng., v. 226, No. 1, March 1963, pp. 64–66.
[31] Chemical & Engineering News. IMC Processes Mixed Potash Ore. V. 41, No. 16, Apr. 22, 1963, pp. 50, 52.

The new process placed in operation at IMC's Carlsbad plant enabled the company to mine mixed langbeinite-sylvinite ores that had not been economic to process.

Technical improvements in crystallization techniques made potash recovery from complex ores and brines more economic.[32]

Patents were issued for improvements in mining[33] and beneficiating[34] potash ores and in processing potash into other marketable products.[35]

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[32] Chemical Engineering Progress. Crystallization of Potash. V. 59, No. 10, October 1963, pp. 59–64.

[33] Edmonds, B. P., J. B. Dahms, and E. P. Helvenston (assigned to Pittsburgh Plate Glass Co., Pittsburgh, Pa.). Recovery of Potassium Chloride. U.S. Pat. 3,096,969, July 9, 1963.

[34] Barry, R. L., and W. W. Richardson (assigned to International Minerals & Chemical Corp., Skokie, Ill.). Production of Potassium Fluosilicate. U.S. Pat. 3,082,061, Mar. 19, 1963.

Henne, H., K. Ratsch, and G. Budan (assigned to Wintershall A. G., Kassel, West Germany). Process for the Production of Potassium Sulfate. U.S. Pat. 3,110,561, Nov. 12, 1963.

Schmidlapp, K. (assigned to Wintershall A. G., Kassel, West Germany). Method and Apparatus for Purifying Potassium Salt-Containing Materials. U.S. Pat. 3,096,034, July 2, 1963.

Wilson, W. P. (assigned to United States Borax & Chemical Corp., Los Angeles, Calif.). Process for Recovering Values From Ores Containing Clay. U.S. Pat. 3,095,282, June 25, 1963.

Wolstein, F., and G. Gelhaus. Separate Precipitation of Sodium and Potassium Bicarbonate From Sodium Chloride-Potassium Chloride Solutions. U.S. Pat. 3,112,173, Nov. 26, 1963.

[35] Hadzeriga, P. (assigned to Standard Magnesium Corp., Inc., Tulsa, Okla.). Ion Exchange Process for Producing Potassium Sulfate and Sulfuric Acid. U.S. Pat. 3,096,153, July 2, 1963.

Pumice

By Timothy C. May [1]

PUMICE and pumiceous materials sold or used by producers in the United States in 1963 increased 15 percent in quantity and 4 percent in value over 1962 sales.

DOMESTIC PRODUCTION

Pumice production was reported by 97 companies, individuals, railroads, or highway departments at 103 operations in 1963.

TABLE 1.—Pumice sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Pumice and pumicite		Volcanic cinder		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1954–58 (average)	933	$2,869	813	$1,332	1,746	$4,201
1959	784	3,267	1,492	2,596	2,276	5,863
1960	601	2,767	1,609	2,802	2,210	5,569
1961	936	4,203	1,527	2,596	2,463	6,799
1962	[1] 533	[1] 3,206	1,738	3,095	[1] 2,271	[1] 6,301
1963	1,050	3,321	1,568	3,257	2,618	6,578

[1] Revised figure.

TABLE 2.—Pumice sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1962		1963	
	Quantity	Value	Quantity	Value
Arizona	756	$1,640	800	$1,877
California	573	2,615	460	2,017
Colorado	76	82	60	87
Hawaii	232	380	274	469
Idaho	[1] 67	[1] 103	161	275
New Mexico	308	741	322	850
Oregon	(2)	(2)	422	664
Utah	28	46	28	46
Wyoming	42	41	(2)	(2)
Other States [3]	[1] 189	[1] 653	91	293
Total	[1] 2,271	[1] 6,301	2,618	6,578
American Samoa	50	108		

[1] Revised figure.
[2] Figure withheld to avoid disclosing individual company confidential data; included with "Other States."
[3] Kansas, Nebraska, Nevada, Oklahoma, Texas, Washington, and States indicated by footnote 2.

[1] Commodity specialist, Division of Minerals.

TABLE 3.—Pumice sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1962 [1]		1963	
	Quantity	Value	Quantity	Value
Abrasive: Cleaning and scouring compounds	35	$1,201	25	$773
Concrete admixture and concrete aggregate	[2] 1,030	[2] 3,096	894	2,972
Railroad ballast	698	623	609	592
Road construction [3]	482	803	846	1,123
Other uses [4]	76	686	244	1,118
Total	[2] 2,321	[2] 6,409	2,618	6,578

[1] Includes American Samoa.
[2] Revised figure.
[3] Includes surfacing, ice control, and maintenance.
[4] Includes abrasive uses (miscellaneous), absorbents, acoustic plaster, brick manufacture, filtration, insecticides, insulation, soil conditioners, and miscellaneous uses.

Total production of pumice was 2.6 million short tons valued at $6.6 million. Arizona, with 10 active pumice mines and 31 percent of total production, continued to be the largest producing State, followed by California, with 18 percent from 33 mines; New Mexico, with 12 percent from 11 mines; and Idaho, with 6 percent from 6 mines.

CONSUMPTION AND USES

The consumption of volcanic cinders was 10 percent less than in 1962. Of all domestic pumice and pumiceous materials used in 1963, the principal uses were 34 percent as aggregate and concrete mixtures, 32 percent for road construction, and 23 percent as railroad ballast.

PRICES

Nominal price quotations of domestic and imported prepared pumice were carried regularly in trade publications. The Oil, Paint and Drug Reporter quoted the following prices per pound, bagged, in ton lots: Domestic, fine and coarse, $0.0430; domestic, medium, $0.0480; imported (Italian), silk-screened, coarse, $0.0634; imported (Italian), fine, $0.0450 to $0.0475. Imported, Italian, sundried, coarse and fine was quoted at $75 per ton each.

E&MJ Metal and Mineral Markets quoted nominal yearend prices per pound, f.o.b. New York or Chicago, in barrels as follows: Powdered, 3 to 5 cents; lump, 6 to 8 cents.

The values per ton of pumice in various categories were cleaning and scouring compounds and other abrasive uses, $30.92; concrete admixtures and aggregate, $3.32; insulation, $4.18; railroad ballast, $0.97; road construction, $1.33; and other and unclassified uses, $4.58.

FOREIGN TRADE

Imports.—Pumice stone imported for use in the manufacture of concrete masonry products, such as building block, brick, and tile, from Greece and Italy was 147,000 short tons valued at $256,000,

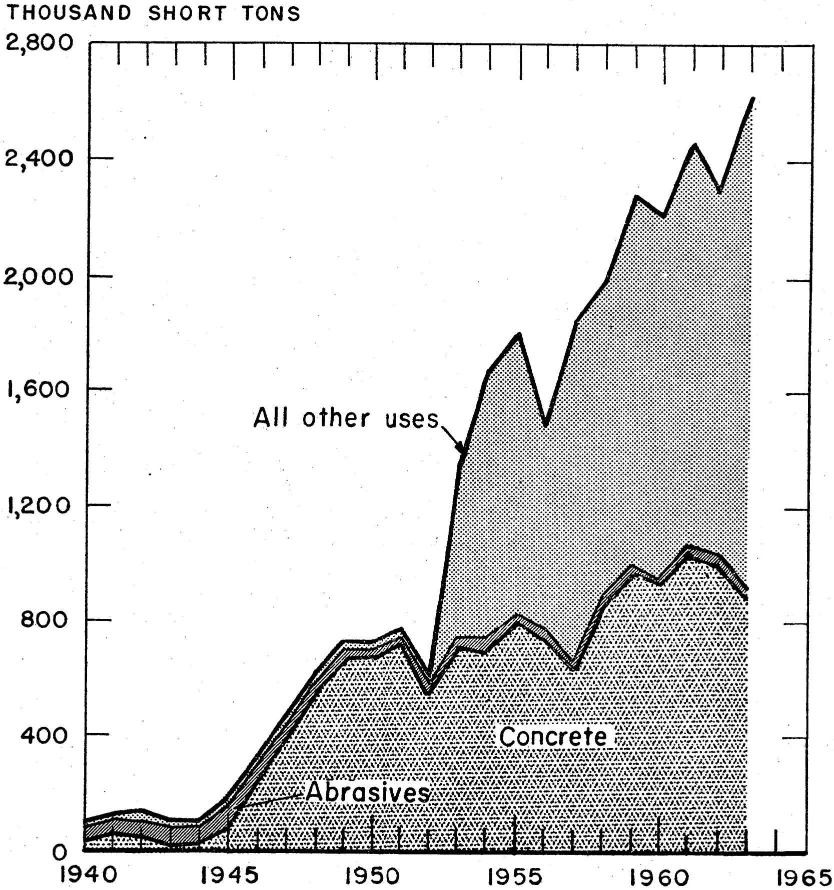

FIGURE 1.—Trends in pumice by uses, 1940–63.

compared with 76,000 tons valued at $148,000 in 1962. Crude pumice, valued at less than $15 per ton, had an average value of $8.47, compared with $8.24 in 1962; crude pumice valued at more than $15 per ton averaged $24.23, compared with $18.18 in 1962; and wholly or partly manufactured pumice averaged $33.46 per ton, compared with $27.99 in 1962.

Exports.—Pumice exports were grouped with other mineral commodities and were therefore not available separately.

Tariff.—Pumice stone to be used in the manufacture of concrete masonry products, such as building blocks, bricks, tiles, and similar forms, was imported duty free. The duty per pound on imported pumice at the beginning of 1963 follows: crude valued at $15 per ton and under, 0.0425 cent; crude valued at over $15 per ton, 0.09 cent; wholly or partially manufactured, 0.38 cent; millstones, abrasive wheels, and abrasive articles, n.s.p.f., 15.5 percent ad valorem. On

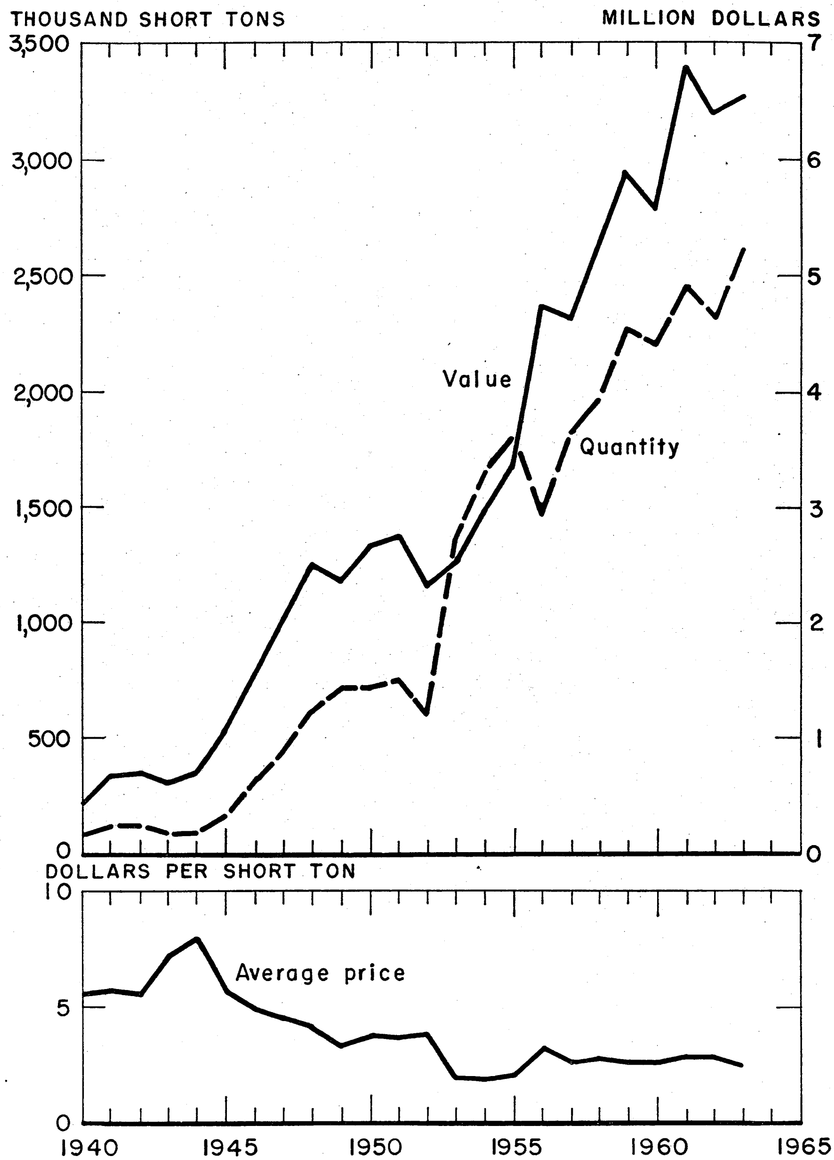

FIGURE 2.—Total value, quantity, and price per ton of pumice, 1940–63.

July 1, 1963, tariff rates were reduced to 0.08 cent for pumice valued at more than $15 per ton; 0.35 cent for wholly or partially manufactured pumice; and 14 percent ad valorem for millstones, abrasive wheels, and abrasive articles, n.s.p.f.

TABLE 4.—U.S. imports for consumption of pumice, by countries

Country	Crude or unmanufactured				Wholly or partly manufactured				Pumice [1]				Manufactured, n.s.p.f.	
	1962		1963		1962		1963		1962		1963		1962	1963
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Value	
Greece	20	$434							54,003	$103,216	52,881	$77,948		
Italy	7,116	69,375	7,576	$83,600	3,184	$89,111	3,555	$118,939	22,166	42,705	93,907	178,231		$24,688
Other									15	1,751			$22,499	22,410
Total	7,136	69,809	7,576	83,600	3,184	89,111	3,555	118,939	76,184	147,672	146,788	256,179	22,499	47,098

[1] To be used in manufacturing concrete masonry products.

Source: Bureau of the Census.

WORLD REVIEW

Greece.—A tax benefit was granted on pumice in the form of a 3 percent deduction from gross export earnings subject to tax.

TABLE 5.—World production of pumice by countries [1] [2]

(Short tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
Argentina [3]	[4] 21,580	19,842	16,573	32,321	12,585	[5] 13,250
Austria: Trass	42,162	34,885	38,581	40,846	30,696	23,349
Cape Verde Islands: Pozzolan	----------	10,033	7,094	7,361	7,503	[5] 7,500
France:						
Pumice	28,543	2,064	995	1,455	1,876	[5] 1,870
Pozzolan	387,420	482,683	475,484	485,724	521,751	559,533
Germany, West (marketable)	3,362,486	4,039,966	4,742,138	5,898,461	6,290,883	7,044,863
Greece:						
Pumice	56,610	71,650	88,185	77,162	[5] 88,000	[5] 88,000
Santorin earth	76,096	93,696	198,416	209,439	[5] 220,000	[5] 220,000
Iceland	[5] 14,330	[5] 10,000	[5] 9,000	[5] 9,000	[5] 7,200	13,779
Italy:						
Pumice	185,633	258,254	345,390	282,834	349,862	
Pumicite	50,094	146,717	124,671	161,488	[5] 165,000	[5] 3,970,000 (Pumice, Pumicite, Pozzolan combined)
Pozzolan	2,350,155	3,055,978	3,494,273	3,213,338	3,320,114	
Japan	[6] 121,250	[5] 121,250	(7)	(7)	(7)	(7)
Kenya	[8] 1,657	2,515	2,711	779	1,243	1,245
New Zealand	13,992	31,803	49,204	36,637	36,425	18,599
Spain: Canary Islands	631	1,836	1,614	1,585	1,918	[5] 1,875
United Arab Republic (Egypt)	756	2,756	3,307	4,335	2,276	[5] 2,200
United States (sold or used by producers):						
Pumice and pumicite	933,495	783,873	601,315	936,039	[9] 583,716	1,050,178
Volcanic cinder	813,311	1,492,247	1,609,050	1,526,546	1,737,587	1,567,825
World total (estimate) [1] [2]	8,500,000	10,700,000	11,900,000	13,100,000	13,500,000	14,710,000

[1] Pumice is also produced in Mexico and U.S.S.R., but data on production are not available; no estimates are included in total, but it is believed that U.S.S.R. produces a sizable quantity.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Includes volcanic ash and cinders, and pozzolan.
[4] Average annual production 1955–58.
[5] Estimate.
[6] Data for year 1958 only.
[7] Data not available; estimate by author included in total.
[8] Average annual production 1956–58.
[9] Includes American Samoa.

TECHNOLOGY

A comprehensive review of the characteristics, classification, uses, and technology of pozzolans was made in connection with a geologic investigation into natural pozzolanic materials in north-central California. Materials most likely to be used for pozzolans are volcanic ashes, tuffs, and pumicites.[2]

The chemical and mechanical properties of 10 Hungarian pumices were determined. They contain montmorillonite as the major ingredient.[3]

[2] Faick, J. N. Geology and Technology of Some Natural Pozzolans in North-Central California. Econ. Geol., v. 58, No. 5, August 1963, pp. 702–719.
[3] Barna, Janos. Hungarian Pumices. Banyasz. Kut. Int. Kozlemen. 7, 283–93, 1962. Chem. Abs., v. 59, No. 2, July 22, 1963, col. 1358.

The eruption of pumice over an area of 2,000 square miles in the South Sandwich Islands area was reported.[4]

Chemical analyses, physical tests, and tensile and compressive strengths of portland-pozzolan mixtures made with standard type I portland cement and 4 types of pumiceous material were reported. Preliminary studies of pumiceous deposits on the Island of Dominica, West Indies, indicated they may be an economic source of supply for Caribbean, Atlantic, and gulf coastal areas of the United States, as lightweight aggregate and pozzolanic materials.[5]

Bulk density of 150 samples of pumice collected from the pumice flow deposits of the Towada Caldera was described.[6]

A froth rock simulating the top layers of the moon has been developed, as part of an effort to create a vehicle to land men on the moon. This froth rock is made by melting pumice in a vacuum until all entrapped gases escape. The resulting material reflects light and radar waves in the same manner as the moon' surfaces. The nature of the frothy, brittle rock indicates that to travel over such a surface a vehicle must have its weight distributed in an extremely flexible manner.[7]

A patent was granted for a process of manufacturing synthetic pumice by adding serpentine or similar rock or mineral to molten blast furnace slag.[8]

A French patent was issued which covered the use of pumice, asbestos, mica, bentonite, or like minerals of a fibrous, platy, or granular nature as filters for tobacco smoke or gaseous products.[9]

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[4] Gass, I. G., P. G. Harris, and M. W. Holdgate. Pumice Eruption in Area of South Sandwich Islands. Geol. Mag. (London), v. 100, No. 4, July-August 1963, pp. 321–330.

[5] Vera, Jr., A. Dominican Pumice Lodes—Fruitful Pozzolan Source. Rock Products, v. 66, No. 8, August 1963, pp. 87–88.

[6] Yagi, K. T. Matsuyama, and O. Nanasaki. Density of Pumice—With Reference to the Mechanism of Welded Tuffs. Kazan (2) 5, 99–109, 1960. Chem. Abs., v. 58, No. 8, Apr. 15, 1963, col. 7738.

[7] Rock Products. V. 66, No. 4, April 1963, p. 11.

[8] Wolf, E. (assigned to Schlosser & Co., G.m.b.H., Micheback, West Germany). U.S. Pat. 3,082,100, Mar. 19, 1963.

[9] Rothstein, G. French Pat. 1,291,062, Mar. 12, 1962.

Quartz Crystal

Electronic-Grade

By Benjamin Petkof [1]

DOMESTIC consumption of raw quartz crystal increased almost 12 percent over that of 1962. Finished crystal units exceeded the 1962 production by almost 16 percent.

TABLE 1.—Salient electronic- and optical-grade quartz crystal statistics

	1954–58 (average)	1959	1960	1961	1962	1963
Imports of electronic- and optical-grade quartz crystal [1] ... thousand pounds..	509	[2] 367	[2] 676	854	325	282
Value ... thousands..	$1,018	[2] $638	[2] $504	$762	$731	$447
Consumption of raw electronic-grade quartz crystal [3] ... thousand pounds..	160	210	230	216	291	325
Production, piezoelectric units, number [4] thousands..	4,980	6,820	8,712	9,822	11,787	13,614

[1] Imports are mostly Brazilian pebble valued at $0.35 or more per pound.
[2] Excludes quartz crystal imported from Brazil and accepted under Government agricultural barter contracts.
[3] For 1954 and subsequent years, data include some reworked scrap quartz crystal.
[4] For 1957–63, includes finished crystal units produced from reprocessed blanks; from raw quartz previously reported as consumption; and from imported blanks.

DOMESTIC PRODUCTION

No domestic production of natural electronic-grade quartz crystal was reported during 1963. At yearend the following companies reported production of manufactured quartz for electronic use: P. R. Hoffman Co., Carlisle, Pa.; Sawyer Research Products, Inc., Eastlake, Ohio; Thermo-Kinetic Corp., Tucson, Ariz.; Transcom Electronics, Inc., Newport, R.I.; and Western Electric Co., North Andover, Mass. Sawyer Research Products, Inc. reported sales of about 18,000 pounds of manufactured quartz to both foreign and domestic consumers. The Western Electric Co. continued to produce quartz for its own use and the use of its affiliated companies.

Total production capacity for manufactured quartz was estimated to be in excess of 70,000 pounds per year at the close of 1963.

[1] Commodity specialist, Division of Minerals.

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CONSUMPTION AND USES

Production of piezoelectric units required the consumption of 325,000 pounds of raw quartz crystal. This exceeded 1962 consumption by 34,000 pounds. The consumption of domestically produced manufactured quartz crystal increased from 19,500 pounds in 1962 to 21,130 pounds for the current year. Approximately 13,175,000 finished crystal units were produced from the raw quartz consumed in 1963, and an additional 438,997 units were obtained from stocks of blanks carried over from prior years. The average yield per pound of raw quartz crystal consumed was 40.5 finished crystal units, compared with 38.2 units in 1962. The yield of finished quartz crystals from manufactured quartz crystal was reported to be 2 to 10 times greater than the yield from natural quartz crystal.

A total of 34 quartz-crystal cutters, representing 35 consumers in 15 States reported to the Bureau of Mines in 1963. Thirty-two of the consumers produced piezoelectric units, and three produced semifinished blanks only. About 87 percent of the raw quartz crystal used was reported by 18 consumers in 5 States. Pennsylvania with 46 percent of the total consumption was the leading State, followed by Illinois, Kansas, Massachusetts, and Missouri.

Piezoelectric units were made by 53 producers in 21 States. One producer had plants in two States. Twenty of the 53 producers did not consume raw quartz crystal but manufactured finished crystal units from partly processed blanks. About 92 percent of the output of finished crystal units came from 36 plants in 10 States. Pennsylvania, Kansas, Illinois, Missouri, and Massachusetts produced the largest quantities of finished crystal units. Oscillator plates comprised 87 percent of the total production of piezoelectric units; the remaining 13 percent consisted of filter plates, telephone resinator plates, transducer crystals and miscellaneous items. Production of filter plates increased slightly and that of resinator plates decreased substantially.

PRICES

Prices for natural electronic-grade quartz crystal sold to domestic users showed no significant change from 1962 prices. Approximate prices for the different weight classes follows:

Weight class (grams):	*Price per pound*
100–200	$2.00–$3.50
201–300	4.00–12.50
301–500	8.00–14.00
501–700	12.00–20.00
701–1,000	18.00–24.00
1,001–2,000	24.00–35.00

The price of manufactured quartz crystal was quoted by one large producer at $27.50 per pound in any quantity.

Lasca, used for manufacturing clear fused quartz and as feed material for manufactured quartz crystal, sold for about $0.50 per pound for first-quality material. The price of second-quality lasca was about $0.25 per pound.

FOREIGN TRADE

Imports of electronic- and optical-grade quartz crystal valued at more than $0.35 per pound declined 13 percent in quantity and 39 percent in value over the previous reporting year of 1962. Brazil, continuing its position as the largest supplier, furnished 274,200 pounds or 97 percent of the total quantity imported. The remainder was supplied by Japan with very minor amounts from Canada, United Kingdom, West Germany, and the Malagasy Republic.

Quartz crystal imports valued at less than $0.35 per pound totaled 430,721 pounds valued at $100,089. This was a decrease of 30 percent in quantity and 10 percent in value over imports in 1962. This material, usually referred to as lasca, was used principally for the manufacture of fused quartz and as a feed material for the production of manufactured quartz crystal.

Exports of raw quartz crystal amounted to $525,084, an increase of 17 percent over 1962. Principal countries of destination were Japan, Canada, United Kingdom, France, and Israel. Data on the quantity of quartz crystal exported were not available. Reexports remained about the same and were valued at $91,854 compared with $90,420 in 1962.

Exports of quartz crystal manufactures, both natural and synthetic, increased in value from $714,378 in 1962 to $878,622. Data on the quantities involved were not available.

WORLD REVIEW

Brazil.—Exports of electronic- and fusing-grade quartz crystal totaled 2,967,418 pounds, value estimated at $1.2 million dollars, a decrease of 15 percent in quantity and 19 percent in value compared with the 1962 figures. Breakdown was not available by grade, but a substantial quantity of the material was lasca.

Malagasy Republic.—The alluvium from the quartz veins of the Graphite system, west of Antongil Bay on the northeast coast (Mananara-Rantabe area), was the principal source of this country's electronic-grade quartz. The Société Le Quartz and its subsidiary, Société de l'Amiante, was the largest producer. The company operated a small shop for preparing hand-gathered quartz for market.

Rabesaotra Rabefanonta was the chief producer of ornamental quartz. Rose quartz was mined at the Marovorona mine near Lakata, Moramanga subprefecture.[2]

During 1963 the Malagasy Republic exported approximately 19,600 pounds of electronic-grade quartz.

South Africa, Republic of.—A quartz crystal processing plant has been set up at Boksburg under a 1962 agreement between Standard Telephones and Cables (S.A.) (Pty) Ltd. and the South African Government for its establishment. This plant has begun to fabricate X-cut crystal plates of the flexural variety for filter use from raw quartz crystal, and is expected to meet the crystal requirements for the manufacture of transmission filters. Future plant development will permit

[2] Bureau of Mines. Mineral Trade Notes. V. 58, No. 4, April 1964, p. 44.

the production of other varieties of finished quartz crystals required by the South African electronics industry.[3]

TECHNOLOGY

A technique has been developed for the conversion of laser light beams to microwave using crystalline quartz or electro-optical materials. A ruby laser and quartz crystal are coupled to produce an S-band microwaves signal from two different laser beam frequencies. The index of refraction of the quartz is changed by the laser beam producing a microwave difference frequency. Laser-to-microwave conversion by materials such as quartz had not been previously observed because of extremely low microwave output. The output was increased by continuous reflection of laser emission into the quartz crystal.[4]

The internal friction of natural quartz was measured using specimens in the shape of cylinders. In specimens that were oriented parallel to the Y or Z axis the internal friction was low and almost independent of the strain amplitude of the vibration. Other crystal orientations showed dependence on vibration amplitude. The internal friction was concluded to be due mainly to the vibration of dislocations in the slip plane parallel to the Y or Z axis.[5]

The transformation of Brazilian quartz to cristobalite was studied by X-ray techniques, using ground material. The effect of particle size and grinding was determined. This transformation is a consecutive reaction having an intermediate transition phase. This reaction was also studied with uranium oxide as a catalyst.[6]

Quartz crystal dielectric losses were investigated at low temperature. Relations were found to exist between deformation losses, color-center dipole losses, and the extension coefficient. Ionization and color-centers were produced by X-ray and electron beams.[7]

A thermometer using a Y-cut quartz crystal as the sensing element, and its associated electrical circuits and mechanical design was described. The instrument provided a temperature resolution of a few ten-thousands of a degree in the temperature interval of 77–435° K.[8]

An optical technique was developed to observe vibration patterns of quartz crystals. This technique depended on a small light beam being modulated by the vibration of a boundary on the surface of the crystal formed by two areas of different reflectance. The modulation was observed by a photomultiplier tube in conjunction with a narrow band amplifier.[9]

The use of an X-ray diffraction technique to determine crystal lattice defects, strain patterns due to fabrication and mountings, and acoustic mode patterns in quartz crystals was described. This method caused

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[3] South African Mining and Engineering Journal. (Johannesburg). STC Begin Production of Quartz Crystals. V. 74, pt. 2, No. 3680, Aug. 16, 1963, p. 615.
[4] Electronic News. Quartz Crystal Conversion of Laser to Microwave Told. V. 8, No. 372. Apr. 13, 1963, p. 33.
[5] Journal of the American Ceramic Society, Ceramic Abstracts. V. 46, No. 6, June 1963, p. 173.
[6] Chaklader, A. C. D. X-ray Study of Quartz-Cristobalite Transformation. J. Am. Ceram. Soc., Ceram. Abs., v. 46, No. 2. February 1963, pp. 66–71.
[7] American Chemical Society, Chemical Abstracts. V. 58, No. 4, Feb. 18, 1963, p. 2932.
[8] American Chemical Society, Chemical Abstracts. V. 53, No. 1, Jan. 7, 1963, p. 250.
[9] Sauerbrey, G. Measurement of Amplitude Distributions of Vibrating AT-Cut Crystals by Means of Optical Observations. Proc. 17th Ann. Symp. on Frequency Control. U.S. Army Signal Res. and Devel. Lab., Fort Monmouth, N.J., May 1963, pp. 28–50.

no crystal damage and can be used until the crystal is ready for encapsulation.[10]

An interesting paper has been published discussing recent advances in the design of crystal filters. The use of modern network synthesis techniques was described in relation to the design of filter networks.[11]

Also methods used to temperature compensate quartz crystal oscillators were described. All were dependent on some type of temperature sensitive reactance device to vary frequency as temperature changes.[12]

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[10] Sykes, R. A., W. L. Smith, and W. J. Spence. Studies on High Precision Resinators. Frequency, v. 1, No. 6. September–October 1963. pp. 18–22.

[11] Kosowsky, D. I., and C. R. Hurtig. Recent Developments in Crystal Filters. Frequency, v. 1, No. 6. September–October 1963, pp. 45–53.

[12] Newell, D. E., and R. E. Bangert. Temperature Compensation of Quartz Crystals. Frequency, v. 1, No. 7, November–December 1963, pp. 23–25.

Rare-Earth Minerals and Metals

By John G. Parker [1]

PRODUCTION of domestic bastnaesite and monazite dropped almost 25 percent but shipments for consumption showed a slight increase. New processing facilities were added in the United States. Increased use of rare-earth materials in laser technology and the improvement of certain metals and alloys was stressed during the year at two international conferences, one in the United States and the other in the U.S.S.R.

DOMESTIC PRODUCTION

Concentrate.—The bastnaesite mine and milling facility at Mountain Pass, Calif., operated by Molybdenum Corporation of America, produced 24 percent less but shipped 16 percent more concentrate than in 1962. Byproduct monazite produced by Titanium Alloy Manufacturing Division, National Lead Co., from northeastern Florida beach sands decreased 25 percent and shipments of concentrate dropped 15 percent. The total increase in shipments was 3 percent.

Metals and Compounds.—Rare-earth compounds were produced from rare-earth concentrates by the following chemical processors: American Potash & Chemical Corp., Rare Earth Division, West Chicago, Ill.; Molybdenum Corporation of America, York, Pa.; W. R. Grace & Co., Davison Chemical Division, Pompton Plains, N.J.; Research Chemicals Division, Nuclear Corporation of America, Phoenix, Ariz.; and Vitro Chemical Co., Chattanooga, Tenn.

Michigan Chemical Corp., St. Louis, Mich., provided ion-exchange processing facilities for producing high-purity rare-earth compounds. Research Chemicals processed 12 tons of euxenite in the production of high-purity heavy rare-earth and yttrium compounds. New facilities at its York, Pa., chemical plant permitted Molybdenum Corp. to commence producing rare-earth chloride.[2]

Rare-earth metals and alloys, including misch metal, ferrocerium, and didymium metal were produced by American Metallurgical Products Co., Inc., New Castle, Pa., and Ronson Metals Corp., Newark, N.J. Lunex Co., Pleasant Valley, Iowa, produced about 100 pounds of high-purity metal, mostly lanthanum, neodymium, praseodymium, and erbium worth over $20,000. American Potash, Michigan Chemical, and Nuclear Corp. also refined high-purity rare-earth metals.

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[1] Commodity specialist, Division of Minerals.
[2] Molybdenum Corporation of America. Annual Report. 1963, p. 5.

Dresser Products, Inc., Great Barrington, Mass., continued as a fabricator of high-purity rare-earth metals, shipping over 3,000 grams of metal, chiefly yttrium, gadolinium, and dysprosium in finished form. Mallinckrodt Chemical Works, St. Louis, Mo., produced no misch metal and it was reported that the company had ceased production of the alloy.

Vanadium Corporation of America developed a process for a rare-earth silicide alloy to be used in foundries and steel production.[3] Union Carbide Corp., Metals Division, Alloy, W. Va., and Vitro Chemical Co. also produced rare-earth silicides for alloys.

CONSUMPTION AND USES

The apparent industrial consumption of rare-earth elements was 2,337 tons of rare-earth oxides, compared with 1,700 tons in 1962. The previously published figure of about 2,400 tons for apparent demand in 1962 included shipment to a Government stockpile of rare-earth sulfate equivalent to 700 tons of rare-earth oxide.

Shipments of high-purity rare-earth metals, including yttrium, totaled about 500 pounds.

The glass industry was the greatest consumer of rare-earth compounds, mostly as oxides for rapid polishing of plate glass as well as precision optical equipment and eyeglasses. Lesser quantities of compounds were used for coloring, decoloring, and opacifying glass. Newer uses were in ultraviolet absorbing glasses, in certain high-lead glass with increased radiation stability, and in color television tubes.

Fluorides and oxides were consumed in the production of carbon electrodes for arc lighting of high light intensity and good color balance.

Most rare-earth compounds consumed in metallurgy were used in the production of misch metal. Much of the misch metal was converted to ferrocerium lighter flints. The use of rare-earth silicides in alloys increased, but that of rare-earth materials in castings appears to have decreased.

Commercial magnesium casting alloys containing rare-earth elements have high strengths at moderately elevated temperatures. They have good weldability and corrosion resistance. Didymium (a neodymium-praseodymium mixture) appears to promote high tensile and creep strengths in magnesium alloys. Magnesium alloys containing rare-earth metals, silver, and zirconium produced in the United Kingdom had a high yield strength at moderately elevated temperatures. An important application was in front bearing housings in aircraft. Rare-earth metals, zinc, and zirconium, were used in another English magnesium alloy which has been made in castings up to almost 500 pounds for use as flatbed plates in printing equipment. Didymium was said to improve the oxidation resistance of chromium and to prevent high-temperature embrittlement by reducing absorption of nitrogen. Stainless steels with rare-earth additives were said to have improved hot workability. In the U.S.S.R., cast iron crankshafts with small additions of ferrocerium were said to be better

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[3] Vanadium Corporation of America. Annual Report. 1963, p. 4.

than forged crankshafts without these additions. Lanthanum boride (LaB_6) was said to be substitutable for tungsten in certain electrical applications because of its high stability and long service life at high temperatures. Although precise information is lacking, appreciable quantities were used in chemical processing—perhaps as catalysts. This would take advantage of hydrogenation reactions and could be used in petroleum cracking.

Usage in enamels accounted for a small quantity of rare-earth consumption. The remainder of the rare-earth compounds was used in such diverse fields as dyeing aids and corrosion-resistant filter cloths in textiles, in microwave and nuclear applications, and in refractories.

Discovered through intense research on the luminescent and emissive properties of the rare-earth elements, such elements as europium, lanthanum, and terbium were added as activators to laser crystals, glasses, plastics, and liquids. Indeed, recent research indicated the possibility of using certain rare-earth host crystals with other rare-earth additives for some of these purposes.

Certain rare-earth oxides have very high neutron cross sections and are excellent neutron absorbers. These rare-earth oxides, encased in stainless steel or in cermets, were used in control rods in commercial nuclear reactors. Europium is preferable to gadolinium because of its slower burnup due to a greater number of absorbing isotopes. Lithium iodide crystals activated by europium are being used as thermoneutron detectors, because the reaction releases no gamma rays as in the disintegration of the boron 10 nucleus. Activated thulium and europium served as sources of secondary radiation in portable radiographic equipment.

STOCKS

Company inventories of rare-earth mineral concentrates, including those of monazite and bastnaesite, were almost 10 percent greater at yearend than at the same time in 1962. Monazite stocks nearly doubled but bastnaesite decreased slightly. Imports of monazite by processors increased about 6 percent and were obtained from the Republic of South Africa, Australia, Malaya, and Ceylon.

A sizable decrease in stocks of the intermediate sulfate material would be augmented by the processing of monazite. Stocks of other commercial grade and high-purity rare-earth compounds expressed as rare-earth oxides increased almost 20 percent; those of high-purity metals increased about 15 percent but misch metal inventories dropped over 10 percent. The national (strategic), U.S. Department of Agriculture Commodity Credit Corp. (CCC), and supplemental stockpiles totaled 15,852 tons of rare-earth oxides in rare-earth chloride, rare-earth sodium sulfate, monazite, and bastnaesite on December 31, 1963.

PRICES

Since 1960, nominal quotations on imported monazite by E&MJ Metal and Mineral Markets have remained constant. Imported concentrates, per pound, c.i.f., U.S. ports, were quoted as follows: Massive, 55 percent total rare-earth oxides including thoria, 14 cents; sand, 55 percent at 10 to 15 cents, 66 percent at 18 cents, and 68 percent at 20 cents. The large quantities purchased by chemical processors were understood to have unit prices well below those published. No price was quoted for domestic bastnaesite.

Price lists on rare-earth materials were issued by American Potash & Chemical Corp., Lunex Co., Michigan Chemical Corp., Nuclear Corporation of America, Ronson Metals Corp., and Vitro Chemical Co. An increase in prices of most of the high-purity rare-earth salts produced by one company was countered by decreases in most of the high-purity oxides refined by another firm. Early in the year E&MJ commenced quoting pound quantities of high-purity metals and in June it started quoting pound prices for multi-pound quantities ordered from three different producers.

Prices per pound in lots of 10 pounds and less of 99.9 percent pure metal ranged from $32 to over $4,000, indicating significant reductions on most items from two producers. In some instances prices on the highest priced metals were reduced over 50 percent, but several instances of substantial increases were noted. In the case of thulium, one company raised its price by 80 percent but another refiner, who issued two changes in metal prices during the year, maintained a significantly lower price on somewhat lower purity thulium metal.

Misch metal ingot prices showed little change from the previous year, with slightly higher prices being quoted for extruded misch metal pellets. A misch metal producer offered ingots of technical-grade lanthanum metal and reduced the prices on didymium metal ingots by about 30 percent.

High-purity oxides of the scarcer rare-earth elements were available in lots as small as 1 gram. As usual, prices for larger pound size lots of high-purity material or ton quantities of commercial-grade compounds and metals were available upon request to the companies.

FOREIGN TRADE

Imports.—Cerium salts weighing 5,405 pounds valued at $6,867 were received from France and the United Kingdom. Rare-earth metals and alloys totaling 1,170 pounds worth $2,734 were received from the United Kingdom and Japan. Ferrocerium and other pyrophoric alloys were imported from Austria, France, Japan, the Netherands, the United Kingdom, and West Germany and totaled 16,260 pounds valued at $47,672. The Bureau of the Census reported that monazite concentrate imported from the Federation of Malaya, Republic of South Africa, and an unidentified country, probably Australia, totaled 6,430 tons valued at $771,120. Of these the Republic of South Africa accounted for nearly 75 percent of the total. Chemical processors reported to the Bureau of Mines that they had received 12 percent more monazite imports than those recorded by Census. A significant quantity was said to have been received from Ceylon and the quantity received from Australia exceeded by over 50 percent that reported by Census as emanating from the unidentified country.

Exports.—The United Kingdom was the destination of 87 percent of the 128,612 pounds of cerium ores, metals, and alloys valued at $41,433 that were exported. Other countries receiving U.S. shipments were: France, nearly 9 percent; Japan, 3 percent; and Canada, a little over 1 percent. The value of shipments to Canada, however, was 20 percent of the total of the class sent abroad. Exported ferrocerium (lighter flints) totaled 40,100 pounds valued at $182,348. Seventeen countries received shipments of this material from the United States, with the United Kingdom receiving nearly 43 percent; Japan, 25 percent; Canada, 18 percent; and Australia, almost 9 percent.

WORLD REVIEW[4]

Australia.—Shipments for the first three quarters totaled about 1,750 short tons, 35 percent of which came from Western Australia.

Ceylon.—Bids by firms of the United States and the United Kingdom were made early in the year for the purchase of 336 short tons of 99-percent pure monazite concentrate which had been stockpiled by the Government of Ceylon. The material had been produced from mineral sands on the southwest coast of Ceylon and refined at a small separating plant near Nagoda.[5] After exporting the monazite concentrate, which was worth $26,114, about 170 tons of the material remained in the stockpile.

Finland.—Production of rare-earth oxides was started by Typpi Oy (Typpi Inc.) at a new plant at Oulu in northern Finland. The company expects to export most of its production which was planned to exceed 100 tons of oxides per year.[6]

TABLE 1.—World production of monazite concentrates by countries [1]

(Short tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
North America: United States (shipments)	[2] 1,364	770	(3)	(3)	(3)	(3)
South America: Brazil	828	1,222	1,153	[4] 930	3,858	1,874
Asia:						
Ceylon	90	94	370	239	----------	----------
India	[5] 4,122	(6)	(6)	(6)	(6)	(6)
Indonesia	[7] 67	(6)	(6)	111	153	(6)
Korea, Republic of [8]	524	65	11	854	(6)	(6)
Malaya (exports)	481	264	47	780	702	991
Thailand	[9] 28	(6)	(6)	(6)	(6)	----------
Africa:						
Congo, Republic of the	2	----------	----------	----------	----------	----------
Malagasy Republic	114	----------	471	503	702	[10] 756
Mozambique	(11)	----------	1	(11)	(11)	(6)
Nigeria	51	15	13	8	10	12
South Africa, Republic of	[4] 8,890	2,402	----------	----------	5,326	2,300
United Arab Republic (Egypt)	3	[4] 165	(6)	(6)	(6)	(6)
Oceania: Australia [12]	337	401	405	1,733	912	[4] 2,300

[1] Monazite is also produced in U.S.S.R., but no data are available.
[2] Average annual production 1957–58.
[3] Figure withheld to avoid disclosing individual company confidential data.
[4] Estimate.
[5] Data for the year 1958 only.
[6] Data not available.
[7] Average annual production 1954–55.
[8] Reported as concentrates containing 45–55 percent of rare-earth oxides; also reported as 30 percent cerium, which may be high.
[9] Average annual production 1956–58.
[10] Exports.
[11] Less than 0.5 ton.
[12] The data listed represent the total for high-grade, low-grade, and concentrate.

[4] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.
[5] Bureau of Mines. Mineral Trade Notes. V. 56, No. 6, June 1963, p. 27.
[6] Metal Bulletin (London). No. 4799, May 24, 1963, p. 20.

Malagasy Republic.—Production of monazite concentrate from the 4-year old plant at Antete was expected to be 50 percent greater than for the preceding year.[7] The plant is operated by Sotrassum (Société de Traitement des Sables du Sud de Madagascar), which is an affiliation of the French Atomic Energy Commissariat and Péchiney Compagnie de Produits Chimiques et Electrométallurgiques. Monazite reserves in the country were estimated at over 100,000 short tons.[8]

Rhodesia and Nyasaland, Federation of.—The Geological Survey Department reported that the Kangankunde Hill rare-earth deposits in the Kasupe area contain over 13,000 tons of recoverable monazite, which is equivalent to 9,000 tons of rare-earth oxides.[9]

Somali Republic.—Examination of beach sands west of Berbera showed monazite to be present in the heavy minerals. Before attempting to develop these deposits, the total reserve of economically recoverable monazite would have to be determined.[10]

South Africa, Republic of.—Although the estimated reserve of monazite was believed large enough for 2 or 3 more years of mine operation, the vein monazite operation at Steenkampskraal operated by Anglo American Corporation fulfilled its contract obligations with a large American chemical processor and was again closed down.[11]

TECHNOLOGY

Papers presented at the Third Rare-Earth Conference held in Clearwater, Fla., were concerned mostly with alloys and metals, particularly their magnetic and electrical properties, the structure and properties of rare-earth compounds, and certain phase relationships. The rising importance of laser technology received attention in discussions on rare-earth fluorescence phenomena, and data concerning the solar system and terrestrial abundances of the rare-earth elements and yttrium were summarized. The geochemical abundance information was published subsequently.[12]

In a conference held in Moscow in March 1963, new trends in the investigation and application of rare-earth elements were reported. Included in the reports presented were such topics as the recovery and refining of rare-earth metals, phase diagrams, investigation of electric, magnetic, and semiconductor properties, the study of crystal structures, and the use of rare-earth metals in the metallurgical industry. It was reported that certain types of stainless steel can be bettered and the rupture strength and creep resistance of a nickel-base alloy at 700° C improved by addition of rare-earth metals. The conference recommended the wider use of rare-earth elements in research and industry.[13]

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[7] Mining Journal (London). Mining in Madagascar. V. 261, No. 6693, Nov. 29, 1963, pp. 517–519.
[8] Murdock, Thomas G. Mineral Resources of the Malagasy Republic. BuMines Inf. Circ. 8196, 1963, 147 pp.
[9] Metal Bulletin (London). No. 4836, Oct. 8, 1963, p. 21.
[10] Mining Journal (London). V. 261, No. 6696, Dec. 20, 1963, p. 583.
[11] Bureau of Mines. Mineral Trade Notes. V. 58, No. 1, January 1964, pp. 28–29.
[12] Schmitt, R. A., R. H. Smith, J. E. Lasch, A. W. Mosen, D. A. Olehy, and J. Vasilevskis. Abundances of the Fourteen Rare-Earth Elements, Scandium, and Yttrium in Meteoritic and Terrestrial Matter. Geochim. et Cosmochim. Acta, v. 27, June 1963, pp. 577–622.
[13] Polyakov, L. (New Directions in Research and Applications of Rare-Earth Metals.) Atomnaya Energiya (Moscow, U.S.S.R.), v. 15, No. 1, 1963, pp. 84–86; abs. in Current Rev. of Soviet Tech. Press (U.S. Dept. of Commerce, OTS), Oct. 11, 1963.

Systematic rare-earth abundance patterns were made apparent by a new procedure for interpreting rare-earth abundances in rocks and minerals.[14] Using neutron activation to determine the rare-earth content, the abundance pattern of lanthanum, europium, and dysprosium in tektites was found to resemble that of granites more than that of oceanic basalts.[15] A study of the standard granite—G-1—and the standard diabase—W-1—indicated that the granite had 5 to 10 times as much lanthanum as the diabase. The diabase had an absolute rare-earth concentration similar to that of shales and sandstones.[16] Neutron activation and X-ray fluorescence techniques were used to analyze rare-earth elements in sea water, in a phosphorite, and in a manganese nodule. At depths of 4,000 meters, sea water showed four times the concentration of rare-earth elements as that contained in surface water.[17]

An unknown white mineral discovered in secondary quartzites in the Saryarka steppes of Kazakhstan was said to contain many rare-earth elements as well as thorium and other elements.[18] Malayan monazite, a byproduct of tin mining, was studied in detail as an initial step in evaluating its commercial possibilities as a source of rare-earth elements. Europium, rarely noted in measurable quantities in monazites, composed nearly 1 atomic percent of the total rare-earth content of one sample examined. Gadolinium and yttrium are enriched relatively in several of the other samples.[19]

Bureau of Mines research stressed the importance of collecting thermochemical data on the oxides of rare-earth elements, mostly of the heavy subgroup, and determining physical properties of other rare-earth oxides in an effort to provide improved refractory and ceramic materials. New amine chelating agents were employed in solvent extraction techniques, and radiotracer methods were used in studying sulfide inclusions and the distribution of rare-earth additives in steel.[20]

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[14] Coryell, Charles D., John W. Chase, and John W. Winchester. A Procedure for Geochemical Interpretation of Terrestrial Rare-Earth Abundance Patterns. J. Geophys. Res., v. 68, No. 2, Jan. 15, 1963, pp. 559–566.

[15] Chase, John W., Charles C. Schnetzler, Gerald K. Czamanske, and John W. Winchester. The Lanthanum, Europium, and Dysprosium Contents of Two Tektites. J. Geophys. Res., v. 68, No. 2, Jan. 15, 1963, pp. 577–579.

[16] Haskin, Larry, and Mary A. Gehl. The Rare-Earth Contents of Standard Rocks G-1 and W-1 and Their Comparison With Other Rare-Earth Distribution Patterns. J. Geophys. Res., v. 68, No. 7, Apr. 1, 1963, pp. 2037–2043.

[17] Goldberg, Edward D., Minoru Koide, R. A. Schmitt, and R. H. Smith. Rare-Earth Distributions in the Marine Environment. J. Geophys. Res., v. 68, No. 14, July 15, 1963, pp. 4209–4217.

[18] Mining Journal (London). V. 260, No. 6665, May 17, 1963, p. 477.

[19] Flinter, B. J., J. R. Butler, and G. M. Harral. A Study of Alluvial Monazite From Malaya. Am. Mineral., v. 48, Nos. 11 and 12, November–December 1963, pp. 1210–1226.

[20] Cochran, A. A., and V. R. Miller. Radiotracer Studies of Cerium and Sulfur Distribution in Steel. BuMines Rept. of Inv. 6256, 1963, 21 pp.

Pankratz, L. B., and K. K. Kelley. High-Temperature Heat Contents and Entropies of Sesquioxides of Lutetium, Dysprosium, and Cerium. BuMines Rept. of Inv. 6248, 1963, 8 pp.

Pankratz, L. B., and E. G. King. High-Temperature Heat Contents and Entropies of the Sesquioxides of Erbium, Holmium, Thulium, and Ytterbium. BuMines Rept. of Inv. 6175, 1963, 8 pp.

Rice, A. C. Chelating Agents in Separation of Rare-Earth Compounds by Solvent Extraction with Amines. BuMines Rept. of Inv. 6205, 1963, 16 pp.

Weller, W. W., and E. G. King. Low-Temperature Heat Capacities and Entropies at 298.15° K. of the Sesquioxides of Scandium and Cerium. BuMines Rept. of Inv. 6245, 1963, 6 pp.

Wilfong, Roy L., Louis P. Domingues, LeRoy R. Furlong, and Joseph A. Finlayson. Thermal Expansion of the Oxides of Yttrium, Cerium, Samarium, Europium, and Dysprosium. BuMines Rept. of Inv. 6180, 1963, 25 pp.

In a method devised for beneficiating monazite by froth flotation, sodium silicate is used as a conditioner and sodium or potassium permanganate is added to improve the flotability of the monazite.[21]

In a new solvent extraction process, heavy-metal ions are absorbed by a trialkyl phosphate complexing agent combined with alkenyl aromatic resin granules which are then separated from the original treated aqueous solution and washed with another aqueous solution to remove the rare-earth elements.[22]

Europium was separated from other rare-earth elements by adding a trivalent chromium salt and zinc amalgam to an aqueous hydrochloric acid or sulfuric acid feed solution containing the elements, flushing with nitrogen, contacting with an organic solution containing esters of phosphoric and phosphonic acids, and then separating this organic phase from the europium-bearing aqueous phase.[23] In another method, sodium or potassium sulfate is added to a solution containing a relatively minute quantity of europium and coprecipitating europous sulfate with part of the rare-earth alkali metal double sulfates, thereby obtaining a product enriched in europium.[24] An effective continuous extraction of samarium or ytterbium from aqueous solutions of rare-earth compounds was achieved by the formation of rare-earth amalgams in a packed column by contacting with sodium amalgam. The rare-earth amalgam was stripped quantitatively by treating with hot hydrochloric acid in a second column.[25]

In separating divalent salts of certain rare-earth metals from trivalent salts of rare-earth elements in solution, the trivalent rare-earth hydroxides are precipitated by using ammonia in excess in a nonoxidizing atmosphere, leaving the divalent salts in solution.[26] Two other methods used controlled heating of aqueous solutions of rare-earth chlorides, controlled cooling, and subsequent gravity separation of the resulting crystals enriched in the lighter and heavier rare-earth subgroups.[27]

In work performed in the United Kingdom, researchers stressed the synthesis of rare-earth-aluminum and rare-earth-gallium garnet crystals as well as the development of methods for making large single crystals of anhydrous rare-earth-chlorides and other rare-earth trihalides. This was necessary for the comprehensive study of the

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[21] Gaudin, A. M., H. R. Spedden, and J. H. Sullivan (assigned to Union Carbide Corp., New York). Flotation Process. Canadian Pat. 661,416, Apr. 16, 1963; Eng. and Min. J., v. 164, No. 10, October 1963, p. 112.

[22] Small, Hamish (assigned to the Dow Chemical Co., Midland, Mich.). Solvent Extraction Process for the Recovery of Uranium and Rare-Earth Metals From Aqueous Solutions. U.S. Pat. 3,102,782, Sept. 3, 1963.

[23] Peppard, Donald F., Earl P. Horwitz, and George W. Mason (assigned to the U.S. Atomic Energy Commission). Separation of Europium From Other Lanthanide Rare Earths by Solvent Extraction. U.S. Pat. 3,077,378, Feb. 12, 1963.

[24] Bril, Kazimierz Jozef, and Jose Behmoiras Madjar. Process for the Recovery of Europium From Low Grade Europium Mixtures With Other Rare Earths. U.S. Pat. 3,092,449, June 4, 1963.

[25] Barrett, M. F., and N. E. Topp. Extraction of Lanthanons With Alkali Metal Amalgams. II. A Counter-Current Process for the Extraction of Samarium or Ytterbium. J. Appl. Chem. (London), v. 13, No. 1, January 1963, pp. 7–12.

[26] Peltier, Maurice Leon, and Paul Antoine Rombau (assigned to Société de Produits Chimiques des Terres Rares, Paris, France). Process for Separating Samarium, Europium and Ytterbium From Other Rare Earths. U.S. Pat. 3, 102, 783, Sept. 3, 1963.

[27] Bronaugh, Hugh J., and Paul R. Kruesi (assigned to Vitro Corporation of America, New York). Concentration of Rare Earths. U.S. Pat. 3,089,795, May 14, 1963.

Kruesi, Paul R. (assigned to Vitro Corporation of America, New York). Concentration of Rare Earths. U.S. Pat. 3,089,758, May 14, 1963.

electrical and magnetic properties of rare-earth-bearing crystals and determining low-temperature specific heats for certain rare-earth-gallium garnets.[28] In a new technique for crystallizing anhydrous single crystals of rare-earth halides, it was found necessary to react rare-earth oxides with a greater excess of ammonium halide at longer heating periods than used in earlier methods.[29]

The vapor pressures of yttrium and rare-earth chlorides were determined, using the Knudsen molecular effusion method. The data gathered proved successful in establishing conditions for industrial production.[30]

Trivalent cerium was readily determined using the synergistic effect in solvent extraction of a mixture of 2-thenoyltrifluoroacetone (TTA) and tri-n-butyl phosphate (TBP), thereby achieving a separation a-thousandfold over either TTA or TBP alone.[31] Microgram quantities of quadrivalent cerium were determined by a spectrophotometric method using TTA in xylene as an extractant.[32]

Cerium metal was obtained from fused fluoride electrolytes, using either cerium trifluoride or cerium dioxide as feed. Use of the oxide, improved by a technique which assimilates the oxide into the system rapidly, permitted current efficiencies greater than 60 percent and almost perfect feed utilization. The method is readily adaptable to continuous withdrawal of the coalesced molten metal.[33] Molten cerium metal, obtained in the reduction of the chloride by a metal of a group consisting of sodium and barium, was separated from the solid reductor metal chloride.[34] Another method consisted of reducing a rare-earth oxide by an admixed carbonaceous reducing agent with several subsequent condensations of the rare-earth vapor, the second condensate being essentially pure rare-earth metal.[35]

Under a grant from a copper research association, it was discovered that the high-temperature oxidation rate of copper was reduced considerably by the addition of minor quantities of rare-earth elements which, however, were too small to affect the electrical conductivity of the copper.[36] An alloy of misch metal and from 8 to 20 percent copper was claimed to be an improved additive to certain metal baths.[37]

It was observed that there was a much larger difference between the melting points of the alloys of lanthanum, cerium, or praseo-

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[28] Bleaney, B. Properties of Rare Earth and Transition Group Ions. U.S. Air Force, Air Research and Development Command, Air Force Cambridge Research Center, Tech. Rept. AFCRL-63-192, April 1963, 206 pp; DDC, AD 411557.

[29] Kiess, Norman H. Preparation of Anhydrous Single Crystals of Rare-Earth Halides. NBS J. Res., v. 67A (Phys. and Chem.), No. 4, July-August 1963, pp. 343-345.

[30] Moriarty, John L. Vapor Pressures of Yttrium and Rare Earth Chlorides Above Their Melting Points. J. Chem. and Eng. Data, v. 8, No. 3, July 1963, p. 422.

[31] Awwal, M. A. Radiochemical Determination of Cerium by Solvent Extraction Method. Anal. Chem., v. 35, No. 13, December 1963, pp. 2048-2050.

[32] Onishi, Hiroshi, and Charles V. Banks. Spectrophotometric Determination of Cerium With Thenoyltrifluoroacetone. Anal. Chem., v. 35, No. 12, November 1963, pp. 1887-1889.

[33] Porter, John A., and LeVerne P. Fernandez. Electrowinning Cerium Metal. U.S. Dept. of Commerce, OTS, DP-802, May 1963, 24 pp.

[34] Domning, William E. (assigned to The Dow Chemical Co., Midland, Mich.). Production and Separation of Molten Cerium From Its Reducing Metal Chloride Which Is in Solid Form. U.S. Pat. 3,104,166, Sept. 17, 1963.

[35] Downing, James H., and Henry L. Gorski (assigned to Union Carbide Corp., New York. Production of Rare Earth Metals. U.S. Pat. 3,104,970, Sept. 24, 1963.

[36] Chemical Engineering. V. 70, No. 23, Nov. 11, 1963, p. 117.
Metalworking News. V. 4, Whole No. 170, Nov. 25, 1963, p. 10.

[37] Knapp, William E., and Wilbur T. Bolkcom (assigned to American Metallurgical Products Co., Pittsburgh, Pa.). Method of Alloying. U.S. Pat. 3,072,476, Jan. 8, 1963.

dymium with ruthenium than is usual with other intermetallic compounds which contain these rare-earth metals. The increase in melting points was more than twice that noted for similar compounds not using ruthenium.[38]

In fluorescent emission research it was discovered that the dominant factor controlling emission intensity of trivalent terbium and europium in tungstates is the coupling of the rare-earth ion to the host structure, whereas the dominant factors for this phenomenon in all the molybdates are the contributions of the lattice processes.[39] In phosphor research, rare-earth elements incorporated into certain oxygen-dominated host lattices were reported to form a new class of efficient luminescent materials. Emitting red light when excited in the ultraviolet, they consist of tungstates and molybdates with additions of one or more of the rare-earth elements, europium, gadolinium, lanthanum, or yttrium.[40]

Orange radiation from an optically clear crystal of lanthanum trifluoride activated by praseodymium ions was said to be more readily detectable by photosurfaces than the more common red-ruby radiation. Of particular interest in applications where radiation is detected photoelectrically or photographically, these improvements in laser capabilities were due to the higher content of rare-earth impurity dissolvable in a rare-earth fluoride host.[41] A liquid laser in the research stage was composed of an organic chelate solution, containing europium, which emits a wavelength of 6129 angstroms at temperatures below −130° C. This was claimed to be the shortest wavelength thus far reported for lasing in the visible spectrum. Development of a clear plastic fiber containing europium chelates was announced. When the plastic was exposed to intense flashes of ultraviolet light at low temperatures, energy was transmitted to the europium atoms which in turn emitted bright flashes of red light. This led to powerful pulses of coherent light bursting from the ends of the fibers.[42] Another laser material is a sodium calcium silicate glass which was doped with 4.7 percent neodymium oxide.[43] Europium orthosilicate (Eu_2SiO_4), a powerful rotator of the plane of polarization of light, was expected to be of importance in laser systems. It is highly transparent to red and yellow light, ferromagnetic at low temperatures, and chemically stable and easy to handle.[44] A glass, containing 0.3 to 2 mole-percent cerous oxide, which scintillates when exposed to neutrons and gamma rays was developed.[45] Amorphous laser materials, such as glass or plastic doped with rare-earth elements, are easier and less costly to make than single crystals.

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[38] Reiswig, Robert D., and Karl A. Gschneider, Jr. Melting Points of $LaRu_2$ $CeRu_2$, and $PrRu_2$. J. Less-Common Metals (Amsterdam, Netherlands), v. 5, No. 5, October 1963, pp. 432–433.

[39] Van Uitert, L. G. A Comparison of the Intensities of Emission of Eu^{3+} and Tb^{3+} in Tungstates and Molybdates. J. Electrochem. Soc., v. 110, No. 1, January 1963, pp. 46–51.

[40] Borchardt, Hans J. Rare-Earth Phosphors. J. Chem. Phys. (Lancaster, Pa.), v. 38, No. 5, Mar. 1, 1963, p. 1251.

[41] Electronic News. V. 8, Whole No. 401, Oct. 28, 1963, p. 52.

[42] Chemistry. New Lasers Use Europium. V. 36, No. 7, March 1963, pp. 17–21.

[43] American Metal Market. V. 70, No. 214, Nov. 6, 1963, p. 11.

[44] Electronic Design. V. 11, No. 23, Nov. 8, 1963, p. 33.

[45] Ginther, Robert Joseph. Radiation Sensitive Glass. U.S. Pat. 3,097,172, July 9, 1963.

Salt

By William H. Kerns [1]

SALT production continued to increase in 1963 with a 6 percent gain, following the record 12-percent production increase of 1962. Total domestic output in 1963 was 31 million tons valued at $185 million, compared with 29 million tons valued at $175 million in 1962.

TABLE 1.—Salient salt statistics [1]

(Thousand short tons and thousand dollars)

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Sold or used by producers	22,669	25,160	25,479	25,707	28,807	30,644
Value [2]	$131,117	$155,839	$161,214	$160,223	$174,841	$184,635
Imports for consumption	395	1,025	1,057	1,050	1,374	1,371
Value	$2,257	$5,438	$4,484	$3,755	$5,097	$5,074
Exports	376	424	420	642	[3] 671	781
Value	$2,687	$2,660	$2,548	$3,876	[3] $3,638	$4,140
Consumption, apparent	22,688	25,761	[3] 26,116	26,115	[3] 29,510	31,234
World: Production	74,900	87,900	93,600	93,400	100,700	104,900

[1] 1954–61 includes Puerto Rico.
[2] Values are f.o.b. mine or refinery and do not include cost of cooperage or containers.
[3] Revised figure.

DOMESTIC PRODUCTION

Louisiana was the leading salt-producing State with 20 percent of the total output; Texas was second with 19 percent; and New York was third with 16 percent. Michigan and Ohio each produced about 14 percent of the total and California 6 percent. These 6 States supplied 89 percent of the total U.S. output. The remaining 11 percent was produced in 12 other States.

Salt was produced at 95 plants by 58 companies. Six companies, operating 25 plants, produced 61 percent of the total production, and 5 other companies with 14 plants provided 23 percent. The remaining plants supplied 16 percent of the output.

Over 1 million tons of salt was produced at each of 7 plants; 12 plants reported production between 500,000 and 1 million tons, 34 plants produced 100,000 to 500,000 tons each, and 23 plants produced 10,000 to 100,000 tons each. The 19 remaining plants each produced less than 10,000 tons.

[1] Commodity specialist, Division of Minerals.

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Two new salt distribution facilities were completed at Port Newark, N.J., by Morton Salt Co. and Diamond Crystal Salt Co.[2] Each facility was equipped to handle and store large shipments of salt—not only northern rock salt but southern salt from Louisiana and solar salt from the Bahamas. The new facilities included the drying, crushing, screening, and bagging operations needed to meet customer requirements.

TABLE 2.—Salt sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1962		1963	
	Quantity	Value	Quantity	Value
California	1,643	(1)	1,716	(1)
Kansas [2]	944	$11,654	924	$11,993
Louisiana	5,248	27,407	6,199	30,450
Michigan	4,274	33,343	4,244	33,656
New Mexico	43	334	57	518
New York	4,456	32,236	4,782	34,228
Ohio	4,187	28,706	4,245	29,682
Oklahoma	5	25	4	26
Texas	5,553	19,485	5,965	22,355
Utah	311	3,349	325	3,462
West Virginia	1,042	4,635	(1)	(1)
Other States [3]	1,101	13,667	2,183	18,265
Total	28,807	174,841	30,644	184,635
Puerto Rico	------------	------------	8	131

1 Included with "Other States" to avoid disclosing individual company confidential data.
2 Quantity and value of brine included with "Other States."
3 Includes States indicated by footnote 1, and Alabama, Colorado, Hawaii, Kansas (brine only), Nevada, North Dakota, and Virginia.

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	1962		1963	
	Quantity	Value	Quantity	Value
Evaporated:				
Bulk:				
Open pans or grainers	316	$8,434	309	$8,168
Vacuum pans	2,305	49,667	2,334	50,802
Solar	1,656	8,940	1,766	10,136
Pressed blocks	366	8,034	365	7,960
Total	4,643	75,075	4,774	77,066
Rock:				
Bulk	7,665	45,298	8,285	50,059
Pressed blocks	61	1,576	60	1,589
Total	7,726	46,874	8,345	51,648
Salt in brine (sold or used as such)	16,438	52,892	17,525	55,921
Grand total	28,807	174,841	30,644	184,635

2 Chemical Week. Boosting Bulk Sales of Salt. V. 93, No. 17, Oct. 26, 1963, pp. 111–112, 114, 118, 120.

TABLE 4.—Evaporated salt sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1962		1963	
	Quantity	Value	Quantity	Value
Kansas	432	$9,446	435	$9,669
Louisiana	246	6,298	250	5,987
Michigan	904	18,274	926	18,724
New Mexico	(1)	(1)	3	64
New York	(1)	(1)	593	13,794
Oklahoma	1	15	2	20
Utah	(1)	(1)	315	3,390
Other [2]	3,060	41,042	2,250	25,418
Total	4,643	75,075	4,774	77,066
Puerto Rico			8	131

[1] Included with "Other" to avoid disclosing individual company confidential data.
[2] Includes States indicated by footnote 1, and California, Hawaii, Nevada, North Dakota, Ohio, Texas and West Virginia.

TABLE 5.—Rock salt sold by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1954–58 (average)	5,298	$33,970	1961	6,439	$42,950
1959	6,160	41,119	1962	7,726	46,874
1960	6,466	44,983	1963	8,345	51,648

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
1954–58 (average)	282	$5,489	55	$1,148	337	$6,637
1959	288	6,763	55	1,406	343	8,169
1960	330	7,575	60	1,526	390	9,101
1961	357	7,866	63	1,661	420	9,527
1962	366	8,034	61	1,576	427	9,610
1963	365	7,960	60	1,589	425	9,549

CONSUMPTION AND USES

Nearly 12 million tons, or 39 percent, of the total salt output was used in making chlorine and its coproduct, caustic soda. This was 1.1 million tons more than in 1962. Tonnage used in manufacturing sodium carbonate (soda ash), the second largest use of salt, continued to rise slightly for the second consecutive year, and accounted for 21 percent of the total output. Manufacture of chemicals, including chlorine and caustic and soda ash, required over 20 million tons, or two-thirds of the total domestic salt production.

The third largest use of salt, 13 percent of the total output, was for highway snow and ice removal and for road stabilization. Table 7 shows this use as "States, counties, and other political subdivisions (except Federal)."

TABLE 7.—Salt sold or used by producers in the United States, by classes and consumers or uses

(Thousand short tons)

Consumer or use	1962				1963			
	Evaporated	Rock	Brine	Total	Evaporated	Rock	Brine	Total
Chlorine	(1)	(1)	9,163	10,860	(1)	(1)	10,121	11,985
Soda ash	--------	(1)	(1)	6,480	(1)	(1)	6,508	6,513
Soap (including detergents)	(1)	8	(1)	133	(1)	(1)	--------	35
All other chemicals	233	656	511	1,400	(1)	(1)	733	1,418
Textile and dyeing	92	123	--------	215	141	119	--------	260
Meatpackers, tanners, and casing manufacturers	338	414	--------	752	333	414	--------	747
Fishing	(1)	(1)	--------	24	(1)	(1)	--------	26
Dairy	66	8	--------	74	59	4	--------	63
Canning	193	54	--------	247	185	54	--------	239
Baking	(1)	(1)	--------	116	(1)	(1)	--------	115
Flour processors (including cereal)	(1)	(1)	--------	54	60	8	--------	68
Other food processing	97	13	--------	110	120	18	--------	138
Ice manufacturers and cold-storage companies	20	29	--------	49	16	22	--------	38
Feed dealers	626	411	--------	1,037	615	415	--------	1,030
Feed mixers	271	107	--------	378	273	110	--------	383
Metals	57	63	--------	120	51	77	--------	128
Ceramics (including glass)	11	9	--------	20	7	8	--------	15
Rubber	8	26	80	114	12	28	67	107
Oil	45	65	42	152	(1)	72	(1)	169
Paper and pulp	11	101	--------	112	(1)	123	(1)	135
Water-softener manufacturers and service companies	209	(1)	(1)	442	(1)	293	(1)	507
Grocery stores	561	259	--------	820	576	286	--------	862
Railroads	12	42	--------	54	14	37	--------	51
Bus and transit companies	(1)	(1)	--------	74	(1)	(1)	--------	33
States, counties, and other political subdivisions (except Federal)	(1)	3,060	(1)	3,241	(1)	3,707	(1)	3,909
U.S. Government	22	118	--------	140	19	55	--------	74
Miscellaneous	1,048	(1)	(1)	1,589	1,126	419	51	1,596
Undistributed [2]	723	2,160	6,642	--------	1,167	2,076	45	--------
Total	4,643	7,726	16,438	28,807	4,774	8,345	17,525	30,644

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Includes items indicated by footnote 1 and some exports and consumption in Territories oversea areas administered by the United States.

TABLE 8.—Distribution (shipments) of evaporated and rock salt produced in the United States, by destination

(Thousand short tons)

Destination	1962		1963	
	Evaporated	Rock	Evaporated	Rock
Alabama	28	242	27	254
Alaska	3		4	
Arizona	17	11	22	19
Arkansas	15	61	13	64
California	742	45	725	65
Colorado	86	23	78	25
Connecticut	14	36	15	90
Delaware	7	10	7	17
District of Columbia	5	15	5	12
Florida	22	81	23	85
Georgia	42	73	45	79
Hawaii	4		4	
Idaho	30	2	29	2
Illinois	241	514	243	569
Indiana	134	264	133	278
Iowa	139	175	139	199
Kansas	66	178	76	171
Kentucky	41	197	37	206
Louisiana	30	156	29	177
Maine	10	147	21	134
Maryland	42	152	42	173
Massachusetts	43	241	47	256
Michigan	202	401	204	337
Minnesota	128	136	133	120
Mississippi	18	69	18	78
Missouri	81	170	82	166
Montana	32	1	33	1
Nebraska	78	83	80	71
Nevada	23	158	21	157
New Hampshire	5	157	5	136
New Jersey	143	287	146	336
New Mexico	11	49	12	45
New York	229	1,382	220	1,500
North Carolina	95	125	98	123
North Dakota	26	4	30	4
Ohio	246	596	257	681
Oklahoma	28	49	28	49
Oregon	54		46	
Pennsylvania	161	402	165	507
Rhode Island	9	23	9	30
South Carolina	25	25	28	21
South Dakota	33	21	35	24
Tennessee	113	182	119	241
Texas	92	244	97	260
Utah	58	(1)	73	5
Vermont	6	81	6	84
Virginia	74	111	74	115
Washington	175		167	
West Virginia	24	59	25	70
Wisconsin	132	221	134	189
Wyoming	15	2	16	2
Other [2]	566	65	649	118
Total	4,643	7,726	4,774	8,345

[1] Included with "Other" to avoid disclosing individual company confidential data.
[2] Includes item indicated by footnote 1, and shipments to Territories, overseas areas administered by the United States, and Puerto Rico, exports, and some shipments to unspecified destinations.

PRICES

Quotations for salt by Oil, Paint and Drug Reporter in 1963 were the same as in 1958–62. Quoted prices and value data follow:

Quoted prices:
- Rock salt, paper bags, carlots, f.o.b. New York ---- per 100 pounds -- $1.09
- Salt, vacuum, common fine, carlots, f.o.b. New York ---------- do ---- 1.34

Average value, bulk salt:
Evaporated, vacuum, grainer, and pressed blocks............per ton..$22.15
Solar-evaporated..do.... 5.74
Rock..do.... 6.19
Salt in brine (sold or used as such).............per ton contained salt.. 3.19

A basic price for rock salt was $8.40 per ton f.o.b. mine. Transportation from Louisiana to eastern markets was $18 per ton by rail and $12 by sea train. Bulk shipments of salt by water made possible the delivery of southern salt to eastern markets at $10.75 per hundred pounds in 5-ton lots.

FOREIGN TRADE

As shown in table 10, imports of salt were 2,776 tons below the record high of 1,374,219 tons reported in 1962. About 47 percent of the imports came from Canada, 26 percent from Mexico, 16 percent from the Bahamas, and 9 percent from Spain. Imports were nearly 5 percent of the U.S. salt production.

Exports of salt were 16 percent above the record high of 670,532 tons reported in 1962, as reported in table 13. Japan, receiving 72 percent, and Canada, receiving 19 percent, continued to be the leading importers. Less than 3 percent of the U.S. production was exported.

A new tariff law referred to as the Tariff Classification Act became effective on August 31. Duties on salt remained unchanged, as follows:

Tariff Classification Act Number	Type of salt	Duty
420.92	In brine	10 percent ad valorem.
420.94	In bulk	$0.017 per 100 pounds.
420.96	Other (packaged)	$0.035 per 100 pounds.

The new act requires that salt in brine must be reported in short tons of anhydrous salt content. Bulk salt must also be reported in short tons, but other salt must be reported in pounds. Previously all imported salt was reported in pounds.

TABLE 9.—Salt shipped to the Commonwealth of Puerto Rico and oversea areas administered by the United States

Area	1962		1963	
	Short tons	Value	Short tons	Value
American Samoa	161	$5,745	197	$7,282
Guam	104	8,695	116	9,934
Puerto Rico	10,984	795,607	9,543	845,390
Virgin Islands	98	12,652	165	18,324
Wake Island	(1)	13		

[1] Less than 1 ton.
Source: Bureau of the Census.

TABLE 10.—U.S. imports for consumption of salt, by countries

Country	1962		1963	
	Short tons	Value	Short tons	Value
North America:				
Bahamas	203,041	$784,217	212,629	$843,058
Canada	677,880	3,557,593	645,118	3,344,373
Dominican Republic	29,269	87,760		
Jamaica	11,359	30,426	10,202	25,507
Mexico	407,273	511,317	353,280	491,830
Total	1,328,822	4,971,313	1,221,229	4,704,768
Europe:				
Spain	45,397	125,695	116,131	296,054
United Kingdom	(1)	251	(1)	187
Total	45,397	125,946	116,131	296,241
Asia: Japan	(1)	127		
Africa:				
Tunisia			26,372	55,030
United Arab Republic (Egypt)			7,711	18,244
Total			34,083	73,274
Grand total	1,374,219	5,097,386	1,371,443	5,074,283

[1] Less than 1 ton.
Source: Bureau of the Census.

TABLE 11.—U.S. imports for consumption of salt, by classes

Year	In bags, sacks, barrels, or other packages (dutiable)		Bulk (dutiable)	
	Short tons	Value	Short tons	Value
1954–58 (average)	22,535	$295,289	372,770	$1,961,584
1959	37,726	531,151	986,903	4,906,490
1960	17,693	267,634	1,039,335	4,216,080
1961	9,259	144,210	1,040,825	3,610,434
1962	15,234	253,963	1,358,985	4,843,423
1963	10,166	158,482	1,361,277	4,915,801

Source: Bureau of the Census.

TABLE 12.—U.S. imports for consumption of salt, by customs districts

Customs district	1962		1963	
	Short tons	Value	Short tons	Value
Buffalo	37,096	$200,389	20,488	$112,084
Chicago	38,088	155,672	76,396	345,723
Connecticut	33,329	196,138	41,446	237,034
Dakota	------	------	7	230
Duluth and Superior	45,460	236,683	30,691	161,033
Georgia	148,222	568,745	130,512	523,011
Hawaii	40	1,316	------	------
Los Angeles	36,477	46,600	48,513	72,770
Maine and New Hampshire	38,755	226,578	91,009	380,324
Maryland	------	------	17,554	36,630
Massachusetts	48,925	155,165	121,921	375,133
Michigan	353,155	1,812,364	299,360	1,482,156
New York	29,269	87,760	6,083	24,332
Ohio	61,458	335,513	80,815	400,522
Oregon	80,405	100,502	54,315	67,900
Puerto Rico	6,073	30,365	11,889	59,445
Rochester	10,000	51,430	------	------
San Diego	25	265	64	1,077
Vermont	5,135	31,486	10,737	49,916
Virginia	48,746	185,107	31,727	118,025
Washington	290,366	363,950	251,211	357,306
Wisconsin	63,195	311,358	46,705	269,632
Total	1,374,219	5,097,386	1,371,443	5,074,283

Source: Bureau of the Census.

TABLE 13.—U.S. exports of salt by countries

Destination	1962		1963	
	Short tons	Value	Short tons	Value
North America:				
Bermuda	105	$2,466	51	$1,620
Canada	119,855	921,458	151,756	1,057,269
Central America:				
British Honduras	20	818	45	1,404
Canal Zone	102	1,212	------	------
Costa Rica	280	8,213	191	5,005
El Salvador	75	1,957	117	3,098
Guatemala	612	7,747	426	9,913
Honduras	188	5,740	267	6,736
Nicaragua	600	14,211	415	9,812
Panama	181	4,552	672	9,597
Mexico	7,765	159,877	3,632	98,244
West Indies:				
Bahamas	192	15,665	9,143	54,088
Dominican Republic	488	3,622	713	6,594
Haiti	105	7,298	45	3,698
Jamaica	110	2,857	1,142	9,399
Netherlands Antilles	798	42,330	562	37,330
Other	71	756	28	676
Total	131,547	1,200,779	169,205	1,314,483
South America:				
Argentina	78	2,640	788	6,299
Chile	1,019	9,968	868	21,309
Ecuador	369	9,667	190	5,152
Peru	328	4,670	446	7,058
Venezuela	3,180	23,357	5,451	29,132
Other	253	2,838	343	2,285
Total	5,227	53,140	8,086	71,235

TABLE 13.—U.S. exports of salt by countries—Continued

Destination	1962		1963	
	Short tons	Value	Short tons	Value
Europe:				
France	361	$5, 636	214	$1, 466
Germany, West	1, 005	10, 238	1, 626	9, 430
Greece	870	5, 644	3, 123	16, 418
Italy	1, 996	17, 131	1, 295	13, 350
Netherlands	2, 052	18, 480	1, 897	16, 189
Spain	1, 844	13, 200	1, 982	19, 800
United Kingdom	2, 226	17, 283	1, 197	9, 543
Other	473	4, 312	402	4, 634
Total	10, 827	91, 924	11, 736	90, 830
Asia:				
Cambodia	128	3, 080	2, 296	10, 295
Hong Kong	349	3, 251	650	5, 527
Japan	[1] 506, 473	[1] 2, 147, 751	563, 255	2, 394, 836
Lebanon	157	6, 326		
Philippines	972	8, 639	910	15, 395
Saudi Arabia	496	14, 101	4, 498	42, 946
Other	1, 100	16, 384	498	14, 060
Total	[1] 509, 675	[1] 2, 199, 532	572, 107	2, 483, 059
Africa:				
Angola	585	2, 340	644	2, 574
Congo, Republic of the, and Ruanda-Urundi	820	7, 468	5, 681	27, 427
Nigeria	790	4, 246	136	5, 441
South Africa, Republic of	3, 406	16, 287	3, 437	14, 935
Western Africa, n.e.c			1, 840	88, 517
Other	418	2, 286	733	4, 913
Total	6, 019	32, 627	12, 471	143, 807
Oceania:				
Australia	3, 943	39, 733	6, 666	26, 665
New Zealand	3, 214	12, 854	140	561
Other	80	7, 604	724	9, 384
Total	7, 237	60, 191	7, 530	36, 610
Grand total	[1] 670, 532	[1] 3, 638, 193	781, 135	4, 140, 024

[1] Revised figure.

Source: Bureau of the Census.

WORLD REVIEW

World production of salt continued to increase, totaling 105 million tons in 1963. About 29 percent of the world output was produced in the United States.

Canada.—A $2 million salt-refining plant was completed at Pugwash, Nova Scotia, finishing a $7 million salt-producing complex, which also includes a mine, a warehousing office, and docking facilities.[3] The new plant was reportedly highly automated and able to use the fine salt resulting from crushing and screening operations. The efficiency of the plant was improved greatly by utilizing the fines as feed for the refining plant.

Ecuador.—After 42 years the Government monopoly ended on April 23. The action by the Government was favorably viewed by the public because of the lower prices and by salt producers because of the increased returns resulting from the abolishment of the salt tax.

[3] Canadian Mining Journal (Gardenvole, Quebec). New Pugwash Salt Utilizes Mine Fines. V. 84, No. 12, December 1963, pp. 52-53.

Two of the larger salt companies were planning modernization programs. A rock salt mining company on the Galapagos Islands was reported to have ordered salt refining and iodizing equipment in the United States. A solar salt plant designed by a consulting firm in the United States was also planned at San Pablo.

TABLE 14.—World production of salt by countries [1] [2]

(Thousand short tons)

Country [1]	1954-58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	1,590	3,317	3,311	3,304	3,665	3,701
Costa Rica	20	14	[3] 14	[3] 13	[3] 10	7
El Salvador	44	14	15	17	20	[3] 20
Guatemala	17	18	17	18	19	[3] 19
Honduras	[3] 12	[3] 11	[3] 11	17	11	[3] 11
Mexico	274	573	1,096	1,172	1,424	[3] 1,350
Nicaragua	12	12	12	13	10	[3] 18
Panama	9	9	8	9	11	[3] 11
United States (including Puerto Rico):						
Rock salt	5,298	6,160	6,466	6,439	7,726	8,345
Other salt	17,373	19,003	19,015	19,268	21,081	22,307
West Indies:						
British:						
Bahamas	133	233	231	230	222	283
Leeward Islands (exports)	3	2	(4)	1	1	(4)
Turks and Caicos Islands	14	35	28	33	21	19
Cuba	68	89	65	[3] 66	[3] 77	[3] 88
Dominican Republic:						
Rock salt	40	71	73	84	[3] 55 (rock and other salt combined)	[3] 55
Other salt	14	22	22	22		
Haiti	28	11	[3] 11	[3] 11	[3] 11	[3] 11
Netherlands Antilles	[3] 2	(4)	(4)	(4)	(4)	(4)
Total	24,951	29,594	30,395	30,717	34,364	36,245
South America:						
Argentina:						
Rock salt	2	(4)	1	2	2	[3] 660 (rock and other salt combined)
Other salt	483	572	628	459	543	
Brazil	839	941	1,017	980	1,370	[3] 1,370
Chile	44	39	47	51	56	53
Colombia:						
Rock salt	214	235	259	294	293	290
Other salt	61	63	75	77	43	37
Ecuador	35	24	33	35	[3] 35	[3] 35
Peru	109	116	117	96	104	96
Venezuela	78	90	65	147	160	[3] 66
Total [1] [3]	1,880	2,100	2,260	2,160	2,625	2,620
Europe:						
Austria:						
Rock salt	1	1	2	3	6	6
Other salt	284	262	335	280	313	376
Bulgaria	79	98	96	139	164	116
Czechoslovakia	164	177	185	207	201	[3] 201
France:						
Rock salt and salt from springs	3,004	2,971	3,306	3,260	3,285	3,223
Other salt	693	850	799	979	1,397	[3] 1,320
Germany:						
East	1,818	1,858	1,968	2,204	[3] 2,200	[3] 2,200
West (marketable):						
Rock salt	3,449	4,377	4,806	4,791	5,027	5,761
Brine salt	359	363	374	376	381	399
Greece	95	108	107	131	127	[3] 94
Italy:						
Rock salt and brine salt	1,135	1,412	1,744	1,744	1,904	[3] 1,900
Other salt	916	780	1,123	1,340	[3] 1,320	[3] 1,320
Malta	2	1	1	2	2	[3] 2
Netherlands	713	1,087	1,208	1,228	1,391	1,630
Poland:						
Rock salt	425	560	574	670	670	711
Other salt	1,027	1,455	1,571	1,591	1,616	1,638
Portugal	301	236	236	294	347	[3] 347
Rumania	765	926	1,152	1,466	1,630	[3] 1,630

See footnotes at end of table.

TABLE 14.—World production of salt by countries [1] [2]—Continued

(Thousand short tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
Europe—Continued						
Spain:						
Rock salt	525	616	592	677	690	[3] 1,760
Other salt [5]	883	873	941	1,086	1,118	
Switzerland	136	151	164	173	185	204
U.S.S.R. [3]	7,200	7,200	7,400	8,300	9,400	9,650
United Kingdom:						
Rock salt	94	160	168	320	535	842
Other salt	5,333	5,956	6,371	6,031	6,164	6,317
Yugoslavia	163	150	166	177	237	184
Total [1] [3]	29,600	32,660	35,420	37,500	40,340	41,860
Asia:						
Aden	244	196	143	94	86	89
Afghanistan:						
Rock salt	42	29	29	25	[3] 24	23
Other salt		[3] 44	[3] 55	73	[3] 72	13
Burma	111	123	163	138	165	177
Cambodia	54	55	41	60	[3] 60	[3] 60
Ceylon	66	36	62	39	51	25
China [3]	8,100	12,200	14,200	12,100	11,000	11,600
Cyprus	4	6	----------	2	7	[3] 7
Goa	11	4	8	[3] 8	11	[3] 11
India:						
Rock salt	4	4	4	4	6	5,000
Other salt	3,707	3,499	3,782	3,833	4,278	
Indonesia	191	347	218	491	335	[3] 335
Iran [6]	271	88	143	160	160	[3] 160
Iraq [7]	26	41	40	42	42	43
Israel	32	37	41	49	42	[3] 42
Japan	774	1,285	977	913	944	862
Jordan	11	18	13	21	21	20
Korea:						
North	243	[3] 485	357	432	464	[3] 500
Republic of	338	430	440	134	428	260
Lebanon	15	14	13	19	[3] 18	21
Mongolia	[3] 4	[3] 6	7	[3] 8	[3] 9	[3] 9
Pakistan:						
Rock salt	175	176	203	222	223	267
Other salt	271	147	278	207	283	[3] 220
Philippines	99	193	105	103	106	77
Ryukyu Islands	4	3	3	4	4	[3] 4
Syrian Arab Republic	24	9	11	8	20	[3] 20
Taiwan	441	474	499	476	656	690
Thailand	340	506	369	276	165	220
Turkey:						
Rock salt	29	28	34	33	31	33
Other salt	473	503	456	262	444	406
Viet-Nam:						
North	[3] 110	143	129	117	159	[3] 165
South	85	172	159	110	213	[3] 213
Yemen	72	110	110	132	165	[3] 110
Total [3]	16,370	21,410	23,090	20,595	20,690	21,680
Africa:						
Algeria	125	144	[3] 158	144	[3] 144	143
Angola	69	76	64	74	66	76
Cape Verde Islands	21	22	26	26	30	[3] 30
Chad, Republic of (Natron) [3]	4	3	7	13	28	28
Congo, Republic of the (formerly Belgian)	1	1	1	1	1	[3] 1
Ethiopia (including Eritrea)	194	155	173	166	191	[3] 281
French Somaliland	19	----------	----------	----------	----------	----------
Ghana	[3] 24	[3] 24	13	20	21	----------
Kenya	24	22	24	25	21	18
Libya	17	17	14	13	17	21
Malagasy	20	[3] 19	[3] 19	[3] 19	[3] 19	[3] 19
Mauritius	4	4	4	4	4	4
Morrocco	60	37	33	23	31	41
Mozambique	18	21	32	[3] 32	[3] 32	[3] 32
Senegal, Republic of (including Mauritania)	71	77	55	49	53	[3] 53
Somali Republic	4	4	[3] 8	2	[3] 2	2
South Africa, Republic of	183	261	279	229	281	218

See footnotes at end of table.

TABLE 14.—World production of salt by countries[1][2]—Continued

(Thousand short tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
Africa—Continued						
South-West Africa:						
Rock salt	7	6	4	4	4	6
Other salt	68	50	76	56	78	66
Sudan	60	60	60	58	76	41
Tanganyika	30	41	39	36	33	37
Tunisia	166	101	183	272	320	331
Uganda	10	10	6	8	3	[3] 3
United Arab Republic (Egypt)	485	422	575	570	617	432
Total	1,684	1,577	1,853	1,844	2,072	1,883
Oceania:						
Australia	451	524	519	570	600	[3] 600
New Zealand	10	23	19	6	10	12
Total	461	547	538	576	610	[3] 612
World total (estimate) [1][2]	74,900	87,900	93,600	93,400	100,700	104,900

[1] Salt is produced in Albania and Bolivia, but figures of production are not available. Estimates for these countries are included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Less than 500 tons.
[5] Includes an average annual production in the Canary Islands of 16,500 short tons of sea-salt.
[6] Year ended March 20 of year following that stated.
[7] Year ended March 31 of year stated.

Ireland.—A 1,500-foot seam of rock salt was discovered under 400 feet of overburden between Carrickfergus and Larne. Salt was mined at Carrickfergus intermittently for many years, but the large size of the deposit was unknown until a borehole sunk at Larne struck what was believed to be a continuation of the Carrickfergus seam.[4]

Mexico.—A contract to provide salt evaporators for the proposed salt factory near Monterrey was let to a U.S. firm which was successful in developing the technique of evaporating fluids by submerged combustion.[5] It was reported that the design of the new plant would be based on this technique.

TECHNOLOGY

Solution-mining techniques for recovering salt as brine from deposits of solid salt continued to be improved.[6] Hydraulic-fracturing techniques developed by the oil producers to increase output were adapted to solution mining of salt. Formerly salt brine was produced from single wells by drilling into the salt formation and putting down a double string of pipe—one inside the other. Fresh water was introduced through one string and saturated brine was removed from the other. In time, adjacent cavities dissolved in the salt formation became connected, and when this occurred, it was more efficient to pump water into one well and remove brine from the other.

[4] Chemical Week. New Look at Irish Salt. V. 93, No. 13, Sept. 28, 1963, p. 60.
[5] Mining World. V. 25, No. 10, September 1963, pp. 56, 58.
[6] Enyedy, G. Improved Hydraulic Fracturing Method Helps Speed Solution Mining of Salt. Eng. and Min. J., v. 164, No. 10, October 1963, pp. 75–79, 87.

To speed the formation of channels between wells the gallery system of brine field development was evolved. A series of wells drilled to the base of a salt formation are caused to interconnect by injecting water under high pressure into one of the wells and continuing to pump water into the well until a fracture occurs to a nearby well. After the fracture, indicated by a pressure increase in the opposing well, high-pressure pumping is continued until the channel becomes large enough for a flow of about 300 gallons per minute, which is considered a satisfactory production rate. Sometimes, several weeks or months are required for completion of the "wash in" phase, which is denoted by a sudden drop in pumping pressure. However, before hydraulic fracturing became common, several years was sometimes required to achieve maximum production.

Pressures and volumes needed in the fracturing and development stages depend on many factors, including distance between the opposing wells, the permeability of the bed, and depth of the well. In one test series, for wells about 500 feet apart, peak fracturing pressures ranged from 1,600 to 4,200 pounds per square inch. Pumping pressures needed to maintain the fracture until a channel was formed ranged from 1,600 to 2,700 pounds per square inch.

A patent was issued for a procedure for causing underground communication between wells drilled into formations of salt, trona, sulfur, or other minerals susceptible to mining by solution methods.[7]

Operation of the newly opened rock salt mine of Cargill Incorporated at Belle Isle, La., was described.[8] The salt dome was reported to contain 18 billion tons of high-purity salt. Attempts to sink a shaft into the dome, which is 200 feet below the surface, had failed until freezing methods were employed to control the inflow of water.

The shaft was sunk to the top of the salt by conventional methods after freezing a 40-foot core of earth down to the salt. When completed the shaft was 1,168 feet deep and 16 feet in diameter with a 2-foot lining of reinforced concrete extending from the surface 175 feet into the salt.

The salt was mined by first undercutting to give a level work floor. Secondly, the salt was drilled and then blasted with ammonium nitrate triggered by dynamite. The broken salt was mechanically loaded on rear dump trucks and hauled to a single-roll crusher. Crushed salt was hoisted to the surface in a 9-ton skip and conveyed to the screening plant. Plans were formulated to place more of the processing equipment underground as the size of the excavations became larger.

Explansion plans of two other rock salt mines in Louisiana were reported. At the Jefferson Island plant of Diamond Crystal Salt Co. a new 1,400-foot level was planned.[9] The old mining level was less than 1,000 feet deep. Tests indicated that fewer impurities were present at the new level. A new 1,400-foot shaft was being drilled at the Cote Blanche Island mine of Carey Salt Co. The first 570 feet

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[7] Bays, C. A. (assigned to FMC Corp., Wilmington, Del.). Method of Creating an Underground Communication. U.S. Pat. 3,086,760, Apr. 23, 1963.
[8] Mining Journal (London). Mining Sodium Chloride at Belle Isle. V. 261, No. 6676, Aug. 2, 1963, p. 103.
[9] Mining World. Diamond Crystal Salt Co. V. 25, No. 3, March 1963, p. 39.

of the shaft was 130 inches in diameter and was reportedly the largest drilled shaft in the United States. Drilling was believed cheaper than sinking the shaft by conventional methods through the water-bearing formations near the surface. The top 570 feet of the shaft was to be cased with prefabricated concrete caissons; at lower depths the diameter was to be reduced to 90 inches and the shaft was to be cased with steel.

Salt stacking at 2,000 tons per hour was claimed for new jetslingers, which are part of a unique salt-handling system in use at Portland, Oreg., and Tacoma, Wash. The time required for unloading and stacking bulk salt from cargo ships was reduced substantially. The key part of the system was the jetslinger—a 14-foot, high-speed concave belt conveyer, which travels at 3,700 feet per minute. When the salt passes over the forward pulley of the conveyer, it is flung outward with sufficient force to traverse a 90-foot trajectory. Salt was stacked 25 feet high without the use of long overhead booms to support conveyer belts.

Several patents were issued describing procedures for purifying and crystallizing solid salt and reducing its tendency to agglomerate. In one procedure a substantially pure sodium chloride product was produced by forcing an aqueous slurry of impure sodium chloride through an orifice and allowing the stream to impinge on a solid surface at high velocity, thus reducing the salt to colloidal-size particles which were separated from the impurities.[10]

A patent was granted for a process for crystallizing hard sharp grains of sodium chloride from a solution of sodium chloride to which a small quantity of soluble carboxymethyl cellulose and a compound supplying nitrilotriacetate ions had been added.[11]

The use of a soluble zirconium compound to reduce the caking tendency of sodium chloride crystals was patented by a German firm.[12] Proportions of zirconium required were between 0.0005 and 0.1 percent of the weight of the salt crystallized.

Adding salt to the mixing water of concrete was found to increase its compressive strength and to reduce its transmission of water vapor.[13] A concentration of 25 grams of salt per kilogram of mixing water solution was effective and did not cause significant corrosion of reinforcing steel.

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[10] Bressett, G. P. (assigned one-half to Pauline L. Parrish, Devon, Pa.). Process for Purifying Salt and Production Thereof. U.S. Pat. 3,097,952, July 16, 1963.

[11] Schinkel, G. (assigned to N. V. Koninklijke Nederlandsche Zoutindustrie, Hengelo, Netherlands). Process for the Preparation of Common Salt by the Evaporation of Solution. U.S. Pat. 3,095,281, July 25, 1963.

[12] Schultz, M., H. Severin, K. Hölscher, and P. Rosenbaum (assigned to Deutsche Solvay—Werke G.m.b.H., Solingen—Ohligs, Germany). Process for Obtaining Sodium Chloride With Decreased Tendency To Agglomerate and Use of the Process for Preventing the Agglomerate of Solid Sodium Chloride. U.S. Pat. 3,112,175, Nov. 26, 1963.

[13] Griffin, D. F., and R. L. Henry. Effect of Salt in Concrete on Compressive Strength, Water Vapor Transmission and Corrosion of Reinforcing Steel. Naval Civil Engineering Lab., Port Hueneme, Calif., Tech. Rept. R-217, Nov. 12, 1962, 61 pp.; abs. in U.S. Govt. Res. Repts., OTS, U.S. Dept. of Commerce, v. 38, No. 8, Apr. 20, 1963, p. 47.

Sand and Gravel

By Perry G. Cotter [1]

CONTINUED expansion in nearly all phases of the construction industry again resulted in a record production of sand and gravel. The reported value of new construction put-in-place increased to nearly $63 billion, an increase of 6 percent over that of 1962.

LEGISLATION AND GOVERNMENT PROGRAMS

Bills were presented to the 88th Congress directed to amendments which would clarify the meaning of the term "common varieties" as applied to deposits of sand and gravel, as well as to a variety of other minerals.

A workable zoning code to provide for multiple use of land for mining, quarrying, and other activities was developed in King County, Oreg. based, to a large extent, upon previous suggestions published by the National Sand and Gravel Association.[2]

DOMESTIC PRODUCTION

The output of 822 million tons of sand and gravel valued at $849 million represents an increase of 6 percent in tonnage and 7 percent in value over that of 1962. California's production of 112 million tons was over twice that of the next highest State, Michigan. Combined production of California, Michigan, Ohio, New York, Wisconsin, Texas, and Illinois, 338 million tons, amounted to 41 percent of the total United States production.

Commercial Production.—Seventy-two percent of the total production was furnished by commercial operators, at an average price of $1.12 per ton.

Government-and-Contractor Production.—The tonnage of sand and gravel reported under this category increased 10 percent and the average price of $0.81 per ton was higher than that in 1962.

Degree of Preparation.—Possibly as a result of increased amounts of sand and gravel used for fill, the percentages of the total sand and gravel, reported as processed, by both commercial and Government-and-contractors declined 1 percent.

Size of Plants.—The 2,188 plants reporting production of 50,000 to 500,000 tons accounted for 56 percent of total production, com-

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[1] Commodity specialist, Division of Minerals.
[2] Boyd, Glen A. An Answer to Zoning Problems. Pit and Quarry, v. 56, No. 2, August 1963, pp. 78–83, 2.

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)

Classes of operation and use	1962		1963	
	Quantity	Value	Quantity	Value
Construction:				
Building:				
Sand	134,249	$140,507	140,352	$145,362
Gravel	111,712	145,257	118,357	149,870
Paving:				
Sand	111,110	100,410	113,346	102,169
Gravel	318,972	289,701	326,437	308,031
Fill:				
Sand	28,022	14,616	32,248	17,037
Gravel	30,601	15,402	47,563	34,463
Railroad ballast:				
Sand	825	880	444	344
Gravel	3,625	2,718	3,509	2,898
Other:				
Sand	5,435	4,907	6,489	5,022
Gravel	6,528	7,472	5,361	6,237
Total construction	751,079	721,870	794,106	771,433
Industrial sand:				
Unground:				
Glass	7,199	23,847	7,204	23,626
Molding	[1] 6,981	[1] 18,771	7,579	20,814
Grinding and polishing	987	1,843	1,130	2,419
Blast sand	802	3,295	764	3,441
Fire or furnace	396	945	568	1,082
Engine	777	1,588	838	1,659
Filtration	176	457	297	756
Oil hydrafrac	266	1,844	552	3,500
Other	1,213	3,613	1,396	3,833
Total unground	[1] 18,797	[1] 56,203	20,328	61,130
Ground [2]	[1] 1,319	[1] 11,040	1,041	8,921
Total industrial	20,116	67,243	21,369	70,051
Miscellaneous gravel	5,506	5,612	6,645	7,273
Grand total	776,701	794,725	822,000	849,000
Commercial:				
Sand	259,086	300,211	271,728	311,473
Gravel	307,893	335,209	319,213	350,908
Government-and-contractor: [3]				
Sand	40,671	28,352	40,836	27,923
Gravel	169,051	130,953	190,343	159,353

[1] Revised figure.
[2] See table 11 for use breakdown, any difference between the total and the detailed figures is due to rounding.
[3] Approximate figures for operations by States, counties, municipalities, and other Government agencies under lease.

pared with the 2,243 plants listed in this group which produced 60 percent of the total in 1962. The number of plants reporting production of less than 25,000 tons per year increased by 652. It is likely that many of these plants are portable and supply material for local use only. There were 6 less plants reporting production of 1 million tons or more, and the tonnage produced in these plants declined by 18 percent. In 1962, 544 dredges were operated to produce sand and gravel and accounted for 10 percent of that year's production.

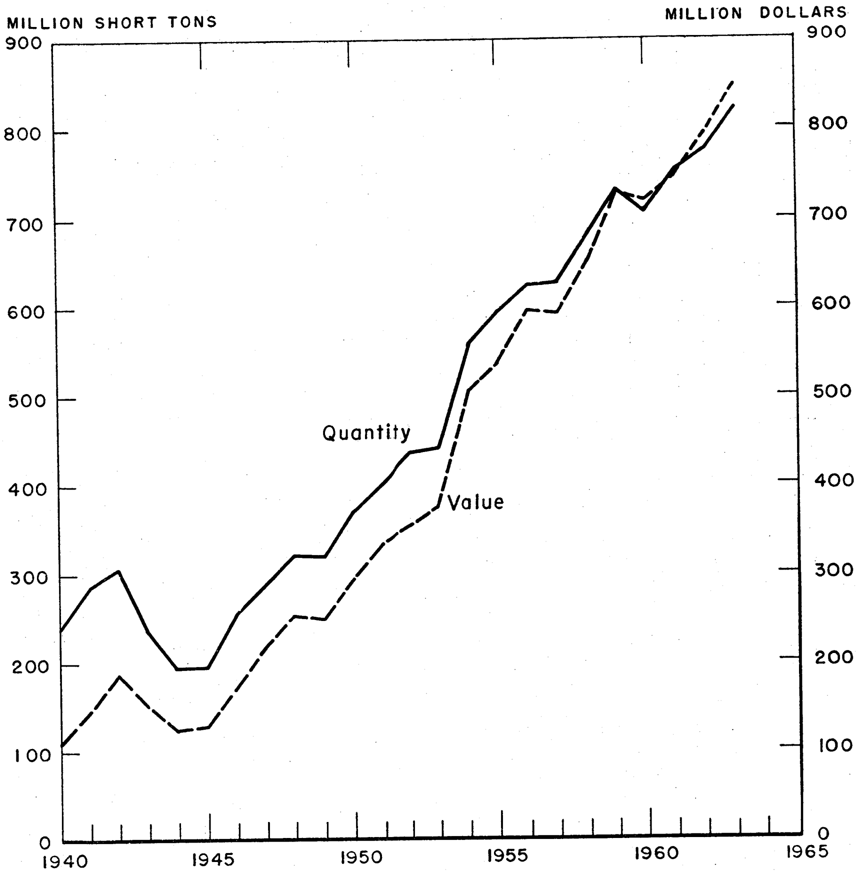

FIGURE 1.—Production and value of sand and gravel in the United States, 1940–63.

TABLE 2.—Sand and gravel sold or used by producers in the United States[1]

(Thousand short tons and thousand dollars)

Year	Sand		Gravel		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1954–58 (average)	225,790	$232,756	392,598	$345,063	618,388	$577,819
1959	269,185	288,531	461,020	440,181	730,205	728,712
1960	265,656	293,599	444,136	426,833	709,792	720,432
1961	283,336	303,549	468,448	447,752	751,784	751,301
1962	299,757	328,563	476,944	466,162	776,701	794,725
1963	312,564	339,396	509,556	509,361	822,000	849,000

[1] Includes possessions and other area administered by the United States (1954–56).

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TABLE 3.—Sand and gravel sold or used by producers in the United States, by States, and classes of operations [1]

(Thousand short tons and thousand dollars)

State	1962						1963					
	Commercial		Government-and-contractor		Total		Commercial		Government-and-contractor		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	4,399	$4,418	256	$68	4,655	$4,486	5,079	$5,610	283	$168	5,362	$5,778
Alaska	533	965	5,198	4,390	5,731	5,355	614	1,573	16,310	20,433	16,924	22,006
Arizona	7,897	8,640	7,682	8,764	15,579	17,404	8,119	8,733	6,918	5,735	15,037	14,468
Arkansas	6,717	7,946	4,130	2,060	10,847	10,006	7,699	9,096	4,400	4,493	12,099	13,589
California	88,572	107,523	19,088	17,399	107,660	124,922	93,835	110,055	18,353	18,120	112,188	128,175
Colorado	10.650	11,785	8,663	7,141	19,313	18,926	11,218	12,365	9,167	8,561	20,385	20,926
Connecticut	7,902	8,283	2,306	961	10,208	9,244	7,632	8,065	2,872	1,277	10,504	9,342
Delaware	1,755	1,445	------	------	1,755	1,445	1,095	1,136	------	------	1,095	1,136
Florida	5,745	5,045	179	134	5,924	5,179	7,258	5,578	284	244	7,542	5,822
Georgia	3,429	3,365	------	------	3,429	3,365	3,817	3,922	------	------	3,817	3,922
Hawaii	354	801	346	321	700	1,122	304	763	------	------	304	763
Idaho	2,686	2,756	11,635	10,273	14,321	13,029	1,723	2,188	10,709	8,426	12,432	10,614
Illinois	32,861	38,231	1,261	750	34,122	38,981	30,061	35,369	1,689	1,063	31,750	36,432
Indiana	20,838	18,466	423	226	21,261	18,692	22,147	20,298	694	384	22,841	20,682
Iowa	11,108	11,033	2,689	1,441	13.797	12,474	11,272	11,095	2.896	1,750	14,168	12,845
Kansas	9,274	6,953	2,278	1,086	11,552	8,039	9,763	7,603	2,299	1,073	12,062	8,676
Kentucky	6,029	5,316	108	62	6,137	5,378	6,273	5,961	206	110	6,479	6,071
Louisiana	11,701	14,682	339	135	12,040	14,817	12,125	14,551	375	150	12,500	14,701
Maine	1,860	1,269	8,154	2,744	10,014	4,013	2,000	1,463	9,196	3,210	11,196	4,673
Maryland	12,604	16,753	158	63	12,762	16,816	13,109	15,991	200	70	13,309	16,061
Massachusetts	13,274	13,302	4,292	1,724	17,566	15,026	16,015	14,347	3,890	1,248	19,905	15,595
Michigan	35,547	34,299	12,016	7,730	47,563	42,029	37,996	35,660	12,463	7,770	50,459	43,430
Minnesota	19,090	16,701	10,309	5,955	29,399	22,656	19,769	16,952	10,691	6,366	30,460	23,318
Mississippi	6,394	6,336	607	926	7,001	7,262	6,306	6,266	519	790	6,825	7,056
Missouri	9,445	10,927	859	645	10,304	11,572	9.808	11,580	845	680	10,653	12,260
Montana	2,124	2,407	16,349	15,235	18,473	17,642	2.873	3,018	11,447	10,737	14,320	13,755
Nebraska	10,938	8,609	1,915	1,188	12.853	9,797	9,895	9,481	1,272	1,201	11,167	10,682
Nevada	3.048	4,857	4,802	4,798	7,850	9,655	3,546	5.675	6,142	4,837	9,688	10,512
New Hampshire	2,394	2,294	5,866	1,825	8,260	4,119	3,203	2,844	4,380	1,533	7,583	4,377
New Jersey	13,697	21,218	31	12	13,728	21,230	16,664	25,241	8	4	16,672	25,245
New Mexico	3,590	4,384	3,299	3,637	6,889	8,021	4,174	5,194	4,229	7,650	8.403	12,844
New York	27,538	30,827	1,909	519	29,447	31,346	27,849	30,107	9.530	7.172	37,379	37,279
North Carolina	8,889	9,205	3.627	2,252	12,516	11,457	7,646	8,064	3.379	2,069	11,025	10,133
North Dakota	2,593	2,224	7,022	4,898	9,615	7,122	2,771	3,036	6,760	6,157	9,531	9,193
Ohio	34,626	42,815	578	518	35,204	43,333	36,812	43,726	978	642	37,790	44,368
Oklahoma	3,802	4,355	634	381	4,436	4,736	4,644	5,756	776	360	5,420	6,116
Oregon	9,629	10,378	5,240	4,178	14,869	14,556	8,929	11,026	6,786	7,824	15,715	18,850
Pennsylvania	14,419	23,587	------	------	14,419	23,587	13,989	23,487	77	51	14,066	23,538

Rhode Island	2, 141	1, 754	205	136	2, 346	1, 890	1, 747	1, 835	3	5	1, 750	1, 840
Nouth Carolina	3, 273	3, 648	45	22	3, 318	3, 670	4, 024	4, 737	27	14	4, 051	4, 751
South Dakota	3, 832	2, 698	11, 539	6, 509	15, 371	9, 207	3, 499	3, 320	17, 308	12, 995	20, 807	16, 315
Tennessee	5, 621	7, 717	454	301	6, 075	8, 018	6, 956	8, 863	657	580	7, 613	9, 443
Texas	25, 619	29, 948	4, 457	3, 149	30, 076	33, 097	27, 511	32, 085	5, 745	4, 226	33, 256	36, 311
Utah	5, 270	4, 929	14, 671	16, 025	19, 941	20, 954	5, 779	5, 062	5, 931	5, 349	11, 710	10, 411
Vermont	677	676	753	400	1, 430	1, 076	1, 090	943	1, 284	466	2, 374	1, 409
Virginia	9, 620	16, 295	125	80	9, 745	16, 375	10, 177	17, 494	222	260	10, 399	17, 754
Washington	12, 786	12, 628	6, 794	5, 517	19, 580	18, 145	12, 399	12, 484	10, 364	8, 004	22, 763	20, 488
West Virginia	5, 202	10, 942	----	----	5, 202	10, 942	4, 808	10, 579	----	----	4, 808	10, 579
Wisconsin	22, 476	17, 833	11, 173	6, 575	33, 649	24, 408	22, 746	19, 080	12, 887	7, 268	35, 633	26, 348
Wyoming	2, 511	1, 952	5, 258	6, 152	7, 769	8, 104	2, 173	2, 124	5, 728	5, 751	7, 901	7, 875
Total	566, 979	635, 420	209, 722	159, 305	776, 701	794, 725	590, 941	661, 481	231, 179	187, 276	822, 000	849, 000
American Samoa	----	----	3	4	3	4	----	----	77	193	77	193
Panama Canal Zone	70	77	----	----	70	77	84	87	----	----	84	87
Puerto Rico	6, 631	9, 161	747	632	7, 378	9, 793	6, 832	9, 743	784	664	7, 616	10, 407

[1] Data shown in the State chapters of volume III may vary slightly due to rounding.

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1963, by States, uses, and classes of operations

(Commercial unless otherwise indicated)

State	Sand, construction							
	Building				Paving			
	Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	1,350,164	$1,268,395	------	------	663,572	$588,706	132,000	$88,000
Alaska	138,036	436,175	27,798	$91,862	(1)	(1)	438,408	735,985
Arizona	1,745,500	2,265,600	7,300	7,300	586,200	612,600	846,100	554,000
Arkansas	1,639,001	1,744,934	5,526	8,289	1,070,942	1,047,754	1,385,107	900,149
California	22,824,657	25,615,440	199,636	219,773	11,863,754	12,199,861	6,977,652	6,714,693
Colorado	2,247,000	2,625,100	200	300	584,200	599,300	656,400	621,000
Connecticut	2,145,018	2,283,593	------	------	1,835,901	1,726,474	110,683	41,100
Delaware	223,896	221,902	------	------	220,584	214,338	------	------
Florida	5,058,713	3,669,692	------	------	139,200	120,229	224,564	205,163
Georgia	2,366,214	1,866,790	------	------	497,245	377,751	------	------
Hawaii	221,086	587,544	------	------	9,210	22,920	------	------
Idaho	168,448	300,593	------	------	131,746	178,413	66,644	47,930
Illinois	6,329,922	5,732,176	473	125	4,598,380	4,147,121	299,033	162,840
Indiana	3,963,268	3,346,238	911	410	4,089,194	3,431,675	724	325
Iowa	2,231,349	2,060,521	------	------	2,088,533	2,019,223	220,616	121,171
Kansas	3,313,407	2,455,605	------	------	2,814,247	2,265,263	1,233,994	605,372
Kentucky	2,010,764	1,908,542	------	------	2,058,150	1,869,672	225	337
Louisiana	2,283,017	2,283,452	------	------	1,821,299	1,729,980	------	------
Maine	324,687	235,927	------	------	231,037	173,195	1,746,287	611,928
Maryland	3,231,420	4,091,209	125	336	2,284,504	2,831,352	5,021	1,757
Massachusetts	2,973,120	2,801,538	------	------	2,409,857	2,252,240	25,400	15,712
Michigan	4,827,471	3,444,148	------	------	5,049,263	4,535,464	1,965,470	1,014,236
Minnesota	3,281,987	2,590,532	------	------	1,568,175	1,055,716	2,055,596	1,095,735
Mississippi	901,969	765,817	------	------	863,483	737,566	279,558	271,731
Missouri	3,658,386	3,333,530	------	------	901,611	914,878	85,029	102,942
Montana	317,225	474,746	------	------	249,103	217,024	(1)	(1)
Nebraska	2,759,200	2,702,600	100	100	974,100	931,000	323,500	328,800
Nevada	564,503	1,321,716	------	------	(1)	(1)	106,429	131,585
New Hampshire	552,075	429,344	------	------	396,614	303,589	(1)	(1)
New Jersey	5,031,122	5,309,302	------	------	2,994,711	2,539,298	------	------
New Mexico	971,000	1,271,700	3,500	3,500	179,400	232,800	100,100	58,000
New York	9,124,705	10,569,723	13,200	19,800	5,357,812	5,659,269	455,173	309,434
North Carolina	2,682,306	2,141,565	------	------	637,270	440,186	1,847,227	1,008,216
North Dakota	410,800	491,600	------	------	194,500	217,200	2,082,000	1,908,600
Ohio	5,820,385	6,376,411	------	------	7,684,645	7,560,427	492,464	369,349
Oklahoma	2,066,701	1,953,178	1,300	1,950	1,052,939	976,757	250,690	118,246

Oregon	1, 278, 389	1, 922, 410	5, 941	5, 673	333, 834	445, 043	35, 294	61, 774
Pennsylvania	4, 260, 795	6, 301, 313			2, 297, 653	3, 187, 940		
Rhode Island	507, 995	533, 875			151, 947	120, 239		
South Carolina	1, 888, 347	1, 201, 744			372, 091	154, 782	3, 096	1, 363
South Dakota	598, 300	596, 600			317, 500	303, 750	1, 351, 900	1, 293, 500
Tennessee	1, 832, 622	2, 735, 068			848, 259	1, 242, 740	9, 000	9, 000
Texas	9, 585, 137	9, 245, 343	76, 273	191, 231	2, 045, 432	2, 001, 653	351, 990	160, 380
Utah	1, 164, 000	1, 224, 200	282, 400	282, 600	166, 100	173, 300	148, 900	148, 600
Vermont	92, 486	88, 777			230, 422	158, 219	345, 168	120, 809
Virginia	1, 901, 102	2, 841, 615			2, 128, 500	2, 927, 665	32, 727	11, 736
Washington	2, 162, 813	2, 519, 788			625, 247	486, 464	376, 831	473, 376
West Virginia	1, 155, 916	1, 493, 259			702, 227	1, 034, 048		
Wisconsin	3, 317, 893	2, 630, 487	103, 432	48, 535	1, 319, 849	934, 432	4, 471, 707	2, 371, 297
Wyoming	122, 800	164, 800	100	100	339, 200	345, 300	35, 800	35, 800
Undistributed [1]					81, 190	85, 617	1, 710, 557	1, 009, 134
Total	139, 627, 117	144, 476, 157	728, 215	881, 884	80, 060, 832	78, 330, 433	33, 285, 064	23, 841, 105
American Samoa								
Panama Canal Zone								
Puerto Rico	1, 856, 000	2, 916, 400			1, 698, 600	1, 712, 900	196, 000	185, 700

[1] Figures 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 1963, by States, uses, and classes of operations—Continued

(Commercial unless otherwise indicated)

State	Sand construction—Continued									
	Railroad ballast		Fill				Other [2]			
			Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	1,000	$500	33,366	$28,085						
Alaska			(1)	(1)	17,468	$7,682				
Arizona	1,300	700	171,700	112,300	21,500	12,900	(1)	(1)		
Arkansas			(1)	(1)	269,300	121,135	39,873	$39,873		
California	38,875	35,390	3,722,413	2,978,748	623,074	468,438	450,098	404,272	4,173	$4,325
Colorado	2,600	3,300	(1)	(1)	24,200	27,200	(1)	(1)		
Connecticut			174,089	78,396			(1)	(1)	30,830	16,029
Delaware			(1)	(1)			(1)	(1)		
Florida			1,488,116	752,059	50,000	30,000	(1)	(1)		
Georgia	(1)	(1)	53,856	38,077						
Hawaii			(1)	(1)						
Idaho	(1)	(1)	905	1,248	312,500	200,000	9,510	90,762		
Illinois	32,000	30,600	(1)	(1)	9,798	5,352	27,813	25,862		
Indiana	(1)	(1)	1,190,256	537,652			(1)	(1)	14,500	5,075
Iowa	(1)	(1)	679,690	391,356	9,844	7,382	(1)	(1)		
Kansas	39,044	27,151	876,096	413,073	1,168	467	95,434	76,231	12,878	5,151
Kentucky	(1)	(1)	494,296	232,195						
Louisiana			(1)	(1)			(1)	(1)		
Maine			175,244	72,049	(1)	(1)	(1)	(1)	(1)	(1)
Maryland			39,368	20,621			(1)	(1)		
Massachusetts	1,191	884	1,194,862	475,347			(1)	(1)	22,960	24,192
Michigan			3,091,899	1,383,217	1,496,719	516,417	(1)	(1)	142,602	70,603
Minnesota	3,996	2,397	489,283	215,116	49,297	22,736	(1)	(1)	6,668	1,445
Mississippi			123,412	51,925			(1)	(1)		
Missouri	(1)	(1)	397,005	341,250			775	1,532		
Montana	(1)	(1)	15,467	11,537	(1)	(1)	2,810	1,686		
Nebraska			312,800	191,000						
Nevada	208	900	77,015	43,835			(1)	(1)		
New Hampshire			391,951	159,221	(1)	(1)	(1)	(1)		
New Jersey			1,525,947	566,798			(1)	(1)	4,261	1,704
New Mexico			42,500	23,000						
New York			1,190,861	527,728	1,730,200	728,900	1,443,079	874,772	385,258	166,218
North Carolina	(1)	(1)	104,029	80,750	320,000	196,300			486,370	225,716
North Dakota			(1)	(1)						
Ohio			807,670	606,073	1,682	1,112	203,105	190,279	23,625	8,269

Oklahoma	----------	----------	533,014	315,796	----------	----------	(1)	(1)	5,490	2,196
Oregon	----------	----------	158,022	140,050	27,354	16,221	28,098	30,696	----------	----------
Pennsylvania	(1)	(1)	38,687	28,872	----------	----------	366,544	574,493	26,858	32,827
Rhode Island	----------	----------	(1)	(1)	----------	----------	38,171	27,557	----------	----------
South Carolina	(1)	(1)	16,429	8,011	----------	----------	(1)	(1)	(1)	(1)
South Dakota	(1)	(1)	(1)	(1)	----------	----------	----------	----------	----------	----------
Tennessee	----------	----------	(1)	(1)	----------	----------	(1)	(1)	----------	----------
Texas	40,527	33,053	593,657	249,462	82,000	32,800	194,592	75,323	----------	----------
Utah	----------	----------	75,700	30,600	67,500	33,800	----------	----------	----------	----------
Vermont	----------	----------	176,315	75,070	----------	----------	(1)	(1)	50,790	20,333
Virginia	----------	----------	435,464	231,455	----------	----------	168,327	239,419	22,984	9,194
Washington	----------	----------	777,198	478,947	5,538	3,343	36,350	60,018	----------	----------
West Virginia	10,400	14,500	(1)	(1)	----------	----------	(1)	(1)	----------	----------
Wisconsin	(1)	(1)	1,236,730	679,440	407,944	139,988	18,623	11,015	162,932	60,001
Wyoming	(1)	(1)	(1)	(1)	----------	----------	----------	----------	----------	----------
Undistributed [1]	273,279	194,181	2,265,772	1,344,884	1,547,274	551,366	1,929,182	1,630,356	27,380	14,303
Total	444,415	343,556	25,171,084	13,915,243	7,074,360	3,123,539	5,052,294	4,354,146	1,430,559	667,581
American Samoa	----------	----------	----------	----------	76,680	192,720	----------	----------	----------	----------
Panama Canal Zone	----------	----------	----------	----------	----------	----------	83,633	87,057	----------	----------
Puerto Rico	----------	----------	418,500	261,800	453,000	344,200	----------	----------	----------	----------

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[2] Includes unspecified.

TABLE 4.—Sand and gravel sold or used by producers in the United States in 1963, by States, uses, and classes of operations—Continued

(Commercial unless otherwise indicated)

State	Sand, industrial									
	Glass		Molding		Grinding and polishing		Blast		Fire or furnace	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama			[1]	[1]						
Alaska										
Arizona							800	$4,700		
Arkansas	234,800	$647,750	64,147	$183,428						
California	720,408	3,493,676	38,686	179,426	[1]	[1]	145,129	346,405	[1]	[1]
Colorado							[1]	[1]		
Connecticut			[1]	[1]						
Delaware										
Florida	108,807	218,219	[1]	[1]			[1]	[1]		
Georgia	[1]	[1]	[1]	[1]			[1]	[1]		
Hawaii							9,200	20,290		
Idaho	6,776	47,755								
Illinois	1,431,265	3,400,159	748,709	2,386,210	[1]	[1]	[1]	[1]		
Indiana	[1]	[1]	[1]	[1]					[1]	[1]
Iowa			[1]	[1]			[1]	[1]		
Kansas							7,243	22,442		
Kentucky			3,598	13,500						
Louisiana							[1]	[1]		
Maine										
Maryland	[1]	[1]			[1]	[1]				
Massachusetts			[1]	[1]			1,450	7,250		
Michigan	[1]	[1]	2,177,820	3,895,776	[1]	[1]	[1]	[1]		
Minnesota	[1]	[1]	57,917	238,243	[1]	[1]	[1]	[1]		
Mississippi			[1]	[1]			858	736		
Missouri	449,799	1,163,572	80,102	212,764	[1]	[1]	[1]	[1]		
Montana										
Nebraska										
Nevada	[1]	[1]	[1]	[1]					[1]	[1]
New Hampshire										
New Jersey	748,381	2,780,401	1,569,935	5,043,140	22,125	$64,243	122,063	652,679		
New Mexico										
New York			162,473	632,232			[1]	[1]		
North Carolina							[1]	[1]		
North Dakota							[1]	[1]		
Ohio	[1]	[1]	443,833	1,742,663			[1]	[1]	[1]	[1]
Oklahoma	[1]	[1]	[1]	[1]			[1]	[1]		
Oregon			734	5,872			[1]	[1]		
Pennsylvania	[1]	[1]	121,510	378,055	[1]	[1]	[1]	[1]	168,244	$382,420
Rhode Island			[1]	[1]						

South Carolina	(1)	(1)	(1)	—	—	—	(1)	(1)	(1)	(1)
South Dakota	—	—	—	—	—	—	—	—	—	—
Tennessee	(1)	(1)	245,664	738,045	(1)	(1)	—	—	6,668	13,336
Texas	(1)	(1)	(1)	(1)	—	—	(1)	(1)	—	—
Utah	—	—	8,600	26,600	—	—	100	400	20,000	20,000
Vermont	—	—	—	—	—	—	—	—	—	—
Virginia	(1)	(1)	—	—	—	—	—	—	—	—
Washington	35,628	254,703	(1)	(1)	—	—	(1)	(1)	—	—
West Virginia	(1)	(1)	(1)	(1)	—	—	(1)	(1)	53,737	61,798
Wisconsin	(1)	(1)	689,521	1,870,775	—	—	(1)	(1)	—	—
Wyoming	—	—	—	—	—	—	—	—	—	—
Undistributed [1]	3,467,655	11,619,267	1,162,891	3,265,953	1,107,023	2,355,715	475,316	2,385,120	319,768	604,790
Total	7,203,519	23,625,502	7,576,140	20,812,682	1,129,148	2,419,958	762,159	3,440,022	568,417	1,082,344
American Samoa	—	—	—	—	—	—	—	—	—	—
Panama Canal Zone	—	—	—	—	—	—	—	—	—	—
Puerto Rico	(1)	(1)	—	—	—	—	—	—	—	—

[1] Figures 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 1963, by States, uses, and classes of operations—Continued

(Commercial unless otherwise indicated)

State	Sand, industrial—Continued									
	Engine		Filtration		Oil (hydrafrac)		Other		Ground sand	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	(1)	(1)	(1)	(1)	---	---	---	---	---	---
Alaska	---	---	---	---	---	---	---	---	---	---
Arizona	---	---	---	---	14,500	$157,300	3,800	$24,000	---	---
Arkansas	---	---	---	---	---	---	---	---	8,001	$154,690
California	46,707	$139,785	21,658	$91,842	(1)	(1)	63,595	284,715	10,077	107,980
Colorado	(1)	(1)	(1)	(1)	---	---	8,400	20,700	---	---
Connecticut	---	---	(1)	(1)	---	---	---	---	---	---
Delaware	17,741	13,306	---	---	---	---	---	---	---	---
Florida	---	---	(1)	(1)	---	---	(1)	(1)	---	---
Georgia	---	---	(1)	(1)	---	---	(1)	(1)	(1)	(1)
Hawaii	(1)	(1)	---	---	---	---	3,186	6,372	---	---
Idaho	---	---	---	---	---	---	---	---	8,550	89,562
Illinois	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	180,997	1,901,356
Indiana	(1)	(1)	---	---	---	---	(1)	(1)	(1)	(1)
Iowa	(1)	(1)	(1)	(1)	---	---	(1)	(1)	---	---
Kansas	22,896	38,033	(1)	(1)	540	1,500	2,700	2,620	---	---
Kentucky	(1)	(1)	---	---	---	---	(1)	(1)	---	---
Louisiana	---	---	2,466	4,770	---	---	---	---	---	---
Maine	(1)	(1)	(1)	(1)	---	---	---	---	---	---
Maryland	(1)	(1)	(1)	(1)	---	---	---	---	---	---
Massachusetts	---	---	1,450	7,250	---	---	(1)	(1)	---	---
Michigan	(1)	(1)	---	---	---	---	(1)	(1)	(1)	(1)
Minnesota	(1)	(1)	---	---	(1)	(1)	---	---	(1)	(1)
Mississippi	110	74	---	---	---	---	---	---	(1)	(1)
Missouri	(1)	(1)	(1)	(1)	---	---	(1)	(1)	102,476	968,414
Montana	---	---	---	---	---	---	---	---	---	---
Nebraska	---	---	---	---	---	---	(1)	(1)	---	---
Nevada	---	---	---	---	---	---	(1)	(1)	---	---
New Hampshire	(1)	(1)	(1)	(1)	---	---	---	---	---	---
New Jersey	27,464	92,758	37,518	141,199	---	---	134,728	565,114	142,757	1,211,091
New Mexico	2,500	6,800	---	---	---	---	---	---	---	---
New York	(1)	(1)	19,484	24.874	---	---	(1)	(1)	(1)	(1)
North Carolina	---	---	(1)	(1)	---	---	---	---	---	---
North Dakota	---	---	---	---	---	---	---	---	---	---
Ohio	(1)	(1)	23,006	66,889	---	---	149,027	381,583	(1)	(1)
Oklahoma	---	---	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Oregon	17,158	19,065	---	---	---	---	---	---	---	---
Pennsylvania	(1)	(1)	(1)	(1)	---	---	(1)	(1)	(1)	(1)
Rhode Island	---	---	---	---	---	---	---	---	---	---

South Carolina	29,513	95,380	(1)	(1)	-----	-----	(1)	(1)	(1)	(1)
South Dakota	-----	-----	-----	-----	-----	-----	2,600	2,100	-----	-----
Tennessee	1,161	1,741	-----	-----	-----	-----	(1)	(1)	-----	-----
Texas	24,415	23,013	(1)	(1)	(1)	(1)	(1)	(1)	86,210	119,441
Utah	5,400	13,600	-----	-----	-----	-----	-----	-----	-----	-----
Vermont	(1)	(1)	-----	-----	-----	-----	-----	-----	-----	-----
Virginia	(1)	(1)	8,296	16,859	-----	-----	(1)	(1)	(1)	(1)
Washington	-----	-----	-----	-----	-----	-----	135,554	88,091	-----	-----
West Virginia	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Wisconsin	(1)	(1)	(1)	(1)	300,404	1,672,220	(1)	(1)	(1)	(1)
Wyoming	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Undistributed [1]	642,613	1,216,394	184,820	398,551	235,853	1,668,314	891,770	2,458,132	499,798	4,365,585
Total	837,678	1,659,949	298,698	752,234	551,297	3,499,334	1,395,360	3,833,427	1,038,866	8,918,119
American Samoa	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Panama Canal Zone	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Puerto Rico	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

[1] Figures 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 1963, by States, uses, and classes of operations—Continued

(Commercial unless otherwise indicated)

State	Gravel, construction							
	Building				Paving			
	Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	1,221,243	$1,486,217	----------	----------	1,284,683	$1,563,304	150,848	$80,334
Alaska	174,938	518,825	139,502	$361,140	179,902	475,662	1,012,059	3,633,547
Arizona	2,181,900	2,246,600	16,800	16,800	1,695,500	1,690,100	6,026,600	5,143,900
Arkansas	1,747,158	2,645,317	----------	----------	2,678,028	2,527,565	2,711,938	3,453,524
California	25,574,261	30,638,558	2,056,641	2,073,497	24,788,499	29,702,329	7,569,683	7,811,839
Colorado	3,282,300	4,103,200	203,200	239,100	4,459,100	4,403,600	7,974,100	7,432,500
Connecticut	1,389,119	2,192,631	675	250	1,161,623	1,175,269	2,705,244	1,210,645
Delaware	75,419	196,062	----------	----------	513,839	459,140	----------	----------
Florida	122,180	166,617	----------	----------	(1)	(1)	9,000	9,000
Georgia	(1)	(1)	----------	----------	(1)	(1)	----------	----------
Hawaii	912	2,280	----------	----------	59,797	123,290	216	241
Idaho	228,744	315,599	----------	----------	1,035,442	1,049,978	9,716,967	7,853,765
Illinois	5,126,128	4,881,104	----------	----------	8,234,291	8,397,968	1,379,325	896,019
Indiana	3,486,666	4,070,464	----------	----------	6,967,045	6,729,229	659,471	372,704
Iowa	1,247,280	1,940,362	15,700	8,690	4,615,916	3,932,309	2,635,263	1,609,044
Kansas	365,717	401,576	----------	----------	1,992,279	1,682,649	1,051,148	463,160
Kentucky	590,892	732,571	----------	----------	936,330	1,084,400	205,780	110,490
Louisiana	3,972,997	5,434,539	240,319	96,127	3,759,678	4,868,662	134,796	53,918
Maine	181,427	170,966	750	263	655,527	596,353	7,432,870	2,591,719
Maryland	2,047,874	3,698,450	----------	----------	2,353,973	2,671,813	195,351	68,746
Massachusetts	3,270,972	3,908,750	----------	----------	2,677,926	2,247,157	1,406,508	887,526
Michigan	4,919,670	6,293,191	66,241	30,364	16,479,664	13,817,687	8,256,719	5,946,930
Minnesota	2,414,254	3,416,304	25,916	14,254	10,835,866	8,257,662	8,090,194	5,060,803
Mississippi	1,719,250	1,887,812	----------	----------	2,325,257	2,497,758	239,415	518,040
Missouri	2,155,853	2,306,618	41,532	30,306	1,452,445	1,247,089	718,029	547,248
Montana	403,869	581,816	----------	----------	1,457,619	1,423,752	10,808,432	10,078,320
Nebraska	790,500	822,200	----------	----------	4,649,700	4,502,600	948,800	871,500
Nevada	579,431	1,304,212	101	113	1,550,566	1,504,330	5,879,980	4,559,854
New Hampshire	611,587	876,096	----------	----------	685,364	767,321	1,676,178	586,661
New Jersey	2,244,240	4,064,619	----------	----------	1,186,548	1,674,169	3,900	1,560
New Mexico	781,700	1,063,900	102,300	101,100	2,051,800	2,498,300	4,023,400	7,486,500
New York	4,248,482	5,669,701	3,450	1,500	4,006,303	4,569,037	4,208,193	4,194,497
North Carolina	1,579,331	2,193,476	----------	----------	2,016,390	2,122,923	724,996	637,485
North Dakota	414,400	630,300	86,600	76,300	927,700	1,038,200	4,591,000	4,171,500
Ohio	5,556,260	6,716,758	----------	----------	12,228,569	14,467,183	417,894	248,812

Oklahoma	259, 394	378, 176	13, 739	15, 346	176, 332	146, 278	506, 461	222, 384
Oregon	2, 086, 594	2, 492, 752	----------	----------	4, 166, 071	4, 968, 409	6, 663, 547	7, 712, 555
Pennsylvania	2, 930, 884	4, 313, 310	----------	----------	2, 278, 412	3, 666, 359	50, 338	17, 618
Rhode Island	349, 417	498, 721	----------	----------	399, 848	418, 802	3, 000	4, 500
South Carolina	(1)	(1)	----------	----------	(1)	(1)	----------	----------
South Dakota	390, 100	420, 860	8, 900	8, 900	1, 897, 460	1, 812, 710	15, 944, 400	11, 689, 150
Tennessee	1, 140, 450	1, 325, 136	----------	----------	2, 227, 495	1, 797, 095	647, 900	570, 900
Texas	9, 813, 609	13, 192, 349	7, 983	16, 642	4, 339, 651	5, 174, 404	5, 226, 697	3, 824, 934
Utah	1, 484, 200	1, 587, 400	1, 009, 100	950, 800	1, 608, 100	1, 439, 500	4, 057, 100	3, 745, 900
Vermont	70, 728	93, 044	----------	----------	407, 571	438, 002	887, 480	325, 340
Virginia	1, 890, 998	4, 012, 714	----------	----------	2, 662, 980	5, 325, 817	151, 236	233, 205
Washington	3, 631, 571	3, 983, 956	----------	----------	2, 865, 960	2, 944, 421	7, 396, 191	5, 954, 310
West Virginia	1, 051, 989	1, 305, 307	----------	----------	629, 866	1, 025, 673	----------	----------
Wisconsin	3, 304, 648	2, 734, 574	34, 522	18, 987	10, 723, 352	7, 297, 977	6, 996, 043	4, 332, 461
Wyoming	172, 200	226, 300	34, 800	30, 800	1, 419, 000	1, 297, 800	5, 576, 700	5, 603, 700
Undistributed [1]	963, 644	1, 637, 194	----------	----------	1, 059, 908	1, 678, 204	----------	----------
Total	114, 247, 380	145, 779, 484	4, 108, 771	4, 091, 279	168, 765, 175	175, 200, 239	157, 671, 390	132, 829, 288
American Samoa	----------	----------	----------	----------	----------	----------	----------	----------
Panama Canal Zone	----------	----------	----------	----------	----------	----------	----------	----------
Puerto Rico	1, 311, 900	2, 456, 900	----------	----------	1, 017, 600	1, 981, 000	18, 000	29, 500

[1] Figures 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 1963 by States uses and classes of operations—Continued

(Commercial unless otherwise indicated)

State	Gravel, construction—Continued										Gravel, miscellaneous	
	Railroad ballast		Fill				Other				Short tons	Value
			Commercial		Government-and-contractor		Commercial		Government-and-contractor			
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value		
Alabama	(1)	(1)	7,470	$9,235							(1)	(1)
Alaska	30,333	$7,280	48,334	70,460	14,675,805	$15,601,954					35,135	$47,778
Arizona	(1)	(1)	(1)	(1)							1,078,800	1,090,900
Arkansas	(1)	(1)	25,855	12,156	27,500	11,000					(1)	(1)
California	484,050	499,345	1,934,736	1,812,608	832,088	665,591	551,545	$601,178	89,213	$163,730	473,902	550,928
Colorado	7,400	11,300	191,400	143,100	308,800	242,200					281,400	298,200
Connecticut			540,656	273,371	(1)	(1)	50,996	61,862	(1)	(1)	109,351	110,024
Delaware			(1)	(1)							(1)	(1)
Florida												
Georgia			(1)	(1)								
Hawaii												
Idaho	(1)	(1)	23,400	23,326	612,940	324,314	27,457	28,617			43,847	36,469
Illinois	147,999	153,530	805,505	474,198			29,103	34,660			215,117	158,455
Indiana	121,704	96,445	1,343,375	702,935	16,190	5,667	19,860	20,679	1,400	420	62,625	57,426
Iowa	(1)	(1)	115,274	78,232			23,027	43,223	14,000	3,500	16,544	10,957
Kansas			58,527	28,739			10,416	23,997			(1)	(1)
Kentucky	(1)	(1)	167,265	111,094								
Louisiana	8,115	12,327	82,228	58,750			(1)	(1)			(1)	(1)
Maine	39,792	28,700	209,399	89,628	4,050	1,500	44,746	21,605	(1)	(1)	68,651	28,878
Maryland	(1)	(1)	2,230,757	1,218,279			(1)	(1)			332,801	299,337
Massachusetts	(1)	(1)	1,463,912	647,239	2,435,046	318,382	818,403	641,101			(1)	(1)
Michigan	(1)	(1)	291,311	162,672	355,335	120,637	63,161	66,183	178,694	72,311	199,025	159,303
Minnesota	384,043	197,966	446,951	295,418	392,599	145,624	8,823	14,403	71,866	24,287	61,014	35,509
Mississippi	(1)	(1)	18,237	16,619			(1)	(1)			(1)	(1)
Missouri	(1)	(1)	8,429	6,231					486	194	96,644	71,986
Montana	128,900	81,176	224,770	155,247	(1)	(1)	62,139	61,447	27,193	14,970	(1)	(1)
Nebraska	(1)	(1)	25,000	24,700							258,400	231,500
Nevada	2,234	1,489	360,309	351,418	119,350	119,350	(1)	(1)	36,620	25,660	(1)	(1)
New Hampshire			351,914	127,581			29,500	60,712			105,080	58,424
New Jersey			430,374	181,158			152,782	158,533			15,637	10,409
New Mexico	(1)	(1)	(1)	(1)							37,700	47,000
New York	(1)	(1)	1,605,239	881,357	2,734,788	1,749,243	(1)	(1)			435,975	391,720
North Carolina	(1)	(1)	7,450	6,000					756	940	(1)	(1)
North Dakota	220,900	85,300	477,700	465,200							48,700	51,900
Ohio	37,927	30,280	1,784,361	938,557	19,343	7,419	1,137,485	1,674,634	23,625	8,269	443,306	740,397

Oklahoma			(1)	(1)			(1)	(1)			(1)	(1)
Oregon	50,946	53,552	543,679	433,332	53,686	28,033	67,489	94,041			(1)	(1)
Pennsylvania	(1)	(1)	153,004	88,886			99,964	102,449			(1)	(1)
Rhode Island			(1)	(1)			17,790	10,264			(1)	(1)
South Carolina	(1)	(1)	1,066	740							(1)	(1)
South Dakota	51,800	39,600	58,000	34,400	2,500	2,500					139,300	79,600
Tennessee	50,000	67,500	(1)	(1)			11,681	10,464			(1)	(1)
Texas	(1)	(1)	198,474	94,490			92,540	41,144			22,112	31,214
Utah	10,500	4,800	1,176,400	492,500	365,600	185,700					59,700	47,900
Vermont			52,901	26,646			(1)	(1)			(1)	(1)
Virginia			(1)	(1)	15,000	5,250	(1)	(1)				
Washington	467,900	446,262	1,255,605	845,145	2,540,030	1,526,750	345,499	280,906	43,331	47,310	56,351	78,017
West Virginia	(1)	(1)	27,482	45,872			(1)	(1)			(1)	(1)
Wisconsin	(1)	(1)	1,279,476	722,129	711,014	295,506	(1)	(1)			94,618	62,833
Wyoming	(1)	(1)	(1)	(1)	80,000	80,000					34,000	37,500
Undistributed [1]	1,265,630	1,080,238	1,161,374	838,908	77,370	39,304	1,199,292	1,819,579	9,810	4,102	1,817,311	2,447,575
Total	3,510,173	2,897,090	21,187,599	12,988,556	26,379,034	21,475,924	4,863,698	5,871,681	496,994	365,693	6,643,046	7,272,139
American Samoa												
Panama Canal Zone												
Puerto Rico			361,500	241,200	117,500	104,500	(1)	(1)				

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

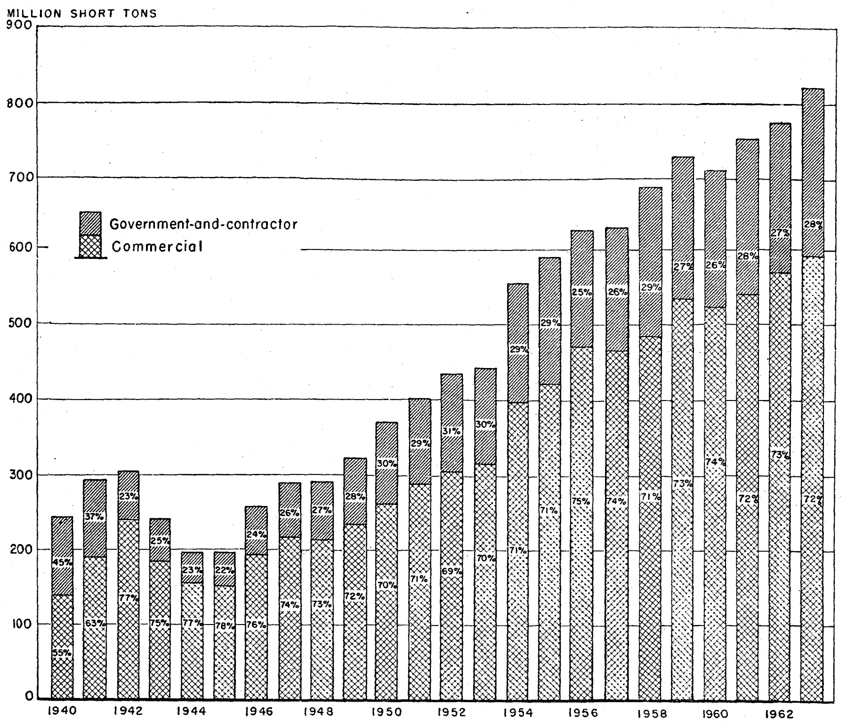

FIGURE 2.—Sand and gravel sold or used in the United States 1940–63.

TABLE 5.—Sand and gravel sold or used by Government-and-contractor producers in the United States [1] by uses

(Thousand short tons and thousand dollars)

Year	Sand							
	Building		Paving		Fill		Other	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1954–1958 (average)	1,838	$1,808	22,301	$11,389	(2)	(2)	(2)	(2)
1959	1,353	1,419	34,097	19,654	1,927	$899	254	$102
1960	962	1,374	26,012	18,500	3,785	2,122	728	338
1961	2,321	3,331	32,243	21,621	7,991	3,256	435	242
1962	1,759	3,287	30,163	21,444	7,482	3,016	1,267	605
1963	728	882	33,285	23,840	7,076	3,124	1,433	668

Year	Gravel								Total Government-and-contractor sand and gravel	
	Building		Paving		Fill		Other			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1954–1958 (average)	8,623	$5,615	136,673	$83,350	(2)	(2)	(2)	(2)	169,435	$102,162
1959	10,387	6,882	144,525	100,308	2,719	$789	20	$14	195,282	130,067
1960	7,320	6,417	130,323	93,859	17,106	7,890	631	522	186,897	131,022
1961	6,480	9,372	148,572	109,155	13,510	4,547	677	493	212,229	152,017
1962	8,626	11,870	145,602	113,094	14,125	5,535	698	454	209,722	159,305
1963	4,110	4,091	157,671	132,829	26,379	21,476	497	366	231,179	187,276

[1] Includes possessions and other areas administered by the United States (1954–56).
[2] Data not available.

TABLE 6.—Sand and gravel sold or used by Government-and-contractor producers in the United States,[1] by types of producer
(Thousand short tons and thousand dollars)

Type of producer	1954–58 (average)		1959		1960	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction and maintenance crews	48,545	$21,942	49,800	$28,643	52,035	$31,212
Contractors	120,890	80,220	145,482	101,424	134,862	99,810
Total	169,435	102,162	195,282	130,067	186,897	131,022
States	102,680	61,582	111,696	74,947	110,157	78,227
Counties	43,813	22,154	56,293	34,975	48,563	31,654
Municipalities	3,378	1,986	3,282	1,972	2,897	1,755
Federal agencies	19,564	16,440	24,011	18,173	25,280	19,386
Total	169,435	102,162	195,282	130,067	186,897	131,022

Type of producer	1961		1962		1963	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction and maintenance crews	54,030	$33,194	55,547	$31,216	57,546	$35,945
Contractors	158,199	118,823	154,175	128,089	173,633	151,331
Total	212,229	152,017	209,722	159,305	231,179	187,276
States	127,004	94,111	129,314	95,787	146,053	124,138
Counties	46,932	30,334	49,590	29,656	57,493	39,728
Municipalities	6,357	3,335	3,236	2,679	3,928	3,436
Federal agencies	31,936	24,237	27,582	31,183	23,705	19,974
Total	212,229	152,017	209,722	159,305	231,179	187,276

[1] Includes possessions and other areas administered by the United States (1954–56).

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)

	1962		1963	
	Quantity	Value	Quantity	Value
Commercial operations:				
Prepared	515,761	$604,703	532,099	$627,582
Unprepared	51,218	30,717	58,842	33,899
Total	566,979	635,420	590,941	661,481
Government-and-contractor-operations:				
Prepared	152,739	134,000	165,519	142,944
Unprepared	56,983	25,305	65,660	44,332
Total	209,722	159,305	231,179	187,276
Grand total	776,701	794,725	822,120	848,757

Production Trends.—Industrialized building methods, operating efficiently up to 100 miles from construction sites, may affect the economy of some sand and gravel operations located near metropolitan areas. In industrialized, prefabricated, or precast manufacturing of building units, the only basic materials brought to the building site are those needed for foundations, footings, or other sublevel work. Other units, walls, staircases, floors, external facing panels of exposed

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crushed stone aggregate or river pebbles, and roofs are produced from molds in factories located near deposits of sand and gravel, dried, and stacked for transportation to the job site. At the job site the prefabricated units are lifted into place by tower or climbing cranes and grouted in place.

Methods of Transportation.—The relative proportions of commercial sand and gravel moved by truck, rail, and waterway showed little change. It is believed that some commercial material is trucked to stock pile and later moved to market by rail. The slight increase in the percentage of Government-and-contractor production hauled by truck is accounted for by the increase in output of sand and gravel classified under this category.

Employment and Productivity.—Although many sections of the country had a longer operating season very little change occurred in the average number of men reported as working or in the total man shifts. There is no discernible relation shown between the tonnages of sand and gravel produced in the various States and average output per man.

TABLE 8.—Number and production of domestic commercial sand and gravel plants by size of operation

Annual production (short tons)	1962				1963			
	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	1,876	35.9	18,604	3.3	2,528	43.3	51,217	8.7
25,000 to 50,000	912	17.5	32,960	5.8	895	15.3	32,702	5.5
50,000 to 100,000	939	18.0	66,826	11.8	896	15.4	64,410	10.9
100,000 to 200,000	744	14.3	103,624	18.3	756	13.0	103,874	17.6
200,000 to 300,000	322	6.2	78,267	13.8	301	5.1	73,542	12.4
300,000 to 400,000	158	3.0	53,248	9.4	150	2.6	51,154	8.6
400,000 to 500,000	80	1.5	35,365	6.2	85	1.5	36,998	6.3
500,000 to 600,000	48	.9	24,743	4.4	44	.7	24,054	4.1
600,000 to 700,000	37	.7	22,364	4.0	65	1.1	24,526	4.1
700,000 to 800,000	16	.3	12,001	2.1	23	.4	17,263	3.0
800,000 to 900,000	21	.4	17,730	3.1	22	.4	18,690	3.1
900,000 to 1,000,000	8	.2	7,537	1.3	16	.3	15,275	2.6
1,000,000 and over	60	1.1	93,710	16.5	54	.9	77,236	13.1
Total	5,221	100.0	566,979	100.0	5,835	100.0	590,941	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 methods of transportation

	1962		1963	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Commercial:				
Truck	476,664	61	502,501	61
Rail	60,734	8	59,271	7
Waterway	26,732	4	27,948	4
Unspecified	2,849	(1)	1,221	(1)
Total commercial	566,979	73	590,941	72
Government-and-contractor: Truck [2]	209,722	27	231,179	28
Grand total	776,701	100	822,120	100

[1] Less than 0.5 percent.
[2] Entire output of Government-and-contractor operations assumed to be moved by truck.

TABLE 10.—Employment in the commercial sand and gravel industry and average output per man in the United States in 1963, by States [1]

State	Employment					Production (thousand short tons)	Average output per man	
	Average number of men	Time employed						
		Average number of days	Total man shifts	Man-hours			Per shift	Per hour
				Average man per day	Total			
Alabama	490	246	120,656	8.4	1,012,183	5,079	42.1	5.0
Alaska	79	137	10,843	9.1	98,766	614	56.6	6.2
Arizona	563	230	129,525	8.0	1,041,022	8,119	62.7	7.8
Arkansas	745	230	171,571	8.6	1,470,190	7,699	44.9	5.2
California	4,399	229	1,006,793	8.1	8,128,408	93,835	93.2	11.5
Colorado	663	199	132,173	8.2	1,087,279	11,218	84.9	10.3
Connecticut	550	222	121,971	8.4	1,029,583	7,632	62.6	7.4
Delaware	77	213	16,405	8.4	137,271	1,095	66.7	8.0
Florida	354	264	93,533	8.8	826,977	7,258	77.6	8.8
Georgia	326	243	79,145	8.8	696,932	3,817	48.2	5.5
Hawaii	46	94	4,309	8.0	34,463	304	70.6	8.8
Idaho	238	129	30,724	8.1	248,041	1,723	56.1	6.9
Illinois	2,142	218	467,525	8.3	3,869,486	30,061	64.3	7.8
Indiana	1,052	239	251,034	8.9	2,234,610	22,147	88.2	9.9
Iowa	1,234	169	208,447	9.0	1,879,730	11,272	54.1	6.0
Kansas	763	207	158,310	8.9	1,410,534	9,763	61.7	6.9
Kentucky	384	274	105,067	9.7	1,013,908	6,273	59.7	6.2
Louisiana	955	274	261,266	8.4	2,193,993	12,125	46.4	5.5
Maine	345	153	52,638	8.7	460,054	2,000	38.0	4.3
Maryland	942	252	237,153	8.7	2,054,405	13,109	55.3	6.4
Massachusetts	1,067	199	211,923	8.4	1,774,076	16,015	75.6	9.0
Michigan	2,710	207	560,797	8.4	4,709,191	37,996	67.8	8.1
Minnesota	2,390	161	384,512	8.5	3,284,608	19,769	51.4	6.0
Mississippi	458	266	121,671	8.9	1,078,217	6,306	51.8	5.8
Missouri	650	237	154,236	8.6	1,323,973	9,808	63.6	7.4
Montana	223	128	28,570	8.1	230,269	2,873	100.6	12.5
Nebraska	957	205	196,380	9.7	1,901,420	9,895	50.4	5.2
Nevada	296	201	59,360	7.1	421,471	3,546	59.7	8.4
New Hampshire	221	168	37,122	8.6	318,215	3,203	86.3	10.1
New Jersey	1,211	237	287,492	8.4	2,406,839	16,664	58.0	6.9
New Mexico	406	186	75,690	8.4	636,228	4,174	55.1	6.6
New York	1,541	193	297,568	8.3	2,476,176	27,849	93.6	11.2
North Carolina	914	211	193,158	8.5	1,638,079	7,646	39.6	4.7
North Dakota	247	174	42,918	9.2	395,546	2,771	64.6	7.0
Ohio	2,398	220	526,637	8.4	4,415,575	36,812	69.9	8.3
Oklahoma	309	264	81,435	8.6	697,776	4,644	57.0	6.7
Oregon	862	205	176,450	8.1	1,421,657	8,929	50.6	6.3
Pennsylvania	1,414	212	300,313	8.7	2,621,604	13,989	46.6	5.3
Rhode Island	90	204	18,321	8.0	147,472	1,747	95.4	11.8
South Carolina	340	262	89,037	8.1	719,941	4,024	45.2	5.6
South Dakota	361	144	51,989	9.1	474,798	3,499	67.3	7.4
Tennessee	628	249	156,241	8.6	1,336,117	6,956	44.5	5.2
Texas	2,064	267	552,091	8.7	4,829,518	27,511	49.8	5.7
Utah	323	188	60,642	8.2	494,248	5,779	95.3	11.7
Vermont	132	212	27,954	8.8	244,970	1,090	39.0	4.4
Virginia	701	229	160,228	9.2	1,472,792	10,177	63.5	6.9
Washington	864	187	161,808	8.0	1,294,045	12,399	76.6	9.6
West Virginia	577	212	122,295	9.3	1,141,419	4,808	39.3	4.2
Wisconsin	2,233	181	403,575	8.5	3,425,886	22,746	56.4	6.6
Wyoming	180	148	26,695	7.9	211,682	2,173	81.4	10.3
Total	43,114	214	9,226,196	8.5	78,471,643	590,941	64.1	7.5

[1] Excludes operations by or for States, counties, municipalities, and Federal Government agencies. All employment data are preliminary.

CONSUMPTION AND USES

Construction Uses.—Commerical production of building sand and gravel, 254 million tons, valued at $290 million represented an 8-percent increase in tonnage and a 7-percent increase in value over that of 1962. Use of sand and gravel for paving declined both in value and tonnage. Production of sand and gravel for railroad ballast also diminished.

Industrial Sands.—Increases were noted in the production of unground sand for filtration, molding, oil well strata fracturing, and grinding and polishing. A notable increase was reported for ground sand used in glass manufacturing. It should be observed that the incorrect figure reported in 1962 for ground sand used in foundries has been revised.

TABLE 11.—Ground sand sold or used by producers in the United States,[1] by uses

Use	1962		1963	
	Short tons	Value	Short tons	Value
Abrasives	278,355	$2,112,076	281,409	$2,056,810
Chemicals	11,952	116,010	15,723	173,063
Enamel	14,263	148,837	14,662	165,791
Filler	69,411	718,629	86,650	678,140
Foundry uses	[2] 193,990	[2] 1,198,989	145,410	1,076,401
Glass	76,216	587,647	105,481	714,649
Pottery, porcelain, and tile	180,313	1,829,964	202,535	2,107,898
Unspecified	494,880	4,327,304	186,996	1,945,367
Total	[2] 1,319,380	[2] 11,039,456	1,038,866	8,918,119

[1] Arkansas, California, Georgia, Idaho, Illinois, Indiana, Massachusetts (1962 only), Michigan, Minnesota, Mississippi, Missouri, Nevada (1962 only), New Jersey, New York (1963 only), Ohio, Oklahoma, Pennsylvania, South Carolina, Texas, Virginia, Washington (1962 only), West Virginia, and Wisconsin.
[2] Revised figure.

PRICES

The average value for commercially produced sand and gravel was $1.12 per ton, the same as in 1962; that for Government-and-contractor production was $0.81, an increase of $0.05 per ton. Representative prices per ton for construction sand in various metropolitan centers were as follows. Birmingham, $1.30, Boston, $3.00, Chicago, $4.13, Denver, $1.42, Minneapolis, $1.70, New York, $2.45, and San Francisco, $2.35.[3]

FOREIGN TRADE

Over 1 million tons of sand and gravel was exported to Canada, in 1963, having an average value of $2.67 per ton. Exports of sand to the United States from Canada were 331,840 tons, valued at $423,154.

[3] Engineering News-Record. V. 172, No. 2, Jan. 9, 1964, p. 48.

TABLE 12.—U.S. imports for consumption of sand and gravel by classes

Year	Sand				Gravel		Total	
	Glass sand [1]		Sand, n.s.p.f., crude or manufactured					
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1954–58 (average)	3,636	[2] $300,754	305,896	[3] $412,042	5,348	[3] $6,253	314,880	[3] $719,049
1959	101	[2] 91,414	348,331	463,589	102,878	92,967	451,310	647,970
1960	10,765	37,111	379,673	515,837	3,752	5,423	394,190	558,371
1961	2	[2] 1,602	335,005	440,759	43,287	44,009	378,294	486,370
1962	31,416	63,950	307,637	414,703	29,198	31,948	368,251	510,601
1963	22,724	68,650	336,547	430,165	(4)	(4)	359,271	498,815

1 Classification reads: "Sand containing 95 percent or more silica and not more than 0.6 percent oxide of iron and suitable for manufacturing glass."
2 Consists mainly of synthetically prepared silica from West Germany for specialized uses and is not comparable in value to ordinary glass sand.
3 Data known not to be comparable with other years.
4 Sand, n.s.p.f. crude or manufactured and gravel no longer separately classified.

Source: Bureau of the Census.

WORLD REVIEW

Canada.—The estimated production of sand and gravel in 1963 was 185,498,913 short tons valued at Can$121,167,131. The Provinces of Ontario and Quebec were the leading producers.[4] Production of quartz was estimated to be 1,942,355 tons valued at Can-$4,209,777.[5]

TECHNOLOGY

General.—Excavation of a tight composite of decomposed granite, brown clay, and well-cemented sandstone, in a residential area where blasting was not feasible, was accomplished by use of medium-volume, high-powered rippers, and earth movers.[6]

An illustrated publication describing the operational methods of nine sand and gravel producers, working deposits located in rapidly growing suburban areas, was issued. Of particular interest were tables showing population trends and zoning ordinances adopted by seven of the communities.[7]

Methods of quarrying high purity silica and processing it for flux, glass, and ceramics, developed by two Canadian producers were described.[8]

Dredging.—One of the first dredgers in England to use the jet venturi principle for pumping sand and gravel from a wet pit was recently installed at a pit on the Thames River, Middlesex, England.[9]

4 Canadian Mining and Metallurgical Bulletins, Montreal, Canada. V. 57, No. 621, January 1964, pp. 28–29.
5 Toombs, R. B. Canadian Minerals in National and International Perspective. Dept. of Mines and Tech. Surveys, Ottawa, Canada. Mineral Inf. Bull. MR 75, 1964, 63 pp.
6 Roads and Streets. Armored Teeth Helped Handle Tough Ripping. V. 106, No. 6, June 1963, pp. 60–61, 64–65.
7 Marshall, L. G. Sand and Gravel Operations and Costs, Minneapolis-St. Paul Area, Minn. BuMines Inf. Circ. 8157, 1963, 66 pp.
8 Mamen, C. High Purity Silica in Quebec. Canadian Min. J. (Gardenvale, Quebec, Canada). V. 84, No. 5, May 1963, pp. 39–46.
9 Cement, Lime and Gravel (London). The Use of Jet-Suction Dredgers in Sand and Gravel Operations V. 38, No. 3, March 1963, pp. 73–78.

Two illustrated articles described the new floating sand and gravel plant of the Cooley Gravel Co., Denver, Colo.[10]

An all-steel multipurpose portable dredge was designed for a St. Paul contractor for use either in a sand and gravel operation or for land fill work. The dredge which can be hauled on five trailers can be dismounted or assembled in less than 1 week.[11]

Bowl, cone, and spiral classifiers enabled a Kansas producer to maintain quality production of concrete and masonry sand from material dredged from the Kaw River.[12]

The barge-mounted sand and gravel plant operated by Material Service, a division of General Dynamics Corp., near Morris, Ill., was able to produce 750 tons per hour of classified sand and gravel. Transportation of the product to other company plants or to the distribution yard is by barge.[13]

The Robertson Sand and Gravel Co., Sacramento, Calif., on the American River, used two dredges to supply semiportable reclaiming plants.[14]

Recent improvements in dredging equipment were discussed.[15]

Methods and equipment used to dredge and process sand and gravel from a fluvio-glacial deposit in the Raccoon River valley, near West Des Moines, Iowa, were described.[16]

Processing Equipment.—The general aspects of removal of clay from sand and gravel were discussed from the viewpoint of using cylindrical-type scrubbers.[17]

The methods used to quarry and process a ferruginous sandstone deposit, in the United Kingdom, were described. Apart from the chief product of the plant, which is a complete range of carefully graded industrial sands, artificially colored sands and resin-coated molding sands are manufactured.[18]

A description was given of the methods and equipment used by a French producer to prepare sands to meet two widely divergent specifications at a single plant using the same raw material. One product was sand for use in precast concrete requiring a high percentage of minus 16-mesh plus 52-mesh material and free from minus 200 mesh. The other specification was for a fine sand for wearing course aggregate, required 17 to 25 percent of fines minus 200 mesh.[19]

Foundry Sand.—Installation of a limited, or partially mechanized, sand conditioning system instead of a more costly, fully mechanized system was found to be profitable for smaller foundries.[20]

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[10] Mitchell, Renald J. Gravel Gertie IV. Rock Products, v. 66, No. 10, October 1963, pp. 59–63. Pit and Quarry. Cooley Gravel Maintains Progress Record. V. 56, No. 4, October 1963, pp. 84–92.

[11] Rock Products. Dredge Transforms Mississippi Mud To Fill. V. 66, No. 1, January 1963, p. 125.

[12] Trauffer, Walter E. Stewart's New Sand Plant Serves Kansas City Metropolitan Area. Pit and Quarry, v. 56, No. 5, November 1963, pp. 121–123, 145.

[13] Lindsay, George C. Floating Sand Plant. Rock Products, v. 66, No. 3, March 1963, pp. 70–76.

[14] Rock Products. Double Dredges Feed Semi-Portable Plants. V. 66, No. 8, August 1963, pp. 62–74.

[15] Kaufmann, Carl P. Dredges Meet "Sink or Swim" Challenge of Underwater Deposits. Rock Products, v. 66, No. 6, June 1963, pp. 89–93, 140.

[16] Marshall, L. G. Sand and Gravel Operations and Costs, Concrete Materials and Construction Division, Martin Marietta Corp., West Des Moines, Iowa. BuMines Inf. Circ. 8202, 1963, 14 pp.

[17] Parker, F. W. The Cleansing of Sand and Gravel. Cement, Lime and Gravel (London). V. 38, No. 3, March 1963, pp. 91–92.

[18] Cement, Lime and Gravel (London). The Winning and Processing of Industrial Sands. V. 38, No. 2, February 1963, pp. 53–58.

[19] Collenot, M. A. A New Fine Sand Preparation Plant. Cement, Lime and Gravel (London), v. 38, May 1963, pp. 157–161.

[20] McIlvaine, R. W. How to Benefit From a Limited Sand System. Foundry, v. 91, No. 11, November 1963, pp. 134–144.

Details of successful procedures in the use of olivine sands for molding, coremaking, mold washes, and ladle lining were reported.[21]

Experimental data of research conducted on the compaction of unbonded molding sands were reported.[22]

The factors to be considered in selecting a molding sand were discussed.[23]

A completely integrated system for processing resin coated sand for molds and cores was installed in a Lynchburg, Va., foundry. Controls provided for either manual or automatic operation. The equipment was capable of producing 1 ton of coated sand per minute.[24]

A new plant was built in Bellingham, Wash., to make foundry sand from olivine. Production of 150 tons per day was planned.[25]

Foundry.—The advantages and disadvantages of both dry and wet methods for reclaiming foundry sand were discussed.[26]

Details of progress in mechanization of the European foundry industry were reported.[27]

Glass.—Glass beads, said to be superior to other materials used in hydraulic fracturing of oil-bearing formations, were developed.[28]

Glass or glass-ceramic mixtures suspended in a resinous or water base slurry were used to prevent oxidation, carburization, or decarburization during heat treatment of stainless, high-carbon, and alloy steels.[29]

Hollow, flame-sealed bricks having a partial vacuum inside were developed for use in the construction of skylights, vaults, domes, and porches. The partial vacuum gives freedom from condensation, superior light diffusion, and good heat and sound insulation.[30]

Spun glass was used as the base for making battery separators.[31]

Manufacturing rights to the Pilkington float glass process have been obtained by France's Societe Glaces de Boussois and Compagnie Saint Gobain. Saint Gobain plans to build a float process plant near Turin, Italy.[32]

A new float-glass plant for production of windshield glass was built near Lathrop, Calif.[33]

Ground was broken for the new multimillion dollar Pittsburgh Plate Glass Co. float-glass plant at Cumberland, Md.[34]

Glass.—The prime factors to be considered in designing automatic batching systems for the glassmaking industry were discussed.[35]

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21 Gould, Herbert E. Olivine in the Ferrous Foundry. Foundry, v. No. 10, October 1963, pp. 84–89.

22 Yearley, B. C. Effect of Green Properties on Ramming of Sand. Foundry, v. 91, No. 10, October 1963, pp. 76–79; No. 11, November 1963, pp. 64–67.

23 Parker, W. B. Choosing a Moulding Sand. Metal Industry (London), v. 102, No. 20, May 16, 1963; No. 21, May 23, 1963, pp. 682–684.

24 Metalworking News. Lynchburg Undertakes $1 Million Improvement. V. 4, No. 154, Aug. 19, 1963, p. 15.

25 Mining World. What's Going On in the Mining World. V. 25, No. 9, August 1963, p. 48.

26 Friedlander, Dan. Production Trial for Dry Sand Unit. Metalworking News, v. 4, No. 172, Dec. 9, 1963, p. 16.

27 Zimnawoda, Henry W. Mechanization Trend Accelerated in European Foundries. Foundry, v. 91 No. 1, January 1963, pp. 104–105, 107, 110.

28 Chemical Week. V. 92, June 22, 1963, p. 49.

29 Sandford, J. E. Molten Glass Protects Hot Steel. Iron Age, v. 192, No. 17, Oct. 24, 1963, pp. 80–81.

30 South African Mining & Engineering Journal (Johannesburg, Republic of South Africa). Insulating With Glass Bricks. V. 74, Pt. 1, No. 3659, Mar. 22, 1963, p. 668.

31 Ceramic Age. Wire Belts Speed Production of Glass Battery Separators. V. 79, No. 3, March 1963, p. 66.

32 Ceramic Age. Float Glass in Common Market. V. 79, No. 7, July 1963, p. 10.

33 Chemical Week. V. 93, No. 3, July 20, 1963, p. 31.

34 Ceramic Age. Ground Broken for PPG's "Float Process" Plant. V. 79, No. 4, April 1963, p. 11.

35 Gold, Alvin J. Automatic Glass Batching—Key to Modern Glass Making. Ceram. Ind., Pt. 1, v. 80, No. 6, June 1963, pp. 60–62; Pt. 2, v. 81, No. 1, July 1963, pp. 66–68, 76–79.

A method was developed by which batches of glassmaking ingredients in a wet free-flowing mixture could be fed directly to the glass forming furnace.[36]

A recent development in glassmaking related to a 90 percent silica glass which contained cerium oxide as an opacifying agent.[37]

Special Silicas.—A joint research organization, the International Calcium Silicate Products Research Organization, was formed by representatives from Holland, West Germany, and the United Kingdom to exchange information on development of calcium silicate bonded bricks and other building products.[38]

A new spray-drying plant which produces 15 tons per day of silica-alumina catalyst for petroleum cracking has gone into operation in Japan. By this process the catalyst is formed into minute spheres having maximum reactive surfaces.[39]

The techniques developed for forming inorganic coatings on fine particles such as silica were discussed.[40]

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[36] Krinov, Stanley (assigned to Pittsburgh Plate Glass Co.). Method of Preparing Glass Batch Ingredients. U.S. Pat. 3,081,180, Mar. 12, 1963.

[37] Elmer, Thomas H (assigned to Corning Glass Works). Opal, 96 percent Silica Glass and Method of Production. U.S. Pat. 3,054,221, Sept. 18, 1962.

[38] European Chemical News (London). Research on Calcium Silicate Products. V. 3, No. 53, Jan. 18, 1963, p. 29.

[39] European Chemical News (London). New Catalyst Plant in Japan. V. 3, No. 55, Feb. 1, 1963, p. 26.

[40] Dunn, E. J., Jr., and Martin Kushner. Coated Pigments Technology. Ind. & Eng. Chem., v. 2, No. 1, March 1963, pp. 4–8.

Silicon

By Gilbert L. DeHuff [1]

PRODUCTION and consumption of metallurgical silicon metal (97 to 98 percent grade) carried along at the same levels as for 1962.

High purity silicon output declined and three companies stopped production. The decline appeared due to increased efficiency in use and in fabrication and not to lessened demand for silicon electronic units.

DOMESTIC PRODUCTION

E. I. du Pont de Nemours & Co., Inc., ceased production of electronic-grade silicon early in 1963, and by the close of the year Merck & Co., Inc., and Trancoa Chemical Corp. had ended production. Other prime producers which were active in 1963 were: Allegheny Electronic Chemicals Co., Lewis Run, Pa.; Dow Corning Corp., Hemlock, Mich.; Linde Co., division of Union Carbide Corp., Cleveland, Ohio; Mallinckrodt Chemical Works, St. Louis, Mo.; Monsanto Chemical Corp., St. Charles, Mo.; and Texas Instruments, Inc., Dallas, Tex.

TABLE 1.—Production, shipments, and value of high-purity silicon in the United States

Type	1962			1963		
	Production (kilograms)	Shipments		Production (kilograms)	Shipments	
		Quantity (kilograms)	Value (thousands)		Quantity (kilograms)	Value (thousands)
Polycrystal	36,902	37,046	$4,922	34,582	24,539	$3,041
Single crystal: [1]						
Negative:						
Rods	5,932	5,139	5,288	3,758	3,027	3,098
Slices [2]	2,117	2,104	4,008	1,651	1,656	3,529
Total	8,049	7,243	9,296	5,409	4,683	6,627
Positive:						
Rods	990	(3)	1,387	485	547	544
Slices [2]	582	(3)	905	771	687	953
Total	1,572	1,600	2,292	1,256	1,234	1,497
Total single-crystal	9,621	8,843	11,588	6,665	5,917	8,124

[1] Does not include data for companies producing single-crystal high-purity silicon solely from scrap and other secondary and purchased polycrystal.
[2] Includes epitaxial wafers.
[3] Figure withheld to avoid disclosing individual company confidential data.

[1] Commodity specialist, Division of Minerals.

Silicon metal for metallurgical use was produced in 11 plants of 7 companies, as follows:

Company:	*Plant location*
Keokuk Electro-Metals Co., Division of Vanadium Corporation of America	Wenatchee, Wash.
National Metallurgical Corp., subsidiary of Apex Smelting Co.	Springfield, Oreg.
Ohio Ferro-Alloys Corp	Brilliant, Ohio
Do	Philo, Ohio
Do	Powhatan Point, Ohio
Do	Tacoma, Wash.
Pittsburgh Metallurgical Co	Charleston, S.C.
Do	Niagara Falls, N.Y.
Reynolds Metals Co	Sheffield, Ala.
Tennessee Products & Chemical Corp	Rockwood, Tenn.
Union Carbide Metals Co., Division of Union Carbide Corp.	Alloy, W. Va.

TABLE 2.—Net production, shipments, and stocks of silvery pig iron, ferrosilicon, and silicon metal in 1963

(Short tons, gross weight)

Alloy and percent of silicon contained	Net production	Shipments	Stocks as of Dec. 31
Silvery pig iron:			
Blast furnace: 5–13	63,908	70,975	24,221
Electric furnace: 14–20	132,545	133,090	18,727
Ferrosilicon:			
21–55	276,256	285,765	41,965
56–70	20,922	22,172	5,142
71–80	63,646	63,415	13,777
81–89	14,288	14,635	2,903
90–95	1,944	2,302	590
Silicon metal: 96–99	64,574	65,005	5,998
Ferrosilicon briquets: 40–50	45,704	45,366	4,086
Miscellaneous silicon alloys	12,276	13,219	3,564
Total	696,063	715,944	120,973

CONSUMPTION AND USES

Polycrystal high-purity silicon shipments in 1963 decreased 34 percent from the quantity shipped in 1962, and the total value of these shipments decreased 38 percent. Shipments of monocrystal high-purity silicon similarly decreased—quantity by 33 percent and total value by 30 percent. The Bureau's statistics for monocrystal do not include data for companies that do not make polycrystal.

The high-purity silicon shipments went primarily to the electronic industry for fabrication into rectifiers, transistors, diodes, and solar cells. Increase in the number of such fabricated silicon products, in the face of diminished output of high-purity silicon, reflected increased efficiency in fabrication as well as greater use of the higher purity grades of silicon.

Silicones were in demand as additives to rubber and plastics, release agents, water-repellents, lubricants, and adhesives. They are stable over a wide temperature range from 70° C to 250° C or more, have good dielectric properties, low surface tension, and are not toxic. Specific applications of interest in 1963 were: As water-repellent coatings to protect electronic circuits, in cosmetics to provide a water-repellent nongreasy film, as a constituent of water-repellent paints, as process aids in the oil and gas industries, and to provide rust resistance to metals. The silicones are derived from the regular 97 to 98 percent grade of silicon metal using silicon tetrachloride as an intermediary.

The principal uses of silicon carbide continued to be as an abrasive and, to a lesser extent, for refractories. However, various grades of briquetted or granular silicon carbide were used as a deoxidizing agent in the production of steel, and granular silicon carbide was used by the oil industry as a catalyst.

TABLE 3.—Consumption by major end uses, and stocks, of silicon alloys in the United States in 1963

(Short tons, gross weight)

Alloy and percent of silicon contained	Stainless steels	Other alloy steels [1]	Carbon steels	Tool steels	Steel mill rolls	Gray and malleable castings
Silvery pig iron:						
5–13	1	731	731	----------	775	85,970
14–20	1	6,571	19,258	----------	114	99,668
Ferrosilicon:						
21–55 [3]	6,710	53,783	85,469	815	914	71,527
56–70	401	5,468	13,941	----------	----------	822
71–80	8,297	11,148	5,722	445	215	11,294
81–89	106	804	2,165	----------	137	4,307
90–95	25	1,226	168	----------	45	277
Silicon metal: 96–99	11	120	55	10	----------	419
Ferrosilicon briquets: 40–50	----------	144	320	----------	17	32,426
Miscellaneous silicon alloys [6]	277	6,025	5,260	54	128	14,228
Total	15,829	86,020	133,089	1,324	2,345	320,938

Alloy and percent of silicon contained	Aluminum base alloys	High temperature alloys	Other alloys	Miscellaneous uses	Total consumption	Stocks Dec. 31, 1963
Silvery pig iron:						
5–13	----------	----------	1	1,771	89,980	6,588
14–20	----------	----------	51	[2] 6,437	132,100	12,643
Ferrosilicon:						
21–55 [3]	44	189	2,410	[4] 16,941	238,802	19,366
56–70	----------	----------	----------	[4] 4,167	24,799	1,128
71–80	----------	22	32	11,014	48,189	4,386
81–89	----------	----------	18	11	7,548	938
90–95	2,563	----------	61	7	4,372	418
Silicon metal: 96–99	32,913	568	734	[5] 7,946	42,776	2,071
Ferrosilicon briquets: 40–50	----------	----------	----------	4	32,911	3,412
Miscellaneous silicon alloys [6]	107	68	53	3,951	30,151	2,279
Total	35,627	847	3,360	52,249	651,628	53,229

[1] Includes quantities of carbon steels because some firms failed to specify individual uses.
[2] Used mainly in high-silicon iron and to beneficiate ores.
[3] Mainly from 40 to 55 percent silicon.
[4] Used mainly in producing ferronickel.
[5] Used mainly in silicones and other chemical compounds.
[6] Includes calcium-silicon, calcium-manganese-silicon, silicon-manganese-zirconium, Ferrocarbo (including briquets), Alsifer, and other miscellaneous silicon alloys.

STOCKS

Producers stocks of polycrystal high-purity silicon at yearend totaled 7,413 kilograms, an increase of 65 percent. Stocks of high-purity monocrystal held by the prime producers decreased 32 percent to 1,622 kilograms.

Yearend producers stocks of silvery pig iron were little changed from those held at the beginning of the year; overall producers stocks of silicon alloys and metal dropped 8 percent.

PRICES

The average value of polycrystal high-purity silicon shipped in 1963 was $124 per kilogram, dropping from $128 for the first quarter to $112 for the final quarter of the year, large price reductions having been announced in April. Expanded plant capacity, more efficient production techniques, and lessened demand occasioned by more efficient fabrication techniques, were said to have been factors. The average value of the year's shipments of monocrystal high-purity silicon, including epitaxial wafers, was $1,373 per kilogram.

Silicon metal, lump, bulk, carloads, 97 to 98 percent minimum silicon, 0.35 percent maximum iron, was quoted by American Metal Market at the end of the year at 17.5 cents per pound, reflecting a drop of 4 cents.

FOREIGN TRADE

Imports of ferrosilicon for consumption decreased 18 percent from those imported in 1962. Almost all of the 1963 imports came from Canada and contained less than 60 percent silicon. There were no imports for consumption of metallurgical grades of silicon metal, nor of ferrosilicon containing more than 80 percent silicon.

A new statistical classification of imports became effective August 31, 1963. Under the new classification, the 8 to 30 and the 30 to 60 percent silicon grades of ferrosilicon were combined into one grade containing over 8 percent but not over 60 percent silicon; classifications remained for over 60 but not over 80, for over 80 but not over 90, and for over 90 percent silicon. A new classification for silicon metal containing not over 99.7 percent silicon will report the metallurgical grades of silicon metal, previously reported simply as silicon metal.

Imports of high-purity silicon were previously lost in a blanket classification with other elements and chemical compounds. They now will be specifically reported as silicon metal containing over 99.7 percent silicon. Imports for consumption of high-purity silicon under this new classification in the last 4 months of 1963 were reported as 856 pounds, valued at $34,949, all from West Germany. The average value of these imports was $90 per kilogram.

TABLE 4.—U.S. imports for consumption of ferrosilicon and silicon metal, by grades and countries

	1961			1962			1963		
	Short tons		Value	Short tons		Value	Short tons		Value
	Gross weight	Silicon content		Gross weight	Silicon content		Gross weight	Silicon content	
Ferrosilicon:									
8 percent and less than 60 percent silicon:									
Canada	13,094	2,179	$683,812	15,172	2,359	$782,588	12,781	1,962	$667,616
Germany, West	580	87	109,403	1,086	163	180,948	38	5	4,850
Total	13,674	2,266	793,215	16,258	2,522	963,536	12,819	1,967	672,466
60 percent and less than 80 percent silicon:									
Canada	35	24	6,438	53	37	9,366	--------	--------	--------
France	--------	--------	--------	11	8	1,873	132	101	17,326
Italy	--------	--------	--------	--------	--------	--------	22	17	2,959
Norway	--------	--------	--------	5	4	845	291	220	38,739
South Africa, Republic of	21	17	3,630	2	2	272	--------	--------	--------
Total	56	41	10,068	71	51	12,356	445	338	59,024
Grand total	13,730	2,307	803,283	16,329	2,573	975,892	13,264	2,305	731,490
Silicon metal:									
Canada	--------	--------	--------	12	12	5,015	--------	--------	--------
France	31	30	8,206	--------	--------	--------	--------	--------	--------
Total	31	30	8,206	12	12	5,015	--------	--------	--------

Source: Bureau of the Census.

Exports of ferrosilicon in 1963 decreased 24 percent from those of 1962. As in 1962, more than half of the exports went to Canada; the remainder was distributed among 22 other countries.

TABLE 5.—U.S. exports of ferrosilicon

Year	Short tons	Value	Year	Short tons	Value
1954–58 (average)	2,142	$410,082	1961	34,764	$6,104,913
1959	10,558	980,658	1962	4,101	1,348,661
1960	5,501	867,140	1963	3,130	947,773

Source: Bureau of the Census.

WORLD REVIEW

Canada.—Union Carbide Canada, Ltd., was installing a second rotating-hearth electric furnace at its Beauharnois, Quebec, plant. When completed in July 1964, the addition will bring to 12,500 tons the annual plant capacity for production of silicon metal and alloys.

Japan.—Production of polycrystal silicon for semiconductor applications was 10,700 kilograms in 1963, compared with an estimated capacity of 13,000 kilograms and a 1962 production of 6,300 kilograms.[2] An 18,000 kilowatt silicon rectifier ordered by an Indian chemical plant will be the largest ever exported from Japan. A 7,500 kilowatt silicon rectifier was shipped to India in 1962.[3]

Norway.—A new silicon carbide plant, having an initial capacity of 4,000 tons per year, was completed at Orkdal in mid 1963. The firm, Orkla Exolon, is jointly owned by Orkla Grube A/S, Christiania Spigerverk, and the Exolon Co. of Tonawanda, N.Y.[4] Silicon metal and ferrosilicon were among the principal products of Fiskaa Verk, Kristiansand.[5]

TECHNOLOGY

In laboratory experiments using induction heating at the Bureau's Norris Metallurgy Research Laboratory, silicon carbide fibers were rapidly synthesized by thermal decomposition of inexpensive silicates in graphite crucibles. Temperatures exceeded 1,365° C, and carbon requirements were provided by the crucibles.[6]

Pinhead-size single crystals of silicon carbide became available on a production basis for use as thermistors having a standard rating of 2,600 ohms, ±2 percent at 25° C. The thermistors, which convert thermal changes into electrical resistance changes, were claimed to be good with respect to resistance reproducibility, stability, temperature coefficient, and response time.[7]

Large, relatively pure, silicon carbide crystals for use in high temperature electronic devices were obtained by applying heat to one side of a sandwich consisting of a thin layer of chromium-based alloy between two slices of silicon carbide. A single crystal extension grows on the cooler silicon carbide slice, while the hotter one is reconstituted as a single crystal.[8]

A silicon carbide diode laser, developed by Tyco Laboratories, Inc., Waltham, Mass., was claimed to be "the first laser capable of direct and continuous conversion of electric current to coherent, monochromatic light at room temperature." This was achieved with threshold current densities as low as 120 amperes per square centimeter. The high energy concentration was obtained with light output in the blue region of the spectrum. A storage battery can be used as the energy source.[9]

Complete electronic circuits etched, or otherwise processed, on small silicon wafers less than a quarter dollar in size and down to one-eighth inch or smaller, assume the functions of as many as 50 component resistors, capacitors, transistors, and diodes. The miniaturization resulting from such integrated circuits is in demand for the guidance and control systems of various missiles and aerospace craft.[10]

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[2] Electronic News. V. 9, No. 422, Mar. 23, 1964, p. 102.
[3] Chemical Trade Journal and Chemical Engineer (London). V. 153, No. 3978, Sept. 6, 1963, pp. 356, 358.
[4] Chemical Trade Journal and Chemical Engineer (London). V. 153, No. 3969, July 5, 1963, p. 26.
[5] Mining Journal (London). V. 261, No. 6682, Sept. 13, 1963, p. 240.
[6] Alley, John K., Robert C. Johnson, Charles Huggins, and H. R. Shell. Synthesis of Fibrous Silicon Carbide by Thermal Reduction of Silicates and Silicon Compounds. BuMines Rept. of Inv. 6220, 1963, 19 pp.
[7] Metal Progress. V. 84, No. 6, December 1963, p. 9. J. Metals. V. 16, No. 1, January 1964, p. 14.
[8] American Metal Market. V. 70, No. 190, Oct. 2, 1963, p. 15.
[9] Iron Age. V. 192, No. 11, Sept. 12, 1963, p. 15. Chemical Week. V. 93, No. 11, Sept. 14, 1963, p. 52.
[10] American Metal Market. V. 70, No. 176, Sept. 12, 1963, p. 9.
Electronic News. V. 8, No. 391, Aug. 22, 1963, p. 10.
Wall Street Journal. V. 163, No. 65, Apr. 1, 1964, pp. 1, 14.

High rectifying efficiency, long life, simplicity of construction, relatively low cooling-water demand, and relatively low initial and maintenance costs were claimed as advantages to be gained by replacing ignitron tubes by silicon diode assemblies in industrial power conversion systems.[11]

Epitaxial silicon preparation [12] continued to be a subject for technical papers, as did its fabrication into diodes, [13] and the chemical polishing of silicon wafers.[14]

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[11] Electonic News. V. 8, No. 393, Sept. 2, 1963, p. 29.
Viola, James A. Simple Equipment Available to Convert Ignitron to Silicon Rectifiers. Iron and Steel Eng., v. 60, No. 9, September 1963, pp. 226, 229, 230.

[12] Bhola, S. R., and A. Mayer. Epitaxial Deposition of Silicon by Thermal Decomposition of Silane. RCA Review, v. 24, No. 4, December 1963, pp. 511–522.
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Joyce, B. A., and R. R. Bradley. Epitaxial Growth of Silicon From the Pyrolysis of Monosilane on Silicon Substrates. J. Electrochem. Soc., v. 110, No. 12, December 1963, pp. 1235–1240.

[13] Kressel, H., and M. A. Klein. High-Power Epitaxial Silicon Varactor Diodes. RCA Review, v. 24, No. 4, December 1963, pp. 616–626.

[14] Lang, G. A., and T. Stavish. Chemical Polishing of Silicon With Anhydrous Hydrogen Chloride. RCA Review v. 24, No. 4, December 1963, pp. 488–498.
Richards, W. H., and H. D. Dibble. A Process for Chemically Polishing Silicon Wafers. Electrochem Tech. pt. 1, v. 2, Nos. 1-2, January-February 1964, pp. 51–52.

Silver

By J. P. Ryan [1]

SALIENT features of the silver industry in 1963 were the rise in the market price of silver to its monetary value, and the enactment of legislation which repealed the silver purchase laws and transactions tax and the authorized replacement of one-dollar silver certificates by Federal Reserve notes. Repeal of the tax on transfers of interest in silver bullion opened the way for trading in silver futures; authorizing the issuance of the Federal Reserve notes provided for eventual elimination of silver as a backing for U.S. currency. Notwithstanding the increase in the silver price, domestic mine production dropped slightly; industrial consumption remained about the same as in 1962, but U.S. coinage requirements advanced sharply. Net imports dropped to less than one-half those in 1962.

A 2-months shutdown of the Sunshine mine in Idaho because of a labor strike was the principal factor in the domestic production decline.

Consumption of silver for some uses such as sterling declined and was curtailed in other uses as the price of silver continued to rise, but increases were noted in the consumption of silver for some industrial uses, particularly electrical and electronic products. Demand for subsidiary silver coins increased as the use of coin-operated vending machines and meters continued to expand and coin collectors and speculators withdrew more coins from circulation. U.S. industrial and coinage requirements accounted for slightly more than one-half of the total free world consumption of silver. Free world production of silver increased slightly over 1962. Overall consumption was about 70 percent greater than production.

LEGISLATION AND GOVERNMENT PROGRAMS

Public Law 88–36 to repeal certain legislation relating to the purchase of silver and for other purposes, was enacted by the 88th Congress.

Title I—Silver Bullion, Silver Certificates, and Federal Reserve Notes

Section 1. The Silver Purchase Act of 1934 (31 U.S.C. 311a, 316a, 316b, 405a, 448–448e, 734a, and 734b), section 4 of the Act of July 6, 1939 (31 U.S.C. 316c) and the Act of July 31, 1946 (31 U.S.C. 316d), are hereby repealed.

[1] Commodity specialist, Division of Minerals.

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Section 2. The Secretary of the Treasury shall maintain the ownership and the possession or control within the United States of an amount of silver of a monetary value equal to the face amount of all outstanding silver certificates. Unless the market price of silver exceeds its monetary value, the Secretary of the Treasury shall not dispose of any silver held or owned by the United States in excess of that required to be held as reserves against outstanding silver certificates, but any such excess silver may be sold to other departments and agencies of the Government or used for the coinage of standard silver dollars and subsidiary silver coins. Silver certificates shall be exchangeable on demand at the Treasury of the United States for silver dollars or, at the option of the Secretary of the Treasury, at such places as he may designate, for silver bullion of a monetary value equal to the face amount of the certificates.

Section 3. The first sentence of the ninth paragraph of section 16 of the Federal Reserve Act (12 U.S.C. 418) is amended by inserting "$1, $2," immediately after "notes of the denominations of".

Title II—Repeal of Tax on Transfers of Silver Bullion

Sec. 201. (a) Subchapter F of chapter 39 of the Internal Revenue Code of 1954 (relating to silver bullion) is hereby repealed.

(b) The table of subchapters for such chapter 39 is amended by striking out the last line thereof.

(c) Section 6422 of such Code (relating to cross references) is amended by striking out paragraph (7) and by renumbering paragraphs (8), (9), (10), (11), (12), (13), and (14) as paragraphs (7), (8), (9), (10), (11), (12), and (13), respectively.

(d) Section 6808 of such Code (relating to special provisions relating to stamps) is amended by striking out paragraph (11) and by renumbering paragraphs (12) and (13) as paragraphs (11), (12), respectively.

Sec. 202. Section 201 shall apply only with respect to transfers after the date of the enactment of this title.

Approved June 4, 1963.

Implementing Public Law 88–36, the Secretary of the Treasury issued the following instructions:

Pursuant to the authority of Public Law 88–36 of June 4, 1963, I hereby designate the United States Assay Office at New York City and the United States Assay Office at San Francisco as places where silver bullion may be obtained in exchange for silver certificates. All requests for silver bullion in exchange for silver certificates shall be directed to the Fiscal Assistant Secretary of the Treasury, Washington, D.C., 20220. Such requests may be made through the Federal Reserve Bank of New York, New York City, or the Federal Reserve Bank of San Francisco, San Francisco, California, attention Fiscal Agency Department.

At the time of making such request, silver certificates shall be tendered to the Treasurer of the United States, Washington, D.C., or the Federal Reserve Bank through which the request is made. If the request is made through one of the Federal Reserve Banks specified, other funds may be tendered, in a form satisfactory to the Bank. If funds other than silver certificates are tendered, they shall be accompanied by a request that the Federal Reserve Bank acquire for the account of the person making the tender silver certificates in an equivalent amount and that, upon acquisition of the required amount of silver certificates, they be accepted for the account of the assay office for exchange for silver bullion of equivalent value computed at the monetary value of silver of $1.292929292 per fine troy ounce. Delivery of the silver bullion shall be effected at the assay office in fine silver bars of approximately 1,000 ounces. The face amount of certificates tendered in exchange must be equal to the monetary value of the silver bullion raised to the next highest dollar.

Where consistent with the public interest, silver bullion shall be delivered at whichever of the designated assay offices is specified by the person requesting silver bullion.[2]

Four contracts totaling $620,660 were executed during 1963 for exploring silver deposits under the Government program of financial assistance to the mining industry administered by the Office of Minerals Exploration. The Government share of the exploration cost was 50 percent.

TABLE 1.—Salient silver statistics

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Mine production thousand troy ounces	37.027	31,194	30,766	34,794	36,798	35,243
Value thousands	$33,512	$28,232	$27,845	$32,167	$34,021	$45,076
Ore (dry and siliceous) produced:						
Gold ore thousand short tons	2,302	2,289	2,267	2,060	2,159	2,460
Gold silver ore do	127	137	347	248	353	223
Silver ore do	658	597	641	565	557	587
Percentage derived from—						
Dry and siliceous ores	34	45	37	39	33	33
Base-metal ores	66	55	63	61	67	67
Imports, general [1] thousand troy ounces	142,067	69,088	60,657	50,256	76,359	59,062
Exports [1] do	5,026	9,180	26,593	39,828	13,057	31,485
Stocks Dec. 31: Treasury million troy ounces	1,993	2,060	1,992	1,863	1,767	1,584
Consumption in industry and the arts thousand troy ounces	93,660	101,000	102,000	105,500	110,400	110,000
Coinage do	36,540	41,400	46,000	55,900	77,368	111,493
Price per troy ounce	[2] $0.905+	[2] $0.905+	[2] $0.905+	[3] $0.924+	[3] $1.085+	[3] 1.279+
World:						
Production thousand troy ounces	227,600	[4] 222,300	[4] 241,000	[4] 236,900	[4] 241,800	249,500
Consumption [5]—industry and the arts thousand troy ounces	194,520	[4] 212,900	[4] 224,600	[4] 239,500	[4] 247,800	247,000
Coinage do	71,260	86,400	[4] 103,900	[4] 137,100	[4] 136,400	172,200

[1] Excludes coinage.
[2] Treasury buying price for newly mined silver.
[3] Average New York price.
[4] Revised figure.
[5] Free world only.

[2] Federal Register. V. 28, No. 143, July 24, 1963, p. 7530.

DOMESTIC PRODUCTION

Mine output of recoverable silver in the United States dropped 4 percent to 35.2 million ounces, but value of the output increased 13 percent to $45.1 million compared with 1962, reflecting a 19 cent per ounce increase in the average price of silver. The falloff in production was attributed chiefly to suspension of operations at the Sunshine mine in Idaho in November and December due to a labor strike, the third such strike in 3 years.

Most of the principal silver-producing States, other than Idaho, also recorded lower production but production gains recorded in Colorado, Michigan, and Utah largely offset these losses. A 1-percent drop in Arizona's silver output reflected lower output of silver-bearing lead-zinc ores not fully offset by increased output of copper ore yielding byproduct silver. The 7-percent decline in silver production in Montana was due principally to reduced output of silver-bearing copper and zinc ores from Butte mines and miscellaneous shippers to the Anaconda Reduction Works. Nevada's silver production, recovered largely as a coproduct or byproduct of lead and copper ores, dropped as production of these allied base metals declined. A decrease in silver production in New Mexico also largely reflected lower yield from base metal ores. Silver output in Missouri, recovered almost entirely from the desilverization of lead bullion, dropped to about a third that recovered in 1962. A 6 month strike at the Herculaneum smelter which ended in March was the principal factor in the production drop. In Colorado, the gain in silver production was attributed chiefly to increased output of lead-zinc-silver ores at the Eagle and Idarado mines. Similarly, the small gain in Utah's silver output reflected increased production of silver-lead-zinc ores which more than offset a decrease in silver recovered as a byproduct of copper ore. A substantial quantity of silver was recovered from copper ore at the White Pine mine in Michigan.

Idaho, the leading silver-producing State, contributed 47 percent of the total domestic output. The four leading silver-producing States, Idaho, Arizona, Utah, and Montana, supplied nearly 88 percent of the total output.

Two-thirds of the total domestic silver output was recovered as a byproduct of ores mined chiefly for copper, lead, zinc, and gold; virtually all of the remainder came from ores in which silver was the principal product. Of the 25 leading silver-producing mines, only 4 in Idaho depended chiefly on the value of silver in ore. Eight mines producing over 1 million ounces each, supplied 60 percent of the total domestic output; the 25 leading mines (table 4) furnished 84 percent. Domestic mines supplied nearly one-third of the total silver used in the Nation's arts and industries.

Sunshine Mining Co., the leading producer, recovered 2.8 million ounces of silver, compared with 2.6 million ounces in 1962. The mine was closed for the last 2 months of the year because of a labor strike. Tons of ore milled declined slightly, but average grade increased from 35.1 to 38.2 ounces per ton. Operating costs averaged $33.54 per ton, compared with $32.44 in 1962. Ore reserves at the four units comprising the Sunshine operation totaled 457,700 tons at yearend compared with 359,700 in 1962.[3]

Lucky Friday Silver-Lead Mines Co. operated without interruption and milled 182,340 tons of ore averaging 19.5 ounces of silver per ton in addition to lead and zinc. Ore reserves at yearend were estimated at 767,000 tons.[4]

The 38-cent rise in the price of silver since November 1961 has provided the incentive for expanding exploration for new deposits, reopening some mines that had been closed for several years, and increasing output at operating mines. These effects, noted particularly in Idaho, Colorado, Montana, Nevada, Utah, Arizona, and in Canada, were described in considerable detail in a trade journal.[5]

Although detailed data on sources are not available, a substantial quantity of secondary silver was recovered by refiners from old jewelry, plate, film, and other forms of scrap. A large quantity of silver is also recovered from wornout coins and returned to monetary use by the U.S. Treasury. Secondary silver returned from industrial and monetary use for re-refining totaled nearly 94.5 million ounces.

Approximately 4,100 persons were employed in the silver- and gold-silver mining industry at 620 separate lode mining operations, compared with 3,900 persons at 570 mines in 1962.

Terminology and definitions used in classifying silver-bearing ores were described in the "Silver" chapter of the 1961 Minerals Yearbook.

Ore production and classification, methods of recovery, and metal yields, embracing all ores that yielded silver in the United States in 1963, are given in tables 6 to 9.

TABLE 2.—Silver produced in the United States according to mine and mint returns

(Thousand troy ounces of recoverable metal)

	1954–58 (average)	1959	1960	1961	1962	1963
Mine	37,027	31,194	30,766	34,794	36,798	35,243
Mint	37,263	23,000	36,800	34,900	36,345	35,000

TABLE 3.—Mine production of silver in the United States in 1963, by months

Month	Thousand troy ounces	Month	Thousand troy ounces
January	3,146	August	3,097
February	2,732	September	2,933
March	2,957	October	3,156
April	3,021	November	2,532
May	3,205	December	2,564
June	2,971		
July	2,927	Total [1]	35,243

[1] Data do not add to total shown because of rounding.

[3] Sunshine Mining Co. Annual Report 1963, Feb. 28, 1964, 9 pp.
[4] Helca Mining Company. Sixty-Sixth Annual Report, 1963, p. 7.
[5] Knoerr, Alvin W., and M. Louise Petersen. High Silver Prices Spark Revival in U.S. and Canadian Mining Camps. Eng. and Min. J., v. 164, No. 9, September 1963, pp. 74–79, 98, 100.

TABLE 4.—Twenty-five leading silver-producing mines in the United States in 1963 in order of output

Rank	Mine	District or region	State	Operator	Source of silver
1	Sunshine	Evolution	Idaho	Sunshine Mining Co	Silver ore.
2	Galena	Placer Center	do	American Smelting and Refining Company	Do.
3	Lucky Friday	Hunter	do	Lucky Friday Silver-Lead Mines Co	Lead ore.
4	Utah Copper	West Mountain (Bingham)	Utah	Kennecott Copper Corp	Copper ore.
5	Bunker Hill	Yreka	Idaho	The Bunker Hill Co	Lead-zinc ore.
6	Butte Hill Mines	Summit Valley (Butte)	Montana	The Anaconda Company	Copper ore.
7	Zinc Mines Group	do	do	do	Zinc ore.
8	United States & Lark	West Mountain (Bingham)	Utah	United States Smelting Refining and Mining Co	Lead-zinc ore.
9	Mission	Pima	Arizona	American Smelting and Refining Company	Copper ore.
10	Berkley Pit	Summit Valley (Butte)	Montana	The Anaconda Company	Do.
11	Iron King	Big Bug	Arizona	Shattuck Denn Mining Corp	Lead-zinc ore.
12	Copper Queen	Warren	do	Phelps Dodge Corp	Copper ore.
13	Eagle	Red Cliff (Battle Mountain)	Colorado	The New Jersey Zinc Co	Lead-zinc, copper ores.
14	Morenci	Copper Mountain	Arizona	Phelps Dodge Corp	Gold-silver, copper ores.
15	Crescent	Yreka	Idaho	The Bunker Hill Co	Silver ore.
16	Star-Morning Unit	Hunter	do	The Bunker Hill Co. & Hecla Mining Co	Lead-zinc ore.
17	Silver Summit	Evolution	do	Hecla Mining Co	Silver ore.
18	United Park City	Uintah	Utah	United Park City Mines Co	Lead-zinc, lead ores.
19	New Cornelia	Ajo	Arizona	Phelps Dodge Corp	Copper, gold-silver ores.
20	Page	Yreka	Idaho	American Smelting and Refining Company	Lead-zinc ore.
21	San Manuel	Old Hat	Arizona	Magma Copper Co	Copper ore.
22	Gold Dollar & Knob Hill	Republic	Washington	Knob Hill Mines Inc	Gold ore.
23	Idarado	Red Mountain	Colorado	Idarado Mining Co	Copper-lead-zinc ore.
24	Magma	Pioneer	Arizona	Magma Copper Co	Gold-silver, copper ores.
25	Mayflower Unit	Blue Ledge	Utah	Hecla Mining Co	Lead-zinc ore.

TABLE 5.—Mine production of recoverable silver in the United States by States
(Troy ounces)

	1954–58 (average)	1959	1960	1961	1962	1963
Alaska	29,624	21,358	25,934	18,485	22,199	14,010
Arizona	4,815,216	3,898,336	4,774,992	5,120,007	5,453,585	5,373,058
California	582,489	172,810	179,780	93,351	132,505	156,528
Colorado	2,663,451	1,340,732	1,659,037	1,965,021	2,087,813	2,307,305
Idaho	14,838,201	16,636,486	13,646,508	17,576,322	17,772,435	16,710,725
Illinois	1,163	------	------	------	------	------
Kentucky	37	75	------	2,065	1,410	1,515
Michigan	257,598	------	------	------	401,491	338,997
Missouri	270,209	339,760	15,594	11,793	490,896	131,664
Montana	5,566,600	3,420,376	3,606,991	3,490,350	4,560,714	4,241,620
Nevada	858,100	611,135	707,291	388,426	245,164	214,976
New Mexico	244,263	158,925	303,903	282,755	301,549	256,475
New York	63,103	51,588	49,324	40,507	19,451	19,544
North Carolina	5,775	16,319	212,368	169,742	100,439	26,754
Oregon	11,069	242	284	2,022	6,047	58,234
Pennsylvania	[1] 3,759	(1)	(1)	(1)	(1)	(1)
South Dakota	145,870	124,425	108,119	127,427	113,052	117,301
Tennessee	58,251	59,739	64,560	83,417	112,251	107,913
Texas	45	------	------	------	------	------
Utah	6,095,601	3,734,297	4,782,960	4,797,583	4,628,446	4,790,511
Vermont	37,743	------	------	------	------	------
Virginia	1,853	866	------	------	------	------
Washington	[1] 477,187	[1] 606,537	[1] 628,678	[1] 625,176	[1] 350,185	[1] 374,373
Wyoming	81	------	4	7	------	------
Total [2]	37,027,288	31,194,000	30,766,000	34,794,000	36,798,000	35,243,000

[1] Combined with Washington, 1956–63.
[2] Data may not add to totals shown because of rounding.

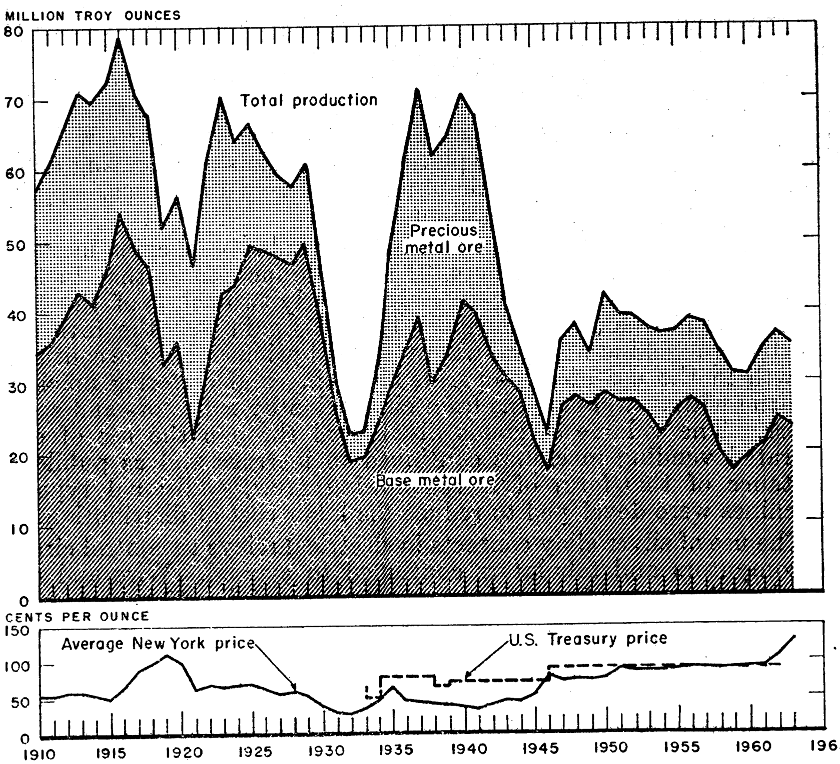

FIGURE 1.—Silver production in the United States and price per ounce, 1910–63

CONSUMPTION AND USES

Consumption of silver in the arts and industries of the United States was 110 million ounces, about the same as in 1962, according to data compiled by the Bureau of the Mint. This was nearly 4 percent above the average for the 5-year period 1959–63. Imports and mine production furnished about three-fourths of the total industrial and defense silver requirements; the remainder was supplied from Treasury stocks.

Although no detailed breakdown by end uses is available, it is estimated that consumption of silver for photographic uses continued at about the same level as in 1962. The expansion in the use of color photography which requires less silver, probably offset any decline in the use of silver in black and white photography. As a result of the continued rise in the price of silver, consumption of sterling silverware declined moderately but the use of silver in silver plated ware was not appreciably affected by the price rise. Likewise, the use of silver in brazing alloys for metal joining probably continued at about last year's level. However, consumption of silver for electrical and electronic uses increased appreciably and probably offset declines in the use of silver in other industrial fields. Increased consumption of silver in space and defense equipment such as batteries and rocket nozzles was noteworthy. Also, because of the price rise, an increased effort was made to develop substitutes and to use silver more economically.

It is estimated that the manufacture of photographic materials accounted for about 30 percent of the total silver used; most of the remainder of the silver consumed in industry and the arts was used in fabrication of sterling and plated ware, solders and brazing alloys, and in electrical and electronic products. Space and defense applications consumed at least 8.5 million ounces.

The quantity of silver used in minting subsidiary coins increased sharply to 111.5 million ounces, 34 million ounces more than in 1962. U.S. coinage requirements constituted nearly two-thirds of the total silver used in free world coinage. The 1963 gain was the fifth consecutive annual increase and was attributed primarily to the continued growth in the use of coin-operated vending and metering machines and the withdrawal of coins from circulation by collectors and speculators. The volume of goods distributed through the use of coin-operated vending machines continued to increase and as public acceptance of this form of merchandising grew, additional types of machines were developed to reduce the labor cost of distribution.

The use of silver alloy contacts in electrical relays to control circuits in computors and tabulators continued to expand. Wire and strip for the relays were formed from an alloy containing 72 percent silver and 28 percent copper. Silver alloys, which have excellent contact properties and are essentially free from oxidation, provide reliable performance in critical applications. The use of silver solders and brazing alloys increased as new industrial and defense-related applications were developed which required high strength at elevated temperature. Republic Aviation Corp. reported that a silver alloy containing 95 percent silver and 5 percent aluminum proved to have the best characteristics for brazing titanium honeycomb panels for potential use in aerospace vehicles.

The rise in the price of silver since the cessation of Treasury sales from 91.375 cents per ounce in November 1961 to 129.3 cents in September 1963 has led to increasing replacement of high silver content alloys by overlay or bonded bimetal components in several electrical and chemical industry applications. Handy & Harman, a leading fabricator of silver, state that cost savings with the bimetals can amount to as much as 50 percent. Some of the more common bimetal combinations include silver-clad copper or brass; sterling-clad phosphor bronze; gold-cored fine silver; and silver-cored brass.

Glass that automatically darkens as the light intensity increases and lightens when in the shade was produced by Corning Glass Works, Corning, N.Y. The photochromic glass contains submicroscopic crystals of silver halide which are light-sensitive turning to metallic silver when exposed to strong visible or ultraviolet light, like photographic film. But unlike photographic film whose darkening is permanent, the silver atoms in the glass reunite when the light source is cut off and the glass becomes transparent again. Such glass has large potential use where protection from solar light and heat is needed.

Silver-plated bearing sleeves were used to provide increased resistance to fatigue, excessive heat and wear in the Leonides air cooled engine which powers the W.S. 55 "Whirlwind" three-bladed rotor helicopter. Silver plated on mild steel with a thin lead overlay was regarded as almost seizure resistant in heavy duty aircraft service and had much higher load-carrying capacity than other types of aircraft bearings.

A palladium-silver alloy was used in the design of fuel cells which provided power for a non-nuclear submarine when submerged. Impure hydrogen from a generator is passed through a coil of palladium and silver, and the resulting pure hydrogen is fed to the fuel cell. Fuel-cell submarines may overcome disadvantages of conventional submarines which must surface frequently to recharge their storage batteries and nuclear submarines which are expensive to build in small sizes.

A 20-cell silver-zinc battery, manufactured by Gould-National Batteries, Inc., supplied power to the control system operating gas jets used for guidance and attitude control of the Aerobee rocket manufactured by Space General Corp.

Silver crucibles were developed by International Telephone and Telegraph Corp. to process chemically reactive materials at high temperatures without contamination. The crucibles are water cooled and hold materials that are heated by radio-frequency power. Metals like molybdenum, iron, vanadium, and boron can be melted without either wetting the cool surface with the molten charge or forming a solid skin.

Electrochemica Corp. developed a sealed silver oxide-cadmium cell for electronic, instrumentation, and satellite applications. The cell, having approximately twice the capacity per unit weight and volume as the nickel-cadmium cell, is designed for long-cycle life under conditions of altitude, temperature shock, and acceleration encountered by aerospace vehicles.

Silver impregnated plastic discs that sense minute changes in electric currents were used in potentiometer control for advanced weapon systems manufactured by Fairchild Controls, a division of Fairchild Camera & Instrument Corp.

An epoxy cold silver solder, "Shurbond," was developed by Anchor Alloys, Inc., to bond the most delicate electronic devices without heat. The paste-like solder is applied directly from a "hypo" applicator to the component being bonded. It hardens at room temperature in 24 hours.

A conductive silver compound was developed by Electro Science Laboratories, Inc., for electronic applications particularly as an adhesive for attaching leads to terminals and as a protective coating. The compound has high conductivity, high bond strength at elevated temperature, and long shelf life.

Littlefuse, Inc., developed a novel fuse using a silver-plated indicating pin which makes contact with an alarm when the fuse blows. The fuse may be used for various electrical or electronic control applications.

Some of the more recent applications of silver and the physical and chemical properties on which its use is based were described.[6] The resistance of silver to corrosion and oxidation, its use as a catalyst in organic reactions, its superior electrical and heat conductivity, the pharmaceutical, antiseptic, and light sensitive properties of silver salts, and the characteristics of silver-bearing alloys, electroplated coatings, and amalgams on which the major uses of silver are based also were discussed.

TABLE 6.—Ore, old tailings, etc., yielding silver produced in the United States, and average recoverable content, in troy ounces of silver per ton in 1963

State	Gold ore		Gold-silver ore		Silver ore		Copper ore	
	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	903	0.305	----------	----------	11	104.727	----------	----------
Arizona	149	.886	146,595	0.166	31,067	.332	80,342,727	0.056
California	11,639	.060	----------	----------	2,510	9.908	2,000	.008
Colorado	352	5.165	254	7.764	5,387	46.153	20,908	20.276
Idaho	1,161	2.288	10	55.900	348,623	29.416	38,964	.280
Michigan	----------	----------	----------	----------	----------	----------	[4] 5,607,024	.060
Missouri	----------	----------	----------	----------	----------	----------	----------	----------
Montana	3,586	.366	17,089	3.421	39,550	5.513	8,139,535	.304
Nevada	357,595	.016	3	12.333	244	58.000	9,073,217	.018
New Mexico	58	10.138	47,679	1.530	27	11.778	6,858,769	.016
South Dakota	1,909,261	.061	----------	----------	----------	----------	----------	----------
Utah	----------	----------	7,035	.072	159,178	1.711	26,282,424	.083
Undistributed [6]	175,326	1.894	4,220	13.711	73	25.562	72	.847
Total	2,460,030	.188	222,885	.972	586,670	18.830	136,365,640	.075

See footnotes at end of table.

[6] Sanderson, L. Silver—Part 2. Canadian Min. J., v. 84, No. 6, June 1963, pp. 64-66.

TABLE 6.—Ore, old tailings, etc., yielding silver produced in the United States, and average recoverable content, in troy ounces of silver per ton in 1963—Con.

State	Lead ore		Zinc		Zinc-lead, zinc-copper, and zinc-lead-copper ores		Total ore	
	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	----------	----------	----------	----------	----------	----------	914	1.561
Arizona	2,129	5.162	8,454	0.745	409,272	1.985	[1] 80,940,393	.066
California	1,294	18.854	----------	----------	3,043	11.734	[2] 20,486	7.404
Colorado	1,809	14.982	1,077	1.899	945,251	1.694	975,038	2.366
Idaho	183,332	18.980	105,538	.541	856,986	3.389	[3] 1,534,894	10.887
Michigan	----------	----------	----------	----------	----------	----------	5,607,024	.060
Missouri	3,253,245	.040	----------	----------	----------	----------	3,253,245	.040
Montana	2,593	4.618	[5] 1,206,614	1.220	154	13.935	9,409,121	.451
Nevada	3,783	6.967	1,573	.556	144	11.556	9,436,559	.023
New Mexico	26,199	.141	154,259	.454	135	16.252	7,087,126	.036
South Dakota	33	27.606	----------	----------	----------	----------	1,909,294	.061
Utah	6,590	13.512	39,144	.202	540,350	4.127	[1] 27,034,721	.177
Undistributed [6]	----------	----------	----------	----------	2,731,362	.058	[7] 3,610,962	.163
Total	3,481,007	1.093	1,516,659	1.006	5,486,697	1.412	150,819,777	.234

[1] Includes uranium ore.
[2] Includes tungsten ore.
[3] Includes antimony ore.
[4] Does not include silver contained in fire-refined copper.
[5] Includes manganese ore.
[6] Includes Kentucky, New York, North Carolina, Oregon, Pennsylvania, Tennessee, and Washington.
[7] Includes calcium fluorite in Kentucky, tungsten ore in North Carolina, and magnetite-pyrite ore in Pennsylvania.

TABLE 7.—Mine and refinery production of silver in the United States in 1963, by States and sources

(Troy ounces of recoverable metal)

State	Mine production							Refinery production [1]
	Placers	Dry ore	Copper ore	Lead ore	Zinc ore	Zinc-lead, zinc-copper, lead-copper, and zinc-lead-copper ores	Total	
Alaska	12,583	1,427	----------	----------	----------	----------	14,010	14,100
Arizona	5	34,793	4,495,459	10,989	6,299	812,458	[2] 5,373,058	5,459,500
California	4,844	25,573	16	24,397	----------	35,707	[3] 156,528	141,500
Colorado	225	252,415	423,932	27,102	2,045	1,601,586	2,307,305	2,478,600
Idaho	43	10,258,260	10,916	3,479,569	57,112	2,904,622	[4] 16,710,725	16,500,000
Illinois	----------	----------	----------	----------	----------	----------	----------	22,000
Kentucky	----------	----------	----------	----------	----------	----------	[5] 1,515	1,700
Michigan	----------	----------	----------	338,997	----------	----------	338,997	321,800
Missouri	----------	----------	----------	131,664	----------	----------	131,664	195,000
Montana	4	277,805	2,477,756	11,975	1,471,934	2,146	4,241,620	4,010,600
Nevada	254	19,992	165,834	26,358	874	1,664	214,976	211,700
New Mexico	----------	73,836	106,782	112	73,551	2,194	256,475	279,100
New York	----------	----------	----------	----------	----------	19,544	19,544	19,500
North Carolina	----------	23	----------	----------	----------	----------	[3] 26,754	40,000
Oregon	62	58,133	39	----------	----------	----------	58,234	36,000
Pennsylvania	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)
South Dakota	18	116,372	----------	911	----------	----------	117,301	117,600
Tennessee	----------	----------	----------	----------	----------	107,913	107,913	129,000
Texas	----------	----------	----------	----------	----------	----------	----------	2,300
Utah	----------	272,906	2,183,632	89,041	7,910	2,229,845	[2] 4,790,511	4,500,000
Washington	1	333,558	22	----------	----------	30,327	[7] 374,373	516,200
Wisconsin	----------	----------	----------	----------	----------	----------	----------	3,800
Total	18,039	11,725,093	9,864,388	4,141,115	1,619,725	7,748,006	[4] 35,241,503	35,000,000
Percent [8]	0.1	33.4	28.1	11.8	4.6	22.0	100.0	----------

[1] U.S. Bureau of the Mint.
[2] Includes silver from uranium concentrates.
[3] Includes silver from tungsten ore.
[4] Includes silver from gold-antimony ore.
[5] From fluorspar ore.
[6] Pennsylvania included with Washington.
[7] Includes silver from magnetite-pyrite ore in Pennsylvania.
[8] Percentage based on total, excluding 125,137 ounces obtained from other ores.

TABLE 8.—Silver produced in the United States from ore and old tailings in 1963 by States and methods of recovery in terms of recoverable metal

State	Total ore, old tailings, etc., treated (short tons)[1]	Ore and old tailings to mills					Crude ore to smelters	
		Short tons[1]	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Short tons	Troy ounces
Alaska	914	903	275				11	1,152
Arizona	81,282,358	80,566,143	6		2,519,846	4,945,100	716,215	427,947
California	20,608	16,229	422		3,651	91,125	4,379	60,137
Colorado	975,038	950,827	2,400		141,897	1,662,410	24,211	642,270
Idaho	1,534,971	1,461,341	374		224,730	16,612,574	73,630	97,734
Michigan	5,607,024	5,607,024			190,696	338,997		
Missouri	3,253,245	3,253,245			109,960	131,664		
Montana	9,506,227	9,351,796	10		343,375	3,966,948	154,431	274,658
Nevada	[2] 9,436,692	9,353,430	403	5,729	312,844	163,469	83,262	45,121
New Mexico	7,443,289	7,308,245			262,429	179,751	135,044	76,724
South Dakota	1,909,296	1,909,261	85,871	30,501			35	911
Utah	27,059,271	26,820,668			796,369	4,378,507	238,603	412,004
Undistributed [3]	3,610,987	3,601,787	16	63,059	143,628	473,191	9,200	52,004
Total	151,639,920	150,200,899	89,777	99,289	5,049,425	32,943,736	1,439,021	2,090,662

[1] Includes some non-silver-bearing ores, not separable.
[2] Excludes leached copper ore.
[3] Includes Kentucky, New York, North Carolina, Oregon, Pennsylvania, Tennessee, and Washington.

TABLE 9.—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 from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting[1]	Placers
1954–58 (average)	92,097	347,332	0.3	0.9	98.7	0.1
1959	92,663	557,034	.3	1.8	97.7	.2
1960	86,353	533,286	.3	1.7	97.9	.1
1961	90,527	214,956	[2] .3	.6	[2] 99.0	.1
1962	89,203	101,887	.2	.3	99.4	.1
1963	89,777	99,289	.2	.3	99.4	.1

[1] Crude ores and concentrates.
[2] Revised figure.

TABLE 10.—Consumption of silver in industry and the arts

(Thousand troy ounces)

Year	Issued for industrial use	Returned from industrial use [1]	Net industrial consumption	Year	Issued for industrial use	Returned from industrial use [1]	Net industrial consumption
1954–58 (average)	122,681	29,021	93,660	1961	155,812	50,312	105,500
1959	142,984	41,984	101,000	1962	180,812	70,412	110,400
1960	151,007	49,007	102,000	1963	204,490	94,490	110,000

[1] Includes secondary materials to monetary use, jewelry, plate, scrap film, and other forms of scrap.

Source: U.S. Bureau of the Mint.

STOCKS

Heavy withdrawals for subsidiary coinage, withdrawal of silver dollars, redemption of silver certificates for commercial use, and sales to other Government agencies reduced Treasury stocks of bullion and coin 182.3 million ounces to 1,584.3 million ounces at yearend. The falloff in Treasury silver stocks, the fifth consecutive annual decline, was partly balanced by the growth of coinage in circulation which increased 142.4 million ounces to 1,716.3 million ounces. Silver received by the Treasury, nearly all of which came from coins withdrawn from circulation for recoinage, totaled about 2.3 million ounces. Silver received from domestic purchases and lend-lease returns totaled only 15,670 ounces. The Treasury used 111.5 million ounces in the minting of subsidiary coins, exchanged 50.6 million ounces in silver dollars, issued 19.0 million ounces to commercial consumers in exchange for silver certificates, and sold about 6.1 million ounces, chiefly to other Government agencies.

The ratio of the value of silver to the total value of gold and silver in the U.S. monetary stocks at yearend was 21.6 percent compared with 20.8 percent at the end of 1962.

Of the 410.8 million ounces of silver shipped to foreign countries under World War II lend-lease agreements, only 1.5 million ounces was due from Pakistan.

TABLE 11.—U.S. monetary silver

(Million troy ounces)

	1959	1960	1961	1962	1963
In Treasury:					
Securing silver certificates:					
Silver bullion	1,741.3	1,741.8	1,730.5	1,654.5	1,532.5
Silver dollars	141.1	124.9	100.7	72.7	22.1
Subsidiary coin	2.4	2.0	2.6	[1] 2.4	4.5
Free silver bullion	175.1	123.5	28.5	37.0	25.2
Total	2,059.9	1,992.2	1,862.3	[1] 1,766.6	1,584.3
Coinage in circulation:					
Silver dollars	236.3	252.5	276.4	303.6	352.9
Subsidiary coin	1,094.7	1,140.0	1,194.0	[1] 1,270.3	1,363.4
Total	1,331.0	1,392.5	1,470.4	[1] 1,573.9	1,716.3
Grand total	3,390.9	3,384.7	3,332.7	[1] 3,340.5	3,300.6

[1] Revised figure.

Source: Compiled from U.S. Treasury Department Statements.

PRICES

The price of silver in the New York market fluctuated from a low of 121 cents at the beginning of the year to a high of 129.3 cents an ounce in September after which it remained unchanged to the end of the year. The average price for the year was 127.912 cents an ounce. Virtually no silver was purchased by the Treasury at prices established under the Silver Purchases Acts, as the New York price greatly exceeded the Treasury buying price.

The enactment on June 4 of Public Law 88–36 repealed the Silver Purchase Act of 1934 and subsequent Acts of 1939 and 1946, thus freeing silver from restrictive legislation. The repeal of the silver transactions tax permitted the resumption of trading in silver futures on the New York Commodity Exchange on June 12, the first such trading since August 1934. As speculative interest developed, prices for forward delivery advanced quite rapidly from 127.50 cents an ounce on June 12 for August 1963 delivery to a high of 131.35 cents ounce on July 5 for June 1964 delivery, notwithstanding the availability of Treasury silver at 129.3 cents an ounce. Trading volume on the Exchange for the period from June 12 to December 31 amounted to 3,944 contracts, equal to 39.44 million ounces. At yearend open contracts for 9.4 million ounces were outstanding.

Increased demand for prompt delivery of silver from abroad and for contracts on the Commodity Exchange for future delivery, brought the New York market price of silver up to 129 cents in July where it remained relatively stable for several weeks due to sales by the Bank of Mexico. After stocks of the Bank of Mexico became depelted and sales terminated, the price rose on September 9, to 129.3 cents. The availability of silver from Treasury stocks through redemption of silver certificates, to balance the deficit in supply effectively established a ceiling on the price of silver at its monetary value of 129.3 cents per ounce.

Based on the average 1963 New York price of 127.9 cents, the price ratio of gold to silver was 27.4 to 1 compared with 32.1 to 1 in 1962 when the average price was 108.5 cents.

In the London market, spot prices of silver ranged from a low of 103.875d on January 2 to a high of 111.750d on October 21, equivalent to 121.343 cents and 130.300 cents per ounce respectively, corresponding approximately to the cost at New York plus transportation charges to London with dollar-sterling exchange about 2.7975. The average price at London for the year was 110.126d, equivalent to 128.480 cents.[7]

FOREIGN TRADE

Imports.—Imports of silver in ore and bullion aggregated 59.1 million ounces valued at $67.3 million, a decline of nearly 23 percent in quantity and 7 percent in value from 1962. Imports from Canada dropped about 5.6 million ounces to 18.6 million ounces. Canada, Mexico, and Peru supplied about 80 percent of the total imports. Imports from Mexico decreased 9 percent to 13.9 million ounces excluding 3.8 million ounces of demonetized silver coins. About 15.3 million ounces were received from Peru, slightly less than in 1962, and about 8.3 million ounces was received from other Western Hemisphere countries.

Exports.—U.S. exports of silver were 31.5 million ounces, more than twice the quantity exported in 1962. The United Kingdom received 8.3 million ounces compared with 1.6 million ounces in 1962; about 8.1 million ounces went to Canada; 12.1 million ounces to West European countries, Italy, France, and West Germany. Virtually all of the remaining 3 million ounces went to four other countries.

[7] S. Montagu & Co., Ltd. Annual Bullion Review, 1963. January 1964, pp. 16, 17, 25.

TABLE 12.—U.S. imports of silver in 1963, 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		
North America:						
Canada	14,083	$16,971	4,548	$5,731	$67	$40
El Salvador	133	167				
Guatemala	52	52				
Honduras	2,459	2,722	1	2		
Jamaica						1
Mexico	6,411	7,962	7,517	7,069		1,696
Nicaragua	162	193				
Total	23,300	28,067	12,066	12,802	67	1,737
South America:						
Bolivia	3,318	3,796				
Chile	1,843	1,680				
Colombia	51	55				
Ecuador	53	58				1,688
Peru	10,034	10,761	5,237	6,634		
Total	15,299	16,350	5,237	6,634		1,688
Europe:						
Austria						9
France			95	132		3
Italy						4
Netherlands						2
Norway	9	11				
Sweden						3
Switzerland					(1)	12
United Kingdom	94	84				2
Total	103	95	95	132	(1)	35
Asia:						
Burma	13	11				
India						1
Korea, Republic of	22	24				
Philippines	403	474	4	5		
Total	438	509	4	5		1
Africa:						
Liberia					106	2
Rhodesia and Nyasaland, Federation of	80	74				
South Africa, Republic of	413	381				
Total	493	455			106	2
Oceania: Australia	2,027	2,232				1
Grand total	41,660	47,708	17,402	19,573	173	3,464

[1] Less than $1,000.

Source: Bureau of the Census.

TABLE 13.—U.S. exports of silver in 1963, by countries

(Thousand troy ounces and thousand dollars)

Destination	Ore and base bullion		Refined bullion		U.S. coin value	Foreign coin value
	Quantity	Value	Quantity	Value		
North America:						
Bahamas					$21	
Bermuda					21	
Canada			8,070	$10,105		$800
Canal Zone					1	
Jamaica					2	
Netherlands Antilles					9	
Panama			22	28		
Total			8,092	10,133	54	800
South America:						
Argentina					(1)	
Brazil			5	7		
Colombia			39	50		
Surinam					2	
Total			44	57	2	
Europe:						
Belgium-Luxembourg	301	$372				
France			7,256	9,192	1	
Germany, West	2	2	2,254	2,964	3	
Ireland					3	
Italy			2,556	3,299		870
Netherlands			415	533		
Switzerland			352	455	2	
United Kingdom	995	1,276	7,258	9,193	2	
Total	1,298	1,650	20,091	25,636	11	870
Asia:						
Afghanistan			3	4		
Israel					6	
Japan			1,956	2,541		
Philippines			1	1		
Total			1,960	2,546	6	
Grand total	1,298	1,650	30,187	38,372	73	1,670

[1] Less than $1,000.

Source: Bureau of the Census.

WORLD REVIEW

World silver output was estimated at 249.5 million ounces, about 7.7 million ounces more than in 1962. Increased production in Mexico, Peru, Honduras, Bolivia, and Australia more than offset declines in production in United States and the Congo. Changes in the silver output of other countries were small. Mexico, Peru, United States, and Canada contributed about 58 percent of the world output. Consumption of silver in free world countries was estimated at 419.2 million ounces, 9 percent more than in 1962.

The quantity of silver consumed for industrial use was 247.0 million ounces, about the same as last year, but coinage requirements aggregating 172.2 million ounces were more than 26 percent greater than in 1962.[8] The gain in coinage requirements for silver was due almost entirely to increased demand for subsidiary coins in the United States. Consumption of silver for coinage in other countries of the free world was only slightly more than in 1962. Gains in coinage

[8] Handy & Harman. The Silver Market in 1963, p. 20.

requirements in Japan and Canada were nearly balanced by declines in the requirements in France and Italy.

TABLE 14.—World production of silver by countries [1] [2] [3]

(Troy ounces)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	29,704,154	31,923,969	34,016,829	31,381,977	30,422,972	30,739,429
Central America and West Indies:						
Cuba (U.S. imports)	243,634	215,000	121,415	-	-	-
El Salvador	203,647	199,080	76,809	-	-	-
Guatemala	401,832	[4] 88,000	[5] 663,121	[5] 515,905	[4] 32,400	[4] 64,200
Honduras	2,456,558	3,167,376	2,947,021	3,544,702	2,479,658	[6] 4,280,746
Nicaragua	255,869	298,413	326,673	417,253	500,050	405,252
Mexico	45,134,806	44,075,291	44,526,463	40,349,181	41,249,402	42,760,487
United States [7]	37,262,802	23,000,000	36,800,000	34,900,000	36,345,000	35,000,000
Total	115,663,300	102,967,100	119,478,300	111,109,000	111,029,500	113,250,100
South America:						
Argentina	1,523,938	1,549,600	1,671,838	1,430,675	1,318,150	1,546,160
Bolivia (exports)	5,974,490	4,504,126	4,887,138	3,901,203	3,759,193	4,854,762
Brazil	194,313	225,152	252,930	231,936	219,558	[4] 220,000
Chile	1,617,150	1,767,230	1,434,277	2,156,768	2,184,271	2,390,120
Colombia	109,391	102,678	134,333	127,943	131,599	106,278
Ecuador	60,429	162,608	126,419	101,190	127,739	121,784
Peru	23,417,977	[5] 27,225,216	[5] 30,755,496	[5] 34,161,707	[5] 32,930,783	[5] 36,447,110
Total	32,900,000	35,540,000	39,260,000	42,110,000	40,670,000	45,690,000
Europe:						
Austria	2,379	58,193	58,193	58,193	68,481	68,803
Czechoslovakia [8]	1,608,000	1,608,000	1,608,000	1,608,000	1,608,000	1,608,000
Finland	343,357	522,739	390,374	456,155	380,495	579,967
France	639,948	944,750	1,039,851	1,128,523	898,977	610,864
Germany:						
East [8]	4,800,000	4,800,000	4,800,000	4,800,000	4,800,000	4,800,000
West	2,198,275	2,002,059	1,839,247	1,879,436	1,925,701	[4] 2,100,000
Greece	87,038	150,273	105,487	113,396	138,248	[4] 128,600
Hungary [8]	64,300	64,300	64,300	64,300	64,300	64,300
Italy	1,015,018	1,060,749	943,946	973,139	929,832	996,673
Norway	64,301	-	-	-	-	-
Poland [8]	128,600	128,600	128,600	128,600	128,600	128,600
Portugal	55,968	54,141	52,920	48,258	52,920	[4] 54,000
Rumania [8]	643,000	643,000	643,000	643,000	643,000	643,000
Spain	1,459,856	2,180,849	1,739,677	4,526,599	5,684,123	[4] 5,600,000
Sweden	2,526,438	3,098,142	2,756,026	2,825,246	3,459,420	2,874,276
U.S.S.R.[4]	25,000,000	25,000,000	25,000,000	25,000,000	27,000,000	27,000,000
United Kingdom	26,394	13,355	7,098	4,744	514	-
Yugoslavia	2,982,888	2,827,336	3,025,160	3,454,083	3,750,931	3,791,923
Total [4]	43,700,000	45,200,000	44,200,000	47,700,000	51,500,000	51,100,000
Asia:						
Burma	1,560,963	2,041,395	1,984,263	1,743,302	1,940,037	2,076,000
China [8]	508,000	800,000	800,000	800,000	800,000	800,000
India	131,078	124,777	132,718	191,008	138,698	128,314
Indonesia	[9] 112,447	333,050	310,512	324,079	248,236	[4] 200,000
Japan	6,274,822	6,650,928	6,912,602	7,960,202	8,660,510	8,786,798
Korea:						
North [4]	238,000	320,000	500,000	640,000	640,000	640,000
Republic of	170,280	241,898	329,649	460,341	412,812	444,002
Philippines	509,520	504,085	1,133,343	812,793	675,570	774,917
Saudi Arabia	12,736	-	-	-	-	-
Taiwan	58,470	60,974	52,579	77,303	80,129	61,440
Total [4]	9,600,000	11,100,000	12,200,000	13,000,000	13,600,000	13,900,000
Africa:						
Algeria (recoverable) [10]	306,470	400,000	300,000	300,000	275,000	250,000
Bechuanaland	326	42	24	39	33	21
Congo, Republic of the (formerly Belgian)	3,851,434	4,768,180	3,962,836	3,457,877	1,595,513	1,097,176
Ghana (exports)	37,448	16,839	14,160	7,027	4,443	4,827
Kenya	24,996	46,420	35,797	40,731	50,160	50,072
Morocco	2,253,094	1,234,303	1,097,273	907,905	826,338	772,743

See footnotes at end of table.

747-149—64——65

TABLE 14.—World production of silver by countries [1] [2] [3]—Continued

(Troy ounces)

Country	1954–58 (average)	1959	1960	1961	1962	1963
Africa—Continued						
Rhodesia and Nyasaland, Federation of:						
Northern Rhodesia [11]	501,060	937,678	920,601	738,558	697,054	883,681
Southern Rhodesia	114,835	328,947	392,026	106,801	83,540	83,742
South Africa, Republic of	1,571,578	2,020,780	2,226,204	2,288,279	2,549,206	2,736,868
South-West Africa (recoverable)	1,440,138	1,966,955	1,004,921	1,833,437	1,253,200	634,134
Swaziland			58	103	132	120
Tanganyika (exports)	475,500	536,407	614,279	64,144	23,959	22,521
Tunisia	106,612	43,339	34,401	69,767	24,615	9,131
Uganda (exports)	53	54	109	70	39	4
Total	10,700,000	12,300,000	10,600,000	9,810,000	7,380,000	6,550,000
Oceania:						
Australia	14,995,653	15,160,631	15,215,956	13,059,166	17,540,832	18,900,000
Fiji	22,568	23,652	31,319	37,712	38,935	46,870
New Guinea	39,772	36,796	33,037	30,242	24,500	23,696
New Zealand	13,109	4,873	1,353	804	416	286
Total	15,071,000	15,226,000	15,282,000	13,128,000	17,605,000	18,971,000
World total (estimate)	227,600,000	222,300,000	241,000,000	236,900,000	241,800,000	249,500,000

[1] A negligible amount of silver is produced in Bulgaria, Mozambique, Panama, and Turkey, for which countries no estimate has been included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Data derived in part from the Yearbook of the American Bureau of Metal Statistics and the 50th annual issue of Metal Statistics (Metallgesellschaft) Germany.
[4] Estimate.
[5] Recoverable.
[6] Exports.
[7] Refinery production.
[8] Estimate, according to 50th annual issue of Metallgesellschaft (Germany) except 1963 which is an extension of the previous year's estimate.
[9] Average annual production 1957–58.
[10] Estimated recoverable silver content of lead and zinc concentrates, according to the 1962 annual issue of Minerais et Metaux (France) except 1963.
[11] Partially recovered from refinery sludges and blister copper.

Consumption of silver in free world countries continued to exceed mine production by a substantial margin, and in 1963 the excess rose to 208.7 million ounces, a record high. Excluding U.S. coinage requirements, which were not part of the market demand, the production deficit amounting to about 97.4 million ounces was balanced chiefly by liquidation of speculative holdings and withdrawals from U.S Treasury stocks which supplied 40 million and 23 million ounces respectively. Stocks of foreign governments furnished 10 million ounces, demonetized coin contributed 15 million ounces, and 9.4 million ounces came from salvage and other miscellaneous sources.[9]

Australia.—Silver production in Australia rose 8 percent to 18.9 million ounces as output of silver-bearing lead concentrates increased.

Mount Isa Mines, Ltd., Queensland, increased output substantially over 1962 when production was interrupted by an 8-week strike. The company treated 0.92 million tons of silver-lead-zinc ore assaying 6.5 ounces of silver, 8 percent lead and 5.5 percent zinc per ton and increased its ore reserve 0.4 million tons to 26.0 million tons. A total of 5.9 million ounces of silver was recovered from the treatment of all ores. Exploration and underground development increased reserves of silver-lead-zinc ore.

[9] Page 21 of work cited in footnote 19.

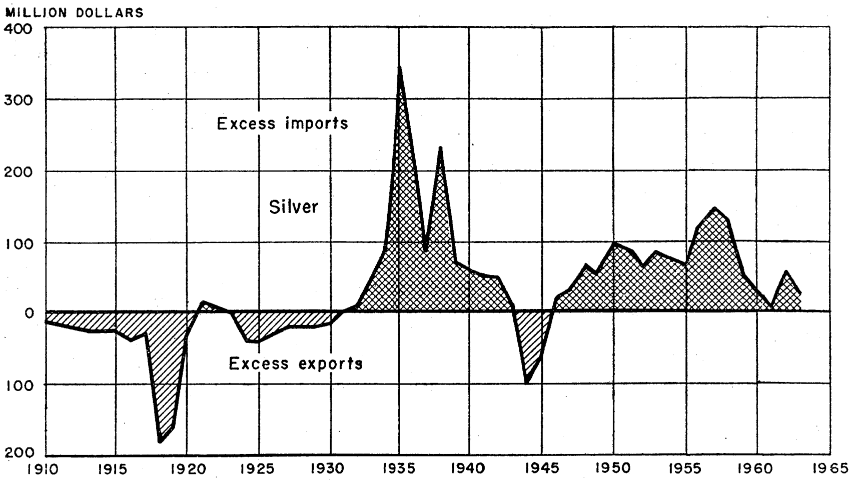

FIGURE 2.—Net imports or exports of silver, 1910–63.

At North Broken Hill production of silver-lead-zinc ore and recovery of metals were increased substantially. The mine treated 0.72 million tons of ore and ore reserves totaling 4.1 million tons averaging 2.8 ounces of silver per ton, 11 percent lead, and 12.8 percent zinc were reported.

Canada.—Production of silver in Canada increased slightly to 30.7 million ounces but was 3.3 million ounces less than the record high of 1960. Production was curtailed by reduced output at copper-nickel smelting operations in the Sudbury district of Ontario and by losses resulting from strikes at the Solbec Copper Mines, Ltd., in Quebec and at the Castle mine in Ontario. Increased production in British Columbia, Ontario, Quebec, and New Brunswick offset declines in silver output in Manitoba, Nova Scotia, Newfoundland, and the Yukon Territory.

British Columbia, Ontario, and the Yukon Territory together continued to supply about two-thirds of the total Canadian silver output. United Keno Hill Mines, Ltd., and Consolidated Mining & Smelting Co. of Canada, Ltd. (Cominco), the two largest silver producers, contributed nearly 40 percent of the total production of silver.

Exports of refined silver and silver in ores and concentrates, most of which went to the United States, aggregated 19.1 million ounces compared with 18.2 million ounces in 1962. Imports of silver dropped 7.3 million ounces to 7.9 million ounces. The United States continued to be the largest supplier, providing 92 percent of the total imports.

Consumption of silver for industrial uses was estimated at 4.4 million ounces, compared with 4.8 million ounces in 1962. About 13.4 million ounces of silver was used in coinage, 23 percent more than in 1962.

United Keno Hill Mines, Ltd., reported a drop of about 1 million ounces in silver production to 6.0 million ounces in the fiscal year ending September 30, due to the lower grade of ore treated. Ore reserves increased to 494,000 tons with an average grade of 34.6

ounces of silver per ton, 6.6 percent lead and 5.5 percent zinc, compared with 445,600 tons averaging 38.4 ounces of silver, 7.1 percent lead, and 5.1 percent zinc in 1962.

The Consolidated Mining & Smelting Co. of Canada reported production of 6.8 million ounces of silver of which 74 percent came from company mines, principally the Sullivan and Bluebell mines. Silver is produced almost entirely as a byproduct of lead-zinc ores.

Siscoe Mines, Ltd., treated 64,660 tons of ore averaging 21.6 ounces of silver per ton and recovered 1.4 million ounces of silver compared with 68,660 tons yielding 1.5 million ounces in 1962. Mill recovery was 97 percent. Total mine operating cost was $13.98 per ton of ore or $0.64 per ounce of silver compared with $12.66 per ton and $0.59 per ounce in 1962.

TABLE 15.—Canada: Mine production of silver

(Troy ounces)

Province or Territory	1962	1963 [1]
Alberta	17	11
British Columbia	6,186,937	6,420,000
Manitoba	847,879	745,802
New Brunswick	178,521	358,000
Newfoundland	1,181,648	1,025,080
Northwest Territories	72,802	76,380
Nova Scotia	724,245	508,921
Ontario	9,383,445	9,925,406
Quebec	4,603,019	4,755,325
Saskatchewan	762,215	808,400
Yukon Territory	6,482,244	6,115,704
Total [2]	30,423,000	30,739,000

[1] Preliminary figures.
[2] Data do not add to totals shown because of rounding.

Source: Canadian Mining Journal. V. 85, No. 2, February 1964, p. 110.

Honduras.—Output of silver was estimated at 4.3 million ounces, about 1.8 million ounces more than in 1962. Production at the El Mochito mine of New York and Honduras Rosario Mining Company declined slightly as a lower grade of ore was treated. Tonnage milled increased 20 percent but average recovery was down nearly 5 ounces per ton to 20.9 ounces per ton. The company reported that ore reserves increased 52 percent to 1.0 million tons, averaging 20.6 ounces of silver per ton, 0.02 ounces per ton gold, 7.7 percent lead, and 7.8 percent zinc. Total silver content of reserves was 21 million ounces.[10]

Japan.—Consumption of silver for industrial uses in Japan was estimated at 20 million ounces, a moderate increase over 1962. Coinage requirements of silver increased 3.6 million ounces to 5.0 million ounces. Silver production increased slightly to 8.8 million ounces but imports were somewhat less than the 3.5 million ounces received in 1962. Government stocks of silver were estimated at 32 million ounces at yearend compared with 45.5 million ounces in 1962.[11]

Mexico.—Production of silver in Mexico, the leading silver-producing country, increased 1.5 million ounces to 43 million ounces.

[10] New York and Honduras Rosario Mining Company. 83d Annual Report. 1963, pp. 14 and 20.
[11] Page 16 of work cited in footnote 19.

Consumption for industrial use declined slightly to 3.2 million ounces, and about 1.4 million ounces was used in minting one-peso, 10-percent silver alloy coins.

Exports of silver bullion increased about 10 million ounces to 44 million ounces, most of which went to European countries.

About 2.7 million ounces was recovered from demonetized coins withdrawn from circulation. It was estimated that 65 to 70 million ounces of silver in such demonetized coin was held by the public.[12]

Stimulated by the rising price of silver, Socieded Cooperativa Minera-Metallurgica Santa Fe de Guanajuato of Mexico developed new silver-gold ore reserves and increased ore production from 10,000 to 14,000 tons per month in mid–1963.

San Francisco Mines of Mexico, Ltd., announced that it had received tax concessions from the Federal Government under the "Mexicanization" plan that will be of substantial benefit to its mining operations.

Peru.—Silver output rose 11 percent to a new record of 36.4 million ounces and Peru became the second largest silver-producing country, surpassing the United States. Exports declined 10 percent in quantity to 31.3 million ounces but increased $3.3 million in value to $36.5 million reflecting the increase in the average price of silver. About 45 percent of the total exports went to the United States, 21 percent to West Germany, and the remainder went to 13 other countries.

Cerro de Pasco Corp., the leading silver producer, reported an output of 19.7 million ounces, a gain of 2.9 million ounces over 1962. About 42 percent of the company's silver output came from its own mines; the remainder came from purchased ores. The gain in output to a record high was attributed principally to uninterrupted operations in contrast to the loss in production due to a 28-day strike in 1962.

San Juan de Lucanas, the second ranking silver producer, reported an output of 2.4 million ounces, slightly less than in 1962. The company treated 155,000 tons of ore averaging 17.8 ounces of silver per ton, 0.03 ounces of gold, and 1 percent lead.

The Cia. Minera Acre constructed a 120-ton-per-day flotation mill at its Machicala mine 40 kilometers east of Triyillo. The mill will go on stream in January 1964

Cia. Minera Yarabamba installed a 50-ton-per-day flotation mill at the Kiowa copper-lead-silver mine, south of Arequipa. Operation of the mill is scheduled to start early in 1964.

A 50-ton-per-day flotation mill also was installed by Cia. Minera Arcata at the Arcata mine near Juli in the Department of Puno. The ore is reported to assay 30 ounces of silver and 0.13 ounces of gold per ton.

United Kingdom.—Consumption of silver in the arts and industries of the United Kingdom was estimated at 20 million ounces, the same as in 1962. Imports of silver bullion dropped to 21.4 million ounces, slightly more than one-half those of 1962. About 71 percent of the total imports came from the Western Hemisphere countries, United States, Mexico, and Peru, in contrast to last year when two-thirds of United Kingdom imports came from China. Imports from China

[12] Pages 15 and 16 of work cited in footnote 19.

dropped to less than 300,000 ounces. In addition, it was estimated that 3 million ounces of silver in coin was imported, of which about one-half was exported to the continent in the original coins, the remainder being refined for consumption in the United Kingdom.[13]

Exports also dropped sharply to 27.9 million ounces compared with 39.2 million ounces in 1962. About 55 percent of total exports went to France, Italy, Switzerland, and West Germany; most of the remainder went to other European countries.

The quantity of silver recovered from demonetized silver coinage continued to decline and probably did not exceed 2.25 million ounces. Official sales of the Bank of England were nearly 3 million ounces. Several million ounces of silver still remain in circulation.

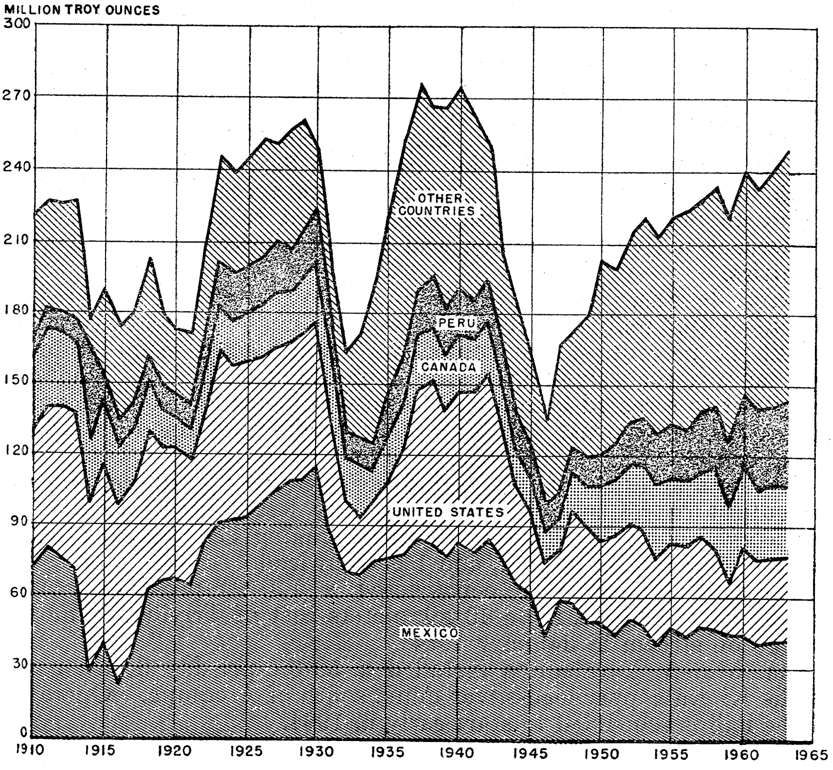

FIGURE 3.—World production of silver, 1910–63.

TECHNOLOGY

An instrument based on the mercury halo system was developed and used in the search for silver deposits. Silver is found frequently at the center of the mercury halo which forms around deposits of other metals. The instrument, involving ultraviolet spectroscopy and gas chromatography was used in the laboratory to test soil

[13] Pages 20, 22, and 24 of work cited in footnote 18.

samples but has potential application in airborne or mobil equipment[14] used for mineral exploration.

The geology, mining methods, and processes used in recovery of silver, lead, and zinc at the Naica operation of Cia. Fresnillo, S.A. in Chihuahua, Mexico, were described.[15] About 1,500 tons per day are mined by room-and-pillar and cut-and-fill mining methods and treated by selective flotation to yield silver-bearing lead concentrate.

Mining and milling operations and some unique problems of transporting equipment and supplies at the Tayoltita silver-gold mine of the Minas de San Luis, S.A. in Western Mexico were also described in two articles.[16] About 300 tons of ore per day are mined chiefly by cut-and-fill methods and treated in a counter-current cyanidation mill of unique design.

A changeover from square set to hydraulic cut-and-fill stoping methods, adoption of more efficient techniques of drilling, blasting and ground support, and the modernization of ore handling and transportation have enabled the Sunshine Mining Co. to improve operating efficiency and reduce costs at the Nation's largest silver mine.[17]

The geologic features, mineralization, structural control, and exploration of the silver deposits of the Yukon Territory were described.[18]

One of the earliest commercial applications of autogenous grinding was in milling silver ore at San Juancito, Honduras, by the New York and Honduras Rosario Mining Co. The flowsheet of the plant and results of autogenous grinding were discussed in a technical journal.[19]

The treatment of silver-bearing ores, particularly silver-manganese ores, by salt roasting was reviewed in a recent article.[20]

A patent [21] was issued on a method of recovering metallic silver from thiosulfate photographic fixing baths by the addition of alkali metal borohydride and separation of metallic silver from the bath. After silver separation, the bath is reusable for photographic fixing.

A newly-developed silver-bearing solder, "Sil-Solder," designed to bridge the gap between lead-tin solder and silver brazing alloys, was found to be superior to conventional solders in a wide range of applications. The alloy, which contains no lead, zinc, or cadmium, complies with all pure food law requirements, has higher capillary action and is harder and more corrosion-resistant than tin-lead, causes less distortion and provides a better color match on stainless steel than silver.[22]

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[14] Engineering and Mining Journal. V. 164, No. 11, November 1963, p. 102.

[15] Bogert, J. Naica Battles Water and Costs as Lead-Zinc-Silver Mining Goes Deeper, Part I. Min. World, v. 25, No. 9, June 1963, pp. 26-29, 38.

Bogert, J. Naica Concentrator Floats Lead-Silver and Zinc; Recovery High, Part II. Min. World, v. 25, No. 10, September 1963, pp. 32-34.

[16] Bogert, J. R. Tayoltita, Mexico's Most Important Silver-Gold Mining Operation, Part I. Min. World, v. 25, No. 7, June 1963, pp. 20-24; Part II, v. 25, No. 8, July 1963, pp. 22-25.

[17] Mining World. Improved Methods at Sunshine Mine Send Higher Grade Ore to Mill. V. 25, No. 2, February 1963, pp. 14-17.

[18] Aho, Aaro E. Silver in the Yukon. Canadian Min. and Met. Bull. V. 56, No. 611, March 1963, pp. 232-239.

[19] Bond, Fred C. Rosario, Pioneer of Autogenous Grinding. Mining Eng., v. 15, No. 5, May 1963, pp. 55-58.

[20] Mellen, R. J. How Silver-Gold Ores Respond to Salt Roasting, Cyanidation. Eng. and Min. J. v. 164, No. 4 April 1963, pp. 76, 77, 83.

[21] Bulloch, D. K., and D. S. Thomas (assigned to Eastman Kodak Co.). Silver Recovery from Photographic Fixing Solutions. U.S. Pat. 3,082,079, Mar. 19, 1963.

[22] Scrap Age. New Silver-Bearing Solder Alloy Now Offered by American Brazing. V. 20, No. 7, July 1963, p. 19.

The Du Pont process for large-scale production of high-purity silver nitrate for photographic film, electroplating, silver powders, and catalysts, was described.[23] The process was adopted in the new plant of Englehard Industries Inc. in Newark, N.J.

A dry tape silver-zinc battery developed for aerospace use may have commercial potential where high efficiency and weight reduction are essential. The tape has anode material on one side and cathode compound on the other, and has indefinite shelf life. Chemical activation is accomplished by running the tape through an electrolyte or breaking an encapsulation which activates the battery.[24]

[23] Chemical Engineering. Silver Nitrate From New Plant: 99.9999 Percent Pure. V. 70, No. 16, Aug. 5, 1963, pp. 86–88.

[24] American Metal Market. Disclose New Silver-Zinc Tape Battery—Can Be Stored Indefinitely. V. 70, No. 177, Sept. 13, 1963, pp. 1, 16.

Slag

Iron-Blast-Furnace

By Perry G. Cotter[1]

BASED upon reported production of over 71 million tons of pig iron in 1963, the total amount of iron-blast-furnace slag produced was estimated to be approximately 29 million tons. Of this amount 82 percent was supplied to processors. Output of processed slag increased slightly in both tonnage and value.

TABLE 1.—Iron-blast-furnace slag processed in the United States, by types

(Thousand short tons and thousand dollars)

Year	Air-cooled				Granulated		Expanded		Total	
	Screened		Unscreened							
	Quantity	Value	Quantity	Value	Quantity	Value[1]	Quantity	Value	Quantity	Value
1954–58 (average)	23,752	$36,013	1,458	$998	3,956	$1,552	2,882	$7,946	32,048	$46,509
1959	21,816	36,774	1,039	957	2,702	1,396	2,812	8,037	28,369	47,164
1960	21,908	37,671	1,237	1,049	3,027	1,489	2,626	7,773	28,798	47,982
1961	19,250	33,906	1,493	985	2,663	1,367	2,275	6,806	25,681	43,064
1962	18,496	32,680	312	340	2,385	1,258	2,249	6,615	23,442	40,893
1963	18,290	32,408	689	624	2,461	1,663	2,251	6,703	23,691	41,398

[1] Excludes value of slag used for manufacturing hydraulic cement.

Source: National Slag Association.

DOMESTIC PRODUCTION

Although combined production of processed iron-blast-furnace slag from the 3 leading States, Pennsylvania, Ohio, and Alabama, declined nearly 2 million tons, increased production in other States raised the national total to 23.7 million tons, compared with 23.4 million tons in 1962.

Thirty-nine companies, 1 less than in 1962, reported operating 59 air-cooled, 21 expanded, and 16 granulated slag plants.

Recovery of Iron.—Recovery of iron for remelting amounted to 403,953 tons; an increase of approximately 5 percent over that of 1962.

[1] Commodity specialist, Division of Minerals.

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
1962:				
Alabama	2,062	$3,801	2,570	$4,536
Ohio	4,936	9,407	5,760	11,325
Pennsylvania	4,971	9,281	6,233	11,061
Other States [1]	6,527	10,191	8,879	13,971
Total	18,496	32,680	23,442	40,893
1963:				
Alabama	1,911	3,853	2,321	4,597
Indiana } Illinois }	2,473	3,169	4,040	5,269
Ohio	3,460	6,554	4,461	8,793
Pennsylvania	4,696	8,809	5,882	10,600
Other States [1]	5,750	10,023	6,987	12,139
Total	18,290	32,408	23,691	41,398

[1] California, Colorado, Indiana (1962), Illinois (1962), Kentucky, Maryland, Michigan, Minnesota, New Jersey, New York, Tennessee, Texas, and West Virginia.

TABLE 3.—Shipments of iron-blast-furnace slag in the United States, by methods of transportation

Method of transportation	1962		1963	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Rail	7,158	30	6,630	28
Truck	15,614	67	16,259	69
Waterway	670	3	576	2
Total shipments	23,442	100	23,465	99
Interplant handling [1]			226	1
Total processed	23,442	100	23,691	100

[1] Confined to granulated slag used in manufacturing cement.

Source: National Slag Association.

Employment and Injuries.—Top honors in the National Slag Association Safety Competition, for 1962, were awarded to the Sparrows Point Foamed Slag Plant of Bethlehem Steel Co. at Sparrows Point, Md., and to the Sheffield Plant of Houston Slag Materials Co. at Houston, Tex. Twelve plants in the Class C category also had injury-free operations in 1962.[2] This also marked the third consecutive year in which the slag processing industry worked without a single fatal accident. In the 1963 Competition the Weirton, W. Va., plant of Standard Slag Co. won top honors in the Class A group by working 114,007 man-hours without a disabling injury. The Class B honors went to the Middletown, Ohio, plant of American Materials Corp. which worked 56,641 man-hours without an injury. In 1963 a total of 3,557,581 man-hours was worked by 1,675 plant and yard employees. Production per man-hour was 6.66 tons compared with 6.74 tons reported for 1962.

[2] Bureau of Mines. Awards in the National Slag Association Safety Competition of 1962. Miner. Ind. Survey, Sept. 5, 1963, 8 pp.

Methods of Transportation.—Percentages of slag shipped by rail and water declined while truck haulage increased 2 percent.

CONSUMPTION AND USES

Screened air-cooled slag accounted for 77 percent of the total production of processed slag. Unscreened air-cooled slag amounted to 3 percent of production; granulated 10 percent; and expanded, 10 percent.

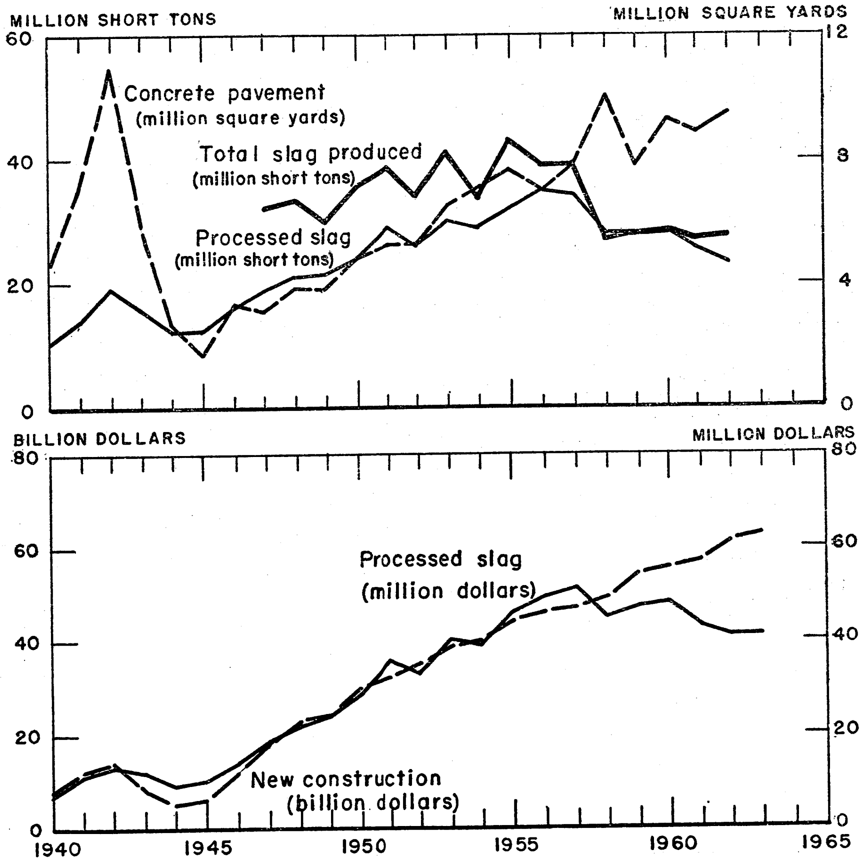

FIGURE 1.—Production of iron-blast-furnace slag compared with yards of concrete pavement (contract awards), monthly average, and value of new construction compared with value of processed slag, 1940–63.

Screened Air-Cooled Slag.—Use of this type of slag for railroad ballast increased slightly, but considerably less was used for the manufacture of mineral wool. Use for sewage trickling medium and for agriculture increased appreciably.

Unscreened Air-Cooled Slag.—Use for highway and airport construction was 50 percent greater than in 1962 and total value increased 29 percent. Total tonnage for all uses more than doubled.

Granulated Slag.—Use in manufacture of various types of cement accounted for 42 percent of the total production of 2.5 million tons. Highway construction uses for base, subgrade, and fill amounted to 41 percent, as compared with 30 percent in 1962. Various other uses, including the manufacture of concrete block and for agriculture, accounted for 17 percent.

Expanded Slag.—Production of expanded slag was 2.3 million tons, slightly more than in 1962. Ninety-eight percent went into manufacturing concrete block. This same percentage of Canadian expanded slag was used in 1962 for concrete block. Canadian expanded slag was processed at Hamilton and Port Colborne, in Ontario, and at Sydney, Nova Scotia.[3]

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)

Year and use	Screened		Unscreened	
	Quantity	Value	Quantity	Value
1962:				
Aggregate in—				
Portland-cement concrete contruction	2,508	$4,719		
Bituminous construction (all types)	3,809	7,171		
Highway and airport construction [1]	7,009	12,641	157	$195
Manufacture of concrete block	423	722		
Railroad ballast	3,067	3,727		
Mineral wool	560	1,026		
Roofing (cover material)	357	1,194		
Sewage trickling filter medium	27	60		
Agricultural slag, liming	5	9		
Other uses	731	1,411	155	145
Total	18,496	32,680	312	340
1963:				
Aggregate in—				
Portland-cement concrete construction	2,662	4,969		
Bituminous construction (all types)	3,099	5,889		
Highway and airport construction [1]	7,013	12,565	235	252
Manufacture of concrete block	438	786		
Railroad ballast	3,093	3,898		
Mineral wool	473	792		
Roofing slag:				
Cover material	348	1,068		
Granules	26	155		
Sewage trickling filter medium	147	287		
Agricultural slag, liming	18	30		
Other uses	973	1,969	454	372
Total	18,290	32,408	689	624

[1] Other than in portland-cement concrete and bituminous construction.

Source: National Slag Association.

[3] Wilson, H. S. Aggregates, Lightweight. Canada Dept. of Mines and Tech. Surveys, Ottawa, Canada, 1962, 6 pp.

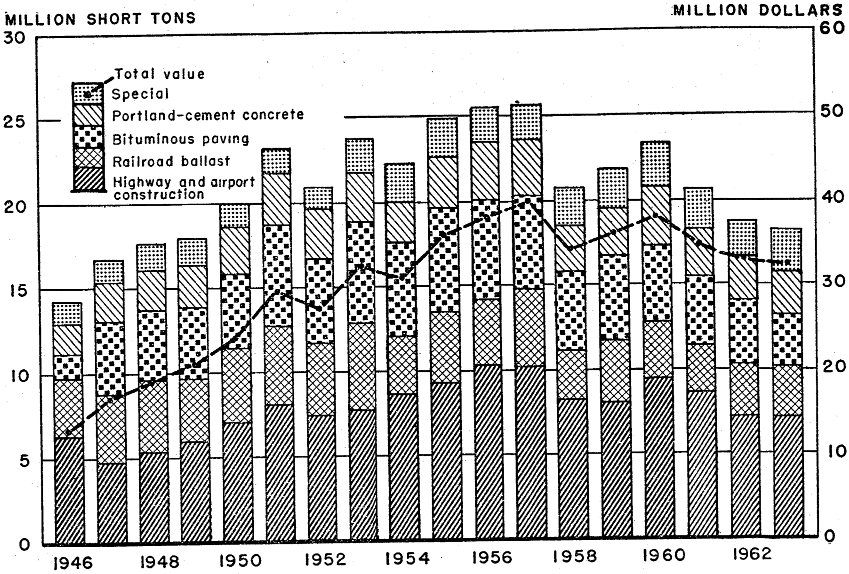

FIGURE 2.—Consumption and value of air-cooled, iron-blast-furnace slag sold or used in the United States, 1946–63.

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	1962				1963			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Highway construction (base and subgrade)	504	$666			745	$1,000		
Fill (road, etc.)	218	237			273	268		
Agricultural slag, liming	59	74			61	86		
Manufacture of hydraulic cement	1,320	(1)			1,041	(1)		
Aggregate for concrete-block manufacture	92	106	2,195	$6,453	160	162	2,206	$6,552
Aggregate in lightweight concrete			8	23				
Other uses	192	175	46	139	181	147	45	151
Total	2,385	[2] 1,258	2,249	6,615	2,461	[2] 1,663	2,251	6,703

[1] Data not available.
[2] Excludes manufacture of hydraulic cement, value not available.

Source: National Slag Association.

PRICES

The average value for total slag produced was $1.75 per ton, an increase of only $0.01 per ton over that of 1962. However, slag of diverse characteristics, produced for a variety of uses, ranged from $0.81 per ton for material which received little processing, to $5.95

for small tonnages of slag which required a high degree of screening, sizing, and washing to meet rigid specifications. Screened air-cooled slag for concrete block manufacture, bituminous construction, and railroad ballast averaged slightly higher in price, as did expanded slag for concrete block and granulated slag for liming soils.

TABLE 6.—Average value of iron-blast-furnace slag sold or used by processors in the United States, by uses

(Per short ton)

Use	Air-cooled				Granulated		Expanded	
	Screened		Unscreened					
	1962	1963	1962	1963	1962	1963	1962	1963
Aggregate in—								
Portland-cement concrete construction	$1.88	$1.87	--------	--------	--------	--------	[1] $2.88	--------
Bituminous construction (all types)	1.88	1.90	--------	--------	--------	--------	--------	--------
Highway and airport construction [2]	1.80	1.79	$1.24	$1.07	[3] $1.32	[3] $1.34	--------	--------
Manufacture of concrete block	1.71	1.79	--------	--------	1.15	1.01	2.94	$2.97
Railroad ballast	1.22	1.26	--------	--------	--------	--------	--------	--------
Mineral wool	1.83	1.68	--------	--------	--------	--------	--------	--------
Roofing slag:								
Cover material	} 3.34	3.07	--------	--------	--------	--------	--------	--------
Granules		5.95	--------	--------	--------	--------	--------	--------
Sewage trickling filter medium	2.22	1.95	--------	--------	--------	--------	--------	--------
Agricultural slag, liming	1.80	1.64	--------	--------	1.25	1.42	--------	--------
Fill (road, etc.)	--------	--------	--------	--------	1.09	.98	--------	--------
Other uses	1.93	2.02	.94	.82	.91	.81	3.02	3.38

[1] Lightweight concrete.
[2] Other than in portland-cement and bituminous construction.
[3] Base and subgrade material.

Source: National Slag Association.

TECHNOLOGY

Experiments in blast-furnace practice, of interest to slag processors as an indication of future trends, were conducted by the Steel Company of Canada, Ltd. to determine the effects of decreasing the slag volume to very low levels. It was found possible to operate furnaces satisfactorily on a slag volume as low as 335 pounds per net ton of hot metal (NTHM) using carefully selected raw materials for the charge.[4]

Results of studies sponsored by the American Iron and Steel Institute to determine the blast furnace reactions between the iron and slag, as concerned silicon, were reported. Metals used in experiments, silicon distribution for various types of slags, and phase diagrams of the slags were shown.[5]

The manganese equilibrium values for three distinctly varying blast-furnace slag compositions were studied.[6]

[4] McKay, J. C., and J. A. Peart. Blast Furnace Practice With Very Low Slag Volume. J. Metals. v. 15. No. 4, April 1963, pp. 288–293.

[5] Rein, Richard H., and John Chipman. The Distribution of Silicon Between Fe-Si-C Alloys and SiO_2–CaO–MgO–Al_2O_3 Slags. Trans. AIME, v. 227 (Met. Soc.), No. 5, October 1963., pp. 1193–1203.

[6] Philbrook, W. O., and S. K. Tarby. Distribution of Manganese Between Silicate and Aluminate Slags and Carbon-Saturated Iron. Trans. AIME, v. 227 (Met. Soc.), No. 5, October 1963, pp. 1039–1044.

Subjects of papers presented at the midyear meeting of the National Slag Association concerned use of slag in concrete masonry, road work, regular and built-up roofing granules, expanded slag as a lightweight concrete aggregate, open-hearth slag for road base and bituminous concrete, and slag sand.[7]

To produce slag in distinct particles the slag was poured into a shallow pool, allowed to cool slightly, flooded with a small amount of water, and cooled for several hours to fragment it.[8]

In the production of expanded blast-furnace slag, a stream of molten slag was dispersed with a blast of gas, the pellets projected through a water spray, and the expanded pellets, in plastic condition, were rolled over a cooled surface to round and glaze them.[9]

Slag sand, for use with cement, lime, or lime-gypsum plaster, was produced by quenching high-silica blast-furnace slag in air or water, crushing to a maximum grain size of 5 millimeters, but with not over 50-percent finer than 0.2 millimeter.[10]

The higher subsidies now allowed by Great Britain on most grades of basic agricultural slag combined with greater emphasis on renewal of grasslands by the British Grassland Renovation Scheme was expected to result in the use of over 500,000 tons of basic slag fertilizer.[11]

The chemical, mineralogical, and physical properties of blast-furnace slag were reviewed and the characteristics of slag concrete were discussed.[12]

Because of expanded use of fly ash, the Waylite Company of Chicago has installed a sintering and grading plant in Detroit to process the material for lightweight aggregate. The plant, which cost more than $1 million, is expected to use from 1,000 to 1,500 tons per day of fly ash from Detroit powerplants.[13]

The Heckett Engineering Co. has erected a new plant at the Geneva, Utah Works of the United States Steel Corp. to process both open-hearth and blast-furnace slag and to recover metal. Several types of railroad ballast and road aggregate are to be produced as well as fines for surface treatment of highways.[14]

Serpentine or similar rock was added to blast-furnace slag to form a porous melt.[15]

The compositions of English, German, Indian, and Scottish blast-furnace slags were discussed in relation to their uses. Research on problems connected with the use of blast-furnace slag as a diluent for ammonium nitrate in fertilizer was suggested. An extensive list of modern references was included.[16]

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7 Herod, Buren C. Midyear NSA Meeting. Pit and Quarry, v. 56, No. 2, August 1963, pp. 101–103, 112.

8 Miller, W. B. Y. (assigned to Colvilles Ltd., Glasgow, Scotland). Method of Producing Slag in Fragmented Form. U.S. Pat. 3,109,727, Nov. 5, 1963.

9 Osborne, F. (assigned to S. P. Kinney Engineers, Inc., Carnegie, Pa.). Method and Apparatus for Processing Slag. U.S. Pat. 3,104,164, Sept. 17, 1963.

10 Quinn, R. G. (assigned to Johns-Manville Corp., New York). Structural Composition Material and Process for Making Same. U.S. Pat. 3,096,188, July 2, 1963.

11 Chemical Age (London). Record Demand for Basic Slag This Winter. V. 90, No. 2311, Oct. 26, 1963, p. 650.

12 Timms, Albert G. Blast-Furnace Slag as a Concrete Aggregate. Pt. 1, Modern Concrete, v. 27, No. 6, October 1963, pp. 29–33; pt. 2, v. 27, No. 7, November 1963, pp. 29–33.

13 Pit and Quarry. Fly Ash To Be Processed for Lightweight Aggregate in Waylite's Detroit Plant. V. 55, No. 12, June 1963, p. 27.

14 Utley, Harry F. $3,000,000 Facility Erected in Utah by Heckett Engineering. Pit and Quarry, v. 56, No. 4, October 1963, pp. 94–96.

15 Wolf, E. (assigned to Schlosser & Co., G.m.b.H., Michelbach, West Germany). Manufacture of Crystalline Porous Stones. U.S. Pat. 3,082,100, Mar. 19, 1963.

16 Khan, A., and C. P. Ramaswamy. Uses of Blast Slag. J. Mines, Metals, and Fuels (Calcutta, India), v. 10, December 1962, pp. 11–19.

Experiments by the Tennessee Coal and Iron Division of United States Steel Corp., indicate that citrus trees grown in soil to which blast-furnace slag was added had a higher average yield than those grown in soils fertilized by most other fertilizers. It was believed that iron and manganese present in blast-furnace slag were more readily utilized by plants than the same elements found naturally in soils, or added to soil conditioners.[17]

Cooperative tests conducted by the Standard Slag Company's Lordstown, Ohio plant, and the Cleveland Wire Cloth and Manufacturing Co. resulted in better performance of screens and lowered costs for the slag screening operation.[18]

Studies conducted by the Edward C. Levy Slag Co. on methods of processing and utilization of open-hearth slag indicate that improved methods for removing metal, gradation control, and in placement as road base should expand markets for this material.

A plant similar to those used to convert blast-furnace slag to aggregate was developed to convert 1,200-tons-per-day fly ash into lightweight aggregate.[19]

Equipment and operating methods of two modern slag processing plants were described.[20]

Three cupolas were operated at the Baldwin-Ehret-Hill Inc. plant in Trenton, N.J., to convert blast-furnace slag and nonferrous slags into mineral wool fibers.[21]

A description was given of a portable magnetic separation plant designed to extract iron from blast-furnace slag.[22]

The J. G. Eccles and Co., Ltd., of Scunthorpe, England, installed an automatic blast-furnace slag coating unit. Controls on the mixer floor, combined with timing clocks, allowed either manual or fully automatic operation.[23]

Experiments were conducted on the operation of a blast furnace with a burden of 100-percent pellets at various hot-blast temperatures both with and without fuel injection. The minimum slag requirements for efficient desulfurization were reported.[24]

A low-cost, high-quality abrasive material for use in sandblasting was produced by granulating blast-furnace slag and reheating sufficiently to fuse the particles without agglomerating. Heating the slag relieved internal stresses which cause disintegration of the blast particles. The properties of this treated slag were stated to compare favorably with corundum.[25]

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[17] Commercial Fertilizer. Slag Found Beneficial for Citrus and Pasture. V. 107, No. 1, July 1963, p. 38.

[18] Pit and Quarry. Slag Producer Tests Screen Factors of Cloth. V. 56, No. 4, October 1963, p. 52.

[19] Mining Engineering. Utility to Profit From Fly Ash. V. 15, No. 10, October 1963, pp. 15–16.

[20] Mine and Quarry Engineering (London). Llanwern Slag. V. 20, No. 8, August 1963, pp. 345–347.
Steel & Coal (London). Slag Processing. V. 187, No. 4955, July 5, 1963, pp. 40–41.

[21] Levine, Sidney. Slag Pyroprocessing for Mineral Wool Production. Minerals Processing, v. 4, No. 2, February 1963, pp. 28–30.

[22] South African Mining & Engineering Journal (Johannesburg). New Portable Unit Extracts Metal From Slag Dumps. V. 74, pt. 2, No. 3680, Aug. 16, 1963, p. 603.

[23] Quarry Manager's Journal. New Coating Plant for Blast-Furnace Slag Processing Unit. V. 47, No. 12, December 1963, pp. 498–499.

[24] Babon, R., and A. Poos. Experience With a Hundred Percent Pellet Burden and a Low Slag Volume. Nat. Met. Laboratory Tech. J., v. 5, No. 2, May 1963, pp. 17–24.

[25] Gesellschaft der Ludw. von Roll'schen Fisenwerke A.G. (Gerlafingen, Switzerland). Improvements in or Relating to Blasting Agents. Brit. Pat. 914,337, Jan. 2, 1963.

A method for producing high-early-strength portland cement with alumina as a byproduct was developed. The raw mix, which comprised blast-furnace slag and other materials capable of reacting to produce dicalcium orthosilicate, and pentacalcium trialuminate were sintered and the sinter disintegrated to form a dicalcium orthosilicate powder from which part of the alumina was extracted with an alkali. The remaining powder was mixed with limestone and burned to portland cement clinker. The method was claimed to allow use of poorer quality, less basic, slags.[26]

Granulated blast-furnace slag was crushed to pass a 5-millimeter screen, with at least 10 percent through a 0.2-millimeter screen, and mixed with lime or portland cement to make a mortar. Use of this slag sand for mortar prevents the formation of so-called "cold bridges" in thin walls because of its low heat-conductivity.[27]

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[26] Grzymek, J. (Warsaw, Poland). Improvements in or Relating to Methods of Producing Portland Cement and Simultaneously Obtaining Alumina as a By-Product. Brit. Pat. 944,127, Dec. 11, 1963.

[27] Maydl, P. (assigned to Etablissment Thermocrete, Baupatente-Verwertungsgesellschaft, Vaduz, Lichtenstein). Production of Mortar or Concrete From Blast-Furnace Slags or the Like. Canadian Pat. 659,211, Mar. 12, 1963.

Sodium and Sodium Compounds

By Robert T. MacMillan [1]

NATURAL sources of soda ash (sodium carbonate) supplied nearly one-fifth of the Nation's requirement for this basic chemical in 1963. More than 1 million tons of high-grade sodium carbonate was produced from deposits, chiefly in Wyoming. Although natural sodium sulfate production fell 5 percent below the 1962 level, byproduct output increased sufficiently to bring the total sodium sulfate production to the highest of record.

DOMESTIC PRODUCTION

As in past years most of the soda ash produced in the United States was manufactured from salt by the ammonia soda process. Nine eastern and midwestern plants strategically situated in regard to salt and limestone deposits, and nearby chemical markets provided the bulk of the Nation's soda ash requirements. The remaining soda output, equal in quality to the ammonia soda product, was supplied from natural sources of sodium carbonate, such as certain lake brines in California and bedded trona deposits in Wyoming.

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] [2]	Natural sodium carbonates [3]	
	Quantity	Quantity	Value
1954–58 (average)	4,718	615	$16,152
1959	4,904	735	19,078
1960	4,558	809	20,865
1961	4,516	806	20,444
1962	4,607	978	24,330
1963	[4] 4,682	1,119	27,616

[1] Bureau of the Census.
[2] Includes quantities used to manufacture caustic soda, sodium bicarbonate, and finished light and dense soda ash.
[3] Soda ash and trona (sesquicarbonate).
[4] Preliminary figure.

[1] Commodity specialist, Division of Minerals.

TABLE 2.—Sodium sulfate produced and sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Production (manufactured[1] and natural)			Sold or used by producers (natural only)	
	Salt cake (crude)	Glauber salt (100 percent $Na_2SO_4 \cdot 10H_2O$)	Anhydrous refined (100 percent Na_2SO_4)	Quantity[2]	Value
1954–58 (average)	702	135	258	309	$5,793
1959	734	99	308	403	7,689
1960	738	72	303	450	8,706
1961	780	64	327	466	9,296
1962	[2] 826	(3)	368	458	9,092
1963	(4)	(4)	(4)	435	8,392

[1] Bureau of the Census.
[2] Includes glauber salt converted to 100-percent Na_2SO_4 basis.
[3] Included with salt cake (crude).
[4] Data not separately available, preliminary total sodium sulfate, 1,206,000 short tons.

Since 1960 the growth of the soda ash industry, rated at 2 to 3 percent annually, was largely from natural soda rather than ammonia soda production. The high capitalization required for new ammonia soda plants compared with natural soda refineries was believed to be the reason for the stalemate in new ammonia soda plant construction and increased interest in natural soda output.

Natural sodium carbonate was produced from brines of Searles and Owens Lake in southern California and from underground trona deposits in Wyoming. The California producers included American Potash & Chemical Corp. and Stauffer Chemical Co.; both of whom produced soda ash and other chemicals from Searles Lake. Pittsburgh Plate Glass Co. produced soda ash from brines of Owens Lake near Bartlett.

In Wyoming extensive trona deposits were mined and processed by two companies near Green River. FMC Corp. first pioneered soda ash production from the area in the 1950's. The operation was successful from the beginning and expanded to become the fourth largest producer of soda ash in the United States. In 1962, Stauffer Chemical Co. opened the second mine in the area. Plans for expanding this operation were formulated, and several other firms were reported to be exploring the area for minable trona deposits.

Sodium sulfate (salt cake) output was 1.2 million tons, approximately the same as in 1962. About 64 percent was produced as byproducts of chemical processes, which produced rayon, cellophane, hydrochloric acid, sodium bichromate, boric acid, phenols, and miscellaneous chemicals; and 36 percent was produced from natural sources.

Natural sodium sulfate was produced in California, Wyoming, and Texas. In California, American Potash & Chemical Corp. and Stauffer Chemical Co., West End Division, produced sodium sulfate from Searles Lake brines at Trona and Westend, respectively; United

TABLE 3.—Soda ash annual production capacity, by company

	Plant location	*Process*	*Annual capacity, thousand short tons*
Manufactured soda producers:			
Allied Chemical Corp	Baton Rouge, La	Ammonia soda	875
Do	Detroit, Mich	do	800
Do	Syracuse, N.Y	do	900
Diamond Alkali Co	Painesville, Ohio	do	700
The Dow Chemical Co	Freeport, Tex	Caustic carbonation	180
Olin Matheison Chemical Corp	Lake Charles, La	Ammonia soda	375
Do	Saltville, Va	do	360
Pittsburgh Plate Glass Co	Barberton, Ohio	do	600
Do	Corpus Christi, Tex	do	240
Wyandotte Chemicals Corp	Wyandotte, Mich	do	700
Total			5,730
Natural soda producers:			
American Potash & Chemical Corp	Trona, Calif	Lake brine evaporation	150
FMC Corp	Green River, Wyo	Trona mining	750
Pittsburgh Plate Glass Co	Bartlett, Calif	Lake brine evaporation	70
Stauffer Chemical Co	Green River, Wyo	Trona mining	200
Do	Westend, Calif	Lake brine evaporation	150
Total			1,320
Grand total			7,050

Source: Chemical and Engineering News. V. 41, No. 34, Aug. 26, 1963, pp. 19, 20.

States Borax & Chemical Corp. produced sodium sulfate as a coproduct in making boric acid from borax. In Texas, Ozark-Mahoning Mining Co. produced sodium sulfate from subterranean brines at Monahans and Brownfield, and in Wyoming, William E. Pratt produced sodium sulfate from semidry lakebeds.

Sodium metal production increased 5 percent from 119,084 in 1962 to 125,566 short tons in 1963. Three companies were reported to be producing sodium and its coproduct, chlorine, by electrolysis of molten salt: E. I. du Pont de Nemours & Co., Inc., with plants at Niagara Falls, N.Y., and Memphis, Tenn.; Ethyl Corp., with plants at Baton Rouge, La., and Houston, Tex.; and National Distillers & Chemical Corp. at Ashtabula, Ohio.

The demand for caustic soda increased substantially. For many years caustic soda was in over supply because of the rapid growth of coproduct chlorine. Among the factors responsible for the market recovery of caustic soda was the increased demand for rayon, which requires the use of caustic in its manufacture, and the trend of alumina manufactures from the use of soda ash to caustic soda in extracting alumina from ores. Because soda ash and caustic soda are both made from the same materials (salt) and are interchangeable in many of their uses, the industry problems are interrelated and should be considered together.[2]

CONSUMPTION AND USES

Consumption of sodium carbonate followed the pattern of previous years. The glass industry consumed more than 40 percent of the output, and chemicals such as sodium tripolyphosphate, sodium silicates, sodium bicarbonate, and lime soda caustic took 26 percent. Estimates of the tonnage in the various use categories for 1962 were published as follows:

Use:	Thousand short tons	Percent of total
Glass	2, 450	43. 7
Chemicals	1, 450	25. 9
Pulp and paper	485	8. 7
Soap and detergents	295	5. 3
Aluminum	225	4. 0
Water treatment	200	3. 6
Exports and miscellaneous	495	8. 8
Total	5, 600	100. 0

Source: Chemical and Engineering News. V. 41, No. 34, Aug. 26, 1963, pp. 19, 20.

The alumina industry, which formerly relied heavily on soda ash to digest alumina ores, was reported to be largely converted to the use of caustic soda. However, in many plants either caustic soda or soda ash may be used.

The most important use of sodium sulfate was in the kraft paper industry. As a reagent in digesting pulpwood, sodium sulfate helps to dissolve the lignin, releasing the cellulose fibers which are processed into various paper products. An estimated 70 percent of the total sodium sulfate output was consumed in this industry.

[2] Oil, Paint and Drug Reporter. Caustic Soda Record Demand in '63. V. 184, No. 16, Oct. 14, 1963, pp. 3, 35, 37.

Sodium sulfate was also used in making glass, ceramic glazers, detergents, stock feeds, dyes, textiles, medicines, and various chemicals.

Metallic sodium was used chiefly in making tetraethyl lead (TEL) and tetramethyl lead (TML), two compounds added in small quantities to automotive fuels to increase their antiknock characteristics.

Other uses of metallic sodium included metal descaling, ore reduction, and manufacture of sodium peroxide, hydride amide, cyanide, borohydride, and other chemicals.

PRICES

Prices quoted for sodium carbonate, sodium sulfate, and metallic sodium by Oil, Paint and Drug Reporter were unchanged from 1962. Prices for these commodities in 1963 were as follows:

Commodity:		*Price*
Sodium carbonate (soda ash 58 percent Na_2O):		
Light, paper bags, carlots	per hundredweight	$1.85
Light, bulk	do	1.55
Dense, paper bags, carlots	do	1.90
Dense, bulk	do	1.60
Sodium sulfate (100 percent Na_2SO_4):		
Technical, anhydrous, bags, carlots	per ton	[1] 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	do	28.00
National Formulary (N.F. VII), drums	per pound	.225
Metallic sodium:		
Bricks, lots of 18,000 pounds and over, works	do	.21
Fused, lots of 18,000 pounds and over, works	do	.195
Bulk, tank, works	do	.17

[1] Delivered east of Mississippi River.

FOREIGN TRADE

With a drop of 15 percent, the imports of sodium sulfate in 1963 were the lowest in 5 years. More than 52 percent came from Belgium-Luxembourg, and 42 percent from Canada. The remainder was from the United Kingdom, West Germany, and the Netherlands.

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
1954-58 (average)	101	$1,975	3	$89	104	$2,064
1959	118	2,478	4	97	122	[2] 2,580
1960	164	3,411	3	62	167	3,473
1961	193	4,089	3	64	196	4,153
1962	181	3,646	7	122	188	3,768
1963	158	3,054	1	27	159	3,081

[1] Includes glauber salt, as follows: 1958, 12 tons ($830); 1959, 227 tons ($4,839); 1960, 7 tons ($479); 1961-62 none; 1963, 3 tons ($285).

[2] Revised figure.

Source: Bureau of the Census.

Exports of sodium sulfate decreased about 12 percent compared with that of 1962. As in past years, Mexico and Canada were the chief recipients. Exports were about 4 percent of the U.S. total output of sodium sulfate.

About 3 percent of the total sodium carbonate production was exported. Exports of this commodity were 21 percent higher than those of 1962.

TABLE 5.—U.S. exports of sodium carbonate and sodium sulfate

(Thousand short tons and thousand dollars)

Year	Sodium carbonate		Sodium sulfate	
	Quantity	Value	Quantity	Value
1954-58 (average)	167	$5,848	25	$875
1959	153	5,644	22	805
1960	155	5,143	31	940
1961	132	4,045	32	992
1962	152	4,693	51	1,486
1963	184	5,722	45	1,379

Source: Bureau of the Census.

Tariff rates of various grades of sodium sulfate were as follows:

	Tariff rate per short ton August 31, 1963
Sodium sulfate, crude	Free
Glaubers salt ($Na_2SO_4 \cdot 10H_2O$)	1.00
Anhydrous sodium sulfate (Na_2SO_4)	.50

Lacking a uniform procedure to distinguish between anhydrous and crude sodium sulfate, classification for tariffs on these commodities has been difficult.[3] Because the crude material has been admitted free while the higher purity grades were subject to duty, it was possible for high-purity sodium sulfate to enter the country free of duty, if it were designated as crude. One possible solution to the problem was to consider as dutiable all material which was suitable for use by the dye and detergent industries; another solution was to base the tariff on the sodium sulfate content of the material. Arguments for and against these and other proposals were expounded but no agreement was reached.

WORLD REVIEW

China.—Four soda ash and one caustic soda factory were reported in operation in China. Twenty alkaline lakes of Inner Mongolia formed an important alkali producing area linked to the Paotao-Lanchow railway.[4]

Japan.—Because of the necessity for importing salt, the manufacture of soda ash in Japan required high efficiency as well as tariff protection to compete economically with soda ash produced in other countries. The Japanese Government was reported willing to liberalize the 25

[3] Oil, Paint and Drug Reporter. Sodium Sulfate Tariff Poser: Should Material be Reclassified? V. 184, No. 21, Nov. 18, 1963, pp. 4, 62.

[4] Mining Journal (London). Chinese Soda Production. V. 260, No. 6652, Feb. 15, 1963, p. 159.

percent duty on imported synthetic soda ash, but was desirous of maintaining the high duty on soda ash valued at less than US$38.89 per ton to discourage importation of inexpensive natural soda.[5]

Kenya.—Exports of natural soda ash from Lake Magadi to the Republic of South Africa were placed under embargo by the Government of Kenya for political reasons. The Republic of South Africa, principal buyer of the Kenya soda ash, was reported negotiating with suppliers in the United Kingdom.

Mexico.—Steps toward Mexican self-sufficiency in both sodium sulfate and sodium carbonate production were made when plans for expanding the output of these commodities were completed. A new 75,000-ton-per-year production unit for sodium sulfate was expected to be on stream in 1963, capable of supplying the 20,000 tons of sodium sulfate imported annually and providing excess sodium sulfate for export to the United States. The plant, owned jointly by Americana Metal Climax, Inc., and Mexicana Penoles, S.A., was under construction at Laguna del Rey, a dry lake in the State of Coahuila.[6]

An 80,000-ton-per-year soda ash plant was planned for Monterrey by Formento de Industria y Commercio and Allied Chemical Corp. The plans were to produce brine from underground salt beds not only to supply the ammonia soda plant, but also to produce high-grade industrial salt.[7]

TECHNOLOGY

Operation and maintenance in the trona mine of FMC Corp., was described in an article.[8] Production from this mine situated in southwestern Wyoming provided an important percentage of the soda ash requirements of the Nation. A 10-foot seam of trona was mined at a depth of 1,500 feet using the room and pillar system employed in coal mining. Continuous miners have been used but the hardness of the trona reduced the speed of advance to one-fourth the rate in coal.

Haulage in the mine was by rubber tired vehicles and conveyer belt. Balanced skips in a two-compartment shaft hoisted 3,000 tons of trona ($Na_2CO_3 \cdot NaHCO,2H_2O$) per day to the surface processing plant. Normally 20 shifts were operated each week and the 21st was used for maintenance work on continuously operating equipment.

Equipment maintenance problems were handled most efficiently by operating between 100 percent preventive maintenance, meaning that equipment was replaced before breakdown; and breakdown maintenance, meaning that machinery was operated without maintenance until failure occurred. Most repairs were made on the site of the breakdown. If extra headroom was needed it was blasted out of the roof. Specially equipped lubrication trucks provided rapid servicing of equipment in widely scattered areas.

Discovery of superheated brines rich in minerals created considerable interest among chemical and power producers in the Salton Sea

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[5] Oil, Paint and Drug Reporter. Japan of Two Minds on Soda Ash Imports. V. 184, No. 22, Nov. 25, 1963, p. 4.

[6] Chemical Week. More Salt Cake Competition is in the Offing. V. 93, No. 17, Oct. 26, 1963. p. 162.

[7] Chemical Age (London). Mexico To Have New $14.5 Million Soda Ash Plant. V. 90, No. 2298, July 27, 1963, p. 144.

[8] Hartman, H. G. Preventive Maintenance in Trona Mining. Min. Cong. J., v. 49, No. 6, June 1963, pp. 48–50.

area of southern California.[9] Five wells were drilled in an effort to develop geothermal power known to be a possibility in the area. Unexpectedly high concentrations of minerals found in the brines were believed to improve the economic feasibility of a combined chemical and power producing project. One well flowing at 280,000 pounds-per-hour and 199° C had the following concentrations in parts-per-million: Sodium–70,000; calcium–34,470; potassium–24,000; iron–4,200; borax as B_4O_7, –537; lithium–150, and chlorine–201,757. Although the economic potential of the brines was supposed to be high, their utilization depended upon developing an economically feasible scheme for extracting and processing the minerals into commercial products.

A dustless, low-density form of soda ash was developed for use in cleaning compounds and detergent products.[10] Particles of the material had a porous shell structure that enabled it to be highly absorbent, structurally strong, and quick to dissolve. Bulk density of the material ranged between 31.9 and 37.6 pounds per-cubic-foot compared with 62 to 74 for dense soda ash. After absorbing up to 30 percent of its weight in various surface active compounds including nonionics, cationics, anionics, and sequestering reagents, the new soda ash still retained many of its original physical properties.

Several patents on methods of producing and treating sodium carbonate were issued. One described a method for producing dense soda ash (sodium carbonate) from crude sodium bicarbonate by cyclic heating of crude bicarbonate at superatmospheric pressures with recycled mother liquor until crystallization of anhydrous sodium carbonate occurred.[11] The crystals were separated from the mother liquor at a point above the transition temperature at which anhydrous sodium carbonate reverts to the monohydrate.

Improvements in recoving soda ash from crude trona were described.[12] In the clarification step following dissolution of the crude trona, a special flocculating agent was added to aid in settling and removing the insoluble material.

Crystallization of sodium carbonate monohydrate from an aqueous solution of sodium carbonate by reacting with a concentrated caustic soda solution was the subject of patent claims.[13] A feature of the process was that crystallization was brought about without the addition of heat to the process.

The use of chlorine in aqueous suspensions of alkali metal carbonate to increase the whiteness of the final alkali carbonate product was patented.[14]

Development of fuel cells to convert heat energy directly into electrical energy continued to occupy the attention of researchers.[15] The

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[9] Chemical Week. Harnessing Hot Brine. V. 93, No. 23, Dec. 7, 1963, p. 43.
[10] Chemical Engineering. Low Density Form of Sodium Carbonate is Highly Absorbent. V. 70, No. 16, Aug. 5, 1963, pp. 70, 72.
[11] Beecher, B. K., and F. C. Mericola (assigned to Wyandotte Chemicals Corp., Wyandotte, Mich.). Dense Sodium Carbonate Process. U.S. Pat. 3,113,834, Dec. 10, 1963.
[12] Frint, W. R., and W. D. Smith (assigned to FMC Corp., Delaware). Method of Producing Soda Ash from Crude Trona. U.S. Pat. 3,084,026, Apr. 2, 1963.
[13] Blumenthal, E. (assigned to Imperial Chemical Industries Ltd., London). Sodium Carbonate Manufacture. U.S. Pat. 3,103,413, Sept. 10, 1963.
[14] Snyder, S. W. (assigned to Pittsburgh Plate Glass Co., Corpus Christi, Tex.). Treatment of Sodium Carbonate. U.S. Pat. 3,082,060, Mar. 19, 1963.
[15] Chemical Engineering. Fuel Cells, Far from Commercial, Command Intense Development Effort. V. 70, No. 12, June 10, 1963, pp. 83, 86.

highest powered fuel-cell assembly that has been tested was believed to be a 6 Kw sodium amalgam unit weighing 650 pounds. The fuel for the unit is metallic sodium and the electrolyte is sodium hydroxide solution. Operating at 150° F the cell yielded 75 amperes per square foot.

Studies were made to improve the sodium vapor lamp long known for its efficiency and characteristic yellow light.[16] By increasing the temperature and pressure of the sodium vapor in the light emitting tube, a golden white light was produced which caused a more natural rendering of colors. The emitting tube was fabricated from translucent sintered aluminum oxide which was able to withstand the temperature and pressure conditions and the corrosive attack of the sodium vapor.

Significant changes in the paper industry, particularly in the field of containers, were brought about by the increasing use of various plastic coatings on paper and paper board.[17] As the paper industry was the chief consumer of sodium sulfate, all factors affecting the paper industry also affected sodium sulfate production. To the extent that improvements in paper coatings created increased markets for paper products, the sodium sulfate market was also expected to increase.

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[16] Chemical Engineering. Better Light from High Temperature Sodium Lamp. V. 70, No. 12, June 10, 1963, p. 102.

[17] Chemical and Engineering News. Coatings for Paper. V. 41, No. 36, Sept. 9, 1963, pp. 86–93.

Stone

By Perry G. Cotter [1]

Contents

COMBINED production of dimension and crushed and broken stone exceeded $1 billion in value for the second consecutive year. In 1963 the value of all types of quarry stone increased although the tonnage of granite decreased slightly.

TABLE 1.—Salient stone statistics in the United States [1]

(Thousand short tons and thousand dollars)

	1954–58 (average)	1959	1960	1961	1962	1963
Sold or used by producers:						
Dimension stone	2, 565	2, 442	2, 257	2, 315	2, 729	2, 616
Value	$80, 687	$87, 571	$86, 009	$88, 093	$90, 687	$96, 318
Crushed stone	490, 737	581, 721	614, 527	609, 623	654, 225	685, 750
Value	$676, 199	$824, 411	$866, 546	$859, 266	$935, 010	$971, 790
Total stone	493, 302	584, 163	616, 784	611, 938	656, 954	688, 366
Value	$756, 886	$911, 982	$952, 555	$947, 359	$1,025,697	$1, 068, 108
Imports for consumption (value) [2]	$7, 210	$11, 064	$11, 344	$12, 268	$17, 204	$18, 978
Exports (value)	$5, 675	$7, 292	$6, 166	$6, 648	$6, 009	$6, 102

[1] Includes slate. 1954–56 includes territories of the United States, possessions, and other areas administered by the United States.
[2] Includes whiting.

[1] Commodity specialist, Division of Minerals.

TABLE 2.—Stone sold or used by producers in the United States, by States

(Thousands short tons and thousand dollars)

State	1962		1963	
	Quantity	Value	Quantity	Value
Alabama	[1] 12,680	[1] $19,667	[1] 13,684	[1] $22,206
Alaska	(2)	(2)	(2)	(2)
Arizona	4,333	6,616	3,257	5,069
Arkansas	20,611	19,866	18,913	22,727
California	34,776	54,722	37,977	58,253
Colorado	2,353	5,597	2,510	5,693
Connecticut	5,090	8,816	5,318	9,612
Delaware	(2)	(2)	(2)	(2)
Florida	27,279	32,608	31,900	38,173
Georgia	19,555	42,037	19,582	46,044
Hawaii	4,071	6,883	3,844	6,480
Idaho	1,381	2,698	1,168	2,217
Illinois	41,293	54,411	40,293	52,217
Indiana	18,709	34,653	19,667	35,616
Iowa	21,618	28,244	20,904	27,788
Kansas	[1] 13,527	[1] 17,274	13,558	18,483
Kentucky	19,472	27,682	24,689	34,571
Louisiana	[1] 5,711	[1] 8,067	[1] 5,408	[1] 7,961
Maine	1,127	4,249	947	3,581
Maryland	11,610	22,595	13,012	26,407
Massachusetts	4,985	12,541	5,570	14,396
Michigan	28,440	29,055	30,316	32,065
Minnesota	3,803	10,360	3,898	11,027
Mississippi	1,199	1,266	1,267	1,267
Missouri	28,876	44,006	30,885	46,130
Montana	996	1,708	6,109	7,081
Nebraska	3,670	6,626	3,700	6,192
Nevada	722	1,220	639	1,101
New Hampshire	154	1,368	137	1,566
New Jersey	14,214	28,979	11,229	25,654
New Mexico	2,004	2,782	2,509	4,236
New York	27,589	47,256	26,611	44,549
North Carolina	19,308	29,533	15,701	25,683
North Dakota	19	19	132	132
Ohio	34,470	57,202	37,537	62,787
Oklahoma	14,666	18,819	13,817	16,160
Oregon	18,258	20,977	19,692	24,197
Pennsylvania	48,144	82,087	49,536	83,450
Rhode Island	[1] 304	[1] 483	442	968
South Carolina	6,382	10,066	7,262	10,926
South Dakota	2,852	6,533	2,794	7,339
Tennessee	24,398	35,614	26,825	38,113
Texas	38,067	48,988	43,142	54,007
Utah	2,118	3,865	2,346	4,040
Vermont	1,715	19,815	2,159	19,193
Virginia	25,766	43,121	27,653	45,529
Washington	12,749	18,180	12,934	16,346
West Virginia	[1] 7,506	[1] 13,242	[1] 9,452	[1] 14,489
Wisconsin	13,392	19,709	13,583	18,744
Wyoming	1,755	3,054	1,940	2,991
Undistributed	3,237	10,538	1,918	4,652
Total	656,954	1,025,697	688,366	1,068,108
American Samoa	1,103	1,788	944	2,351
Canton Island	(3)	(3)	2	6
Guam	82	123	307	439
Panama Canal Zone	207	359	162	281
Puerto Rico	5,589	8,551	5,334	8,237
Virgin Islands	21	82	66	329
Wake Island	5	41	9	51

[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 Statistical Summary chapter of this volume.

[2] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[3] Less than 500 short tons and $500.

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
1954–58 (average)	30,553	$65,551	38,623	$62,224	1,081	$20,665	366,699	$499,539	17,071	$25,151
1959	37,571	78,416	51,779	80,454	1,895	32,269	433,955	600,497	20,180	34,810
1960	42,748	89,654	57,884	87,699	1,644	31,060	451,253	623,437	18,934	33,706
1961	44,058	93,870	62,776	95,576	1,592	30,960	438,253	608,139	18,004	30,375
1962	50,058	102,898	69,768	108,264	1,769	33,117	461,849	649,647	20,054	31,241
1963	48,793	103,633	72,958	111,538	1,902	34,567	489,243	680,060	19,019	29,420

Year	Calcareous marl		Sandstone		Slate		Other stone[1]		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1954–58 (average)	[2] 1,860	[2] $1,732	15,988	$44,623	687	$12,006	20,740	$25,395	493,302	$756,886
1959	2,043	1,926	17,553	46,467	656	11,288	18,531	25,855	584,163	911,982
1960	1,283	1,353	21,013	48,771	532	9,233	21,493	27,642	616,784	952,555
1961	1,099	987	23,386	49,114	496	9,334	22,274	29,004	611,938	947,359
1962	1,182	1,011	26,077	51,119	544	10,100	25,653	38,300	656,954	1,025,697
1963	1,164	989	28,978	58,015	902	11,365	25,407	38,521	688,366	1,068,108

[1] Includes mica schist, conglomerate, argillite, various light-colored volcanic rocks, serpentine not used as marble, soapstone sold as dimension stone, etc.
[2] Average for 1957–58 only.

LEGISLATION AND GOVERNMENT PROGRAMS

A comprehensive report of the changes in the Internal Revenue Code and in Treasury regulations, which affect limestone producers, was published. Subjects detailed were Statutes, percentage depletion rates, definitions of metallurgical and chemical limestones, computation of depletion allowances, allowable processes, economic and mineral property interest, tax bases, and tax returns.[2]

DIMENSION STONE

Shipments of nearly 3 million short tons of dimension stone valued at $96 million represented a decrease of 4 percent in tonnage but an increase of 6 percent in value. The decrease in tonnage may be accounted for by increased use of thin facing panels for construction instead of loadbearing blocks.

Trends In Use.—The disadvantages in use of some types of alternate facing materials, particularily plastics, glass, and metals, is receiving recognition and may work to the benefit of the dimension stone industry. At the same time various methods developed by concrete and facing aggregate producers in designing unique and attractive finishes for facing panels may increase demand for crushed facing aggregates of marble, quartz, and feldspars to the detriment

[2] Pit and Quarry. Percentage Depletion for Limestone Producers. V. 55, No. 11, May 1963, pp. 98–102, 160–170.

of quarrymen who produce solid stone cladding material. A noticeably greater amount of Italian travertine was used in 1962 and 1963 for both interior and exterior walls.

GRANITE

The value of shipments of dimension granite increased 2 percent over 1962. Shipments of dressed architectural granite increased 36 percent in tonnage and 13 percent in value. Both rough and dressed monumental granite increased in tonnage and value.

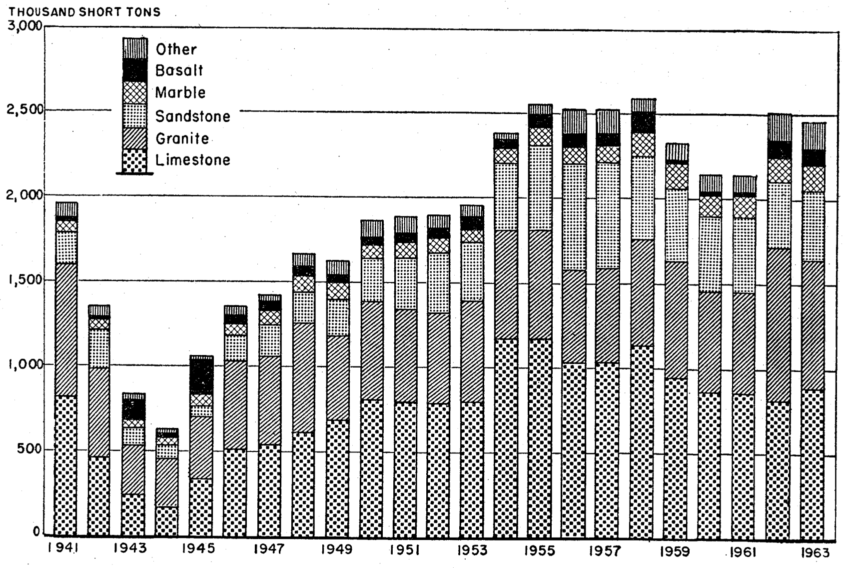

FIGURE 1.—Sales of dimension stone, except slate, in the United States, by kinds, 1941–63.

TABLE 4.—Dimension stone sold or used by producers in the United States, by uses

Use	1962			1963		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	295	-----------	$2,056	271	-----------	$2,103
Architectural [1]	300	3,973	6,380	311	4,170	6,677
Dressed:						
Sawed [1]	515	6,660	18,136	524	6,802	20,136
Cut	210	2,636	28,561	226	2,943	26,764
Rubble	537	-----------	2,022	620	-----------	2,687
Roofing (slate)	30	-----------	1,767	32	-----------	1,965
Millstock (slate)	30	-----------	3,529	30	-----------	3,825
Monumental (rough and dressed) [2]	227	2,744	19,246	277	3,341	24,099
Paving blocks	[3] 264	-----------	[3] 937	4	-----------	86
Curbing	155	1,877	4,236	153	1,867	4,026
Flagging [4]	166	938	3,817	168	2,029	3,950
Total	2,729	-----------	90,687	2,616	-----------	96,318

[1] Includes stone for refractory use to avoid disclosing individual company confidential data.
[2] Includes stone for precision surface plates.
[3] Includes a substantial quantity of blocks for other uses.
[4] Includes a small quantity of slate for miscellaneous uses.

TABLE 5.—Granite (dimension stone) sold or used by producers in the United States, by uses

Use	1962			1963		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	31	-----------	$396	33	-----------	$337
Architectural	24	292	1,176	28	340	1,061
Dressed:						
Construction	20	250	1,728	21	253	1,460
Architectural	42	504	7,459	57	683	8,415
Rubble	165	-----------	463	225	-----------	768
Monumental: [1]						
Rough	157	1,904	8,256	175	2,131	8,692
Dressed	52	625	7,706	59	716	8,037
Paving blocks	[2] 264	-----------	[2] 937	4	-----------	86
Curbing and flagging	147	1,773	3,891	151	1,837	3,940
Total	902	-----------	32,012	753	-----------	32,796

[1] Includes stone for precision plates.
[2] Includes substantial quantity of blocks for other uses.

TABLE 6.—Granite (dimension stone) sold or used by producers in the United States in 1963, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
California	8	61,650	$1,564,241	Oklahoma	8	6,795	$831,564
Colorado	3	965	48,600	South Carolina	5	7,570	258,243
Connecticut	4	3,426	98,447	South Dakota	7	18,930	2,752,773
Georgia	31	184,612	3,897,838	Utah	1	1,000	200,000
Maine	7	18,320	1,689,914	Virginia	1	1,948	94,453
Maryland	1	300	9,000	Washington	1	30	600
Massachusetts	13	122,688	4,039,554	Wisconsin	12	9,146	1,767,409
Minnesota	21	27,422	3,822,428	Other States [1]	33	267,536	11,111,400
Missouri	1	2,715	315,393				
New Mexico	1	96	14,000	Total	161	753,186	32,795,665
New York	3	18,037	279,808	Puerto Rico	--------	7,900	25,600

[1] Includes New Hampshire 2 plants; North Carolina 10; Pennsylvania 4; Rhode Island 2; Texas 5; and Vermont 10.

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BASALT AND RELATED ROCKS (TRAPROCK)

Total shipments of dimension basaltic-type rocks declined in both value and tonnage. The eight plants in Washington produced the greater tonnage although Pennsylvania's production led in value.

MARBLE

The reported value of dimension marble was 12 percent higher than in 1962. The average value for monumental marble (rough and finished) was $14.92 per cubic foot.

LIMESTONE

Shipments of dimension limestone declined slightly in tonnage but value increased 8 percent. As is the case in production of other types of architectural stone, the decrease in tonnage may be attributed to greater use of thin facing panels. The Bedford-Bloomington, Ind., district continued to lead in production of this type of stone.

TABLE 7.—Marble (dimension stone) sold or used by producers in the United States,[1] by uses

Use	1962			1963		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building: [2]						
Rough: Architectural	34	382	$1,330	28	343	$1,134
Dressed:						
Sawed	42	489	2,185	34	415	3,100
Cut	53	624	12,084	46	550	9,474
Monumental (rough and finished)	17	205	3,140	42	489	7,294
Total	146		18,739	150		21,002

[1] Produced by the following States in 1963 in order of value and with number of plants: Georgia 1; Vermont 8; Missouri 4; Tennessee 12; Alabama 2; Arkansas 2; North Carolina 1; Montana 2; Washington 4; Colorado 1; Maryland 1; New Mexico 1; Arizona 2; California 2; and Nevada 1.
[2] Includes: 1962—1,009,000 cu. ft., $9,575,000 for exterior use, and 486,000 cu. ft., $6,024,000, for interior use; 1963—843,000 cu. ft., $7,351,000 for exterior use, and 465,000 cu. ft., $6,357,000, for interior use.

TABLE 8.—Limestone (dimension stone) sold or used by producers in the United States, by uses

Use	1962			1963		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	82		$326	52		$289
Architectural	197	2,708	3,000	196	2,710	3,091
Dressed:						
Sawed [1]	246	3,311	6,628	261	3,497	7,729
Cut	72	962	5,848	86	1,177	5,769
Rubble	284		928	282		1,104
Curbing and flagging	15	194	117	18	230	152
Total	896		16,847	895		18,134

[1] Includes house stone veneer.

TABLE 9.—Limestone (dimension stone) sold or used by producers in the United States in 1963, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
California	4	11,265	$187,796	Ohio	2	6,865	$21,556
Georgia	1	62	4,668	Oklahoma	4	3,246	35,008
Illinois	3	4,635	117,132	Texas	6	42,768	1,139,375
Indiana	24	584,277	10,724,155	Wisconsin	33	78,771	1,594,860
Iowa	3	8,489	151,063	Other States [1]	20	82,624	1,314,494
Kansas	12	21,744	689,657				
Michigan	3	4,938	60,371	Total	125	894,640	18,134,115
Minnesota	6	28,661	2,019,816	Guam		373	1,400
Nebraska	4	16,295	74,164	Puerto Rico		64,647	151,658

[1] Includes Alabama 2 plants; Kentucky 2; Missouri 7; New York 2; Pennsylvania 2; Rhode Island 1; South Dakota 1; Utah 1; and Washington 2.

TABLE 10.—Limestone sold by producers in the Indiana oolitic limestone district, by classes

Year	Construction					
	Rough blocks		Sawed and semi-finished [1]		Cut	
	Thousand cubic feet	Value (thousands)	Thousand cubic feet	Value (thousands)	Thousand cubic feet	Value (thousands)
1954–58 (average)	2,920	$3,258	3,513	$6,186	936	$5,372
1959	2,719	2,731	3,380	6,037	951	5,443
1960	2,817	2,934	2,846	5,340	528	3,005
1961	2,820	3,159	2,498	4,675	497	2,784
1962	2,467	2,695	2,427	4,674	560	3,251
1963	2,183	2,533	2,518	5,217	530	2,258

Year	Construction—Continued			Other uses		Total	
	Total						
	Thousand cubic feet	Thousand short tons	Value (thousands)	Thousand short tons	Value (thousands)	Thousand short tons	Value (thousands)
1954–58 (average)	7,369	534	$14,816	166	$455	700	$15,271
1959	7,050	511	14,211	155	432	666	14,643
1960	6,191	449	11,279	139	413	588	11,692
1961	5,815	422	10,618	161	515	583	11,133
1962	5,454	395	10,620	191	659	586	11,279
1963	5,231	379	10,008	197	640	576	10,648

[1] Includes house stone veneer.

SANDSTONE

Shipments of dimension sandstone increased 6 percent in tonnage and 5 percent in value over those of 1962. Twenty-eight more plants reported shipments. Some dimension quartzite was imported from both Canada and Sweden.

SLATE

Shipments of slate increased 1 percent in tonnage and 8 percent in value over those of 1962. Less millstock for blackboards was produced because of use of alternate blackboard material such as glass and painted metal. Imports of slate, from Italy and Portugal totaled over $1 million.

MISCELLANEOUS STONE

Shipments of coquina, reef limestone, mica schists, and volcanic tuffs, for special or local use, increased in tonnage by 13 percent and in value by 4 percent over those of 1962, although dimension stones included in this category represented less than 1 percent of total dimension stone shipments.

TABLE 11.—Sandstone (dimension stone) sold or used by producers in the United States, by uses

Use	1962			1963		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Rough:						
Construction	82		$1,159	99		$1,308
Architectural [1]	45	591	872	59	774	1,370
Dressed:						
Sawed [1]	105	1,410	3,918	113	1,519	4,167
Cut	42	534	2,852	36	521	2,760
Rubble	55		342	49		365
Curbing	8	104	345	2	28	82
Flagging	53	661	1,416	54	669	1,391
Total	390		10,904	412		11,443

[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 1963, by States

State	Active plants	Short tons	Value	State	Active plants	Short tons	Value
Alabama	1	20	$1,300	Ohio	18	108,411	$5,430,589
Arizona	16	10,382	120,953	Pennsylvania	37	83,894	1,061,946
Arkansas	5	15,273	201,208	Tennessee	12	39,417	1,351,042
California	7	2,378	43,685	Utah	5	1,772	86,019
Colorado	30	24,143	320,698	Virginia	4	1,589	23,594
Connecticut	2	2,350	21,527	Washington	6	4,199	202,310
Georgia	4	7,047	100,006	Wisconsin	17	3,677	59,952
Kansas	1	447	8,887	Wyoming	3	200	1,215
Massachusetts	2	2,421	242,088	Other States [1]	27	48,880	821,297
Michigan	4	8,937	62,348				
Minnesota	1	4	356	Total	215	412,214	11,442,710
New York	13	46,773	1,281,690				

[1] Includes Indiana 9 plants; Kentucky 2; Maryland 2; Missouri 3; Montana 2; Nevada 3; New Mexico 3; Texas 1; and West Virginia 2.

TABLE 13.—Slate (dimension stone) sold or used by producers in the United States,[1] by uses

Use	1962			1963		
	Quantity		Value (thousands)	Quantity		Value (thousands)
	Thousand short tons	Unit of measurement		Thousand short tons	Unit of measurement	
Roofing slate	30	*Thousand squares* 79	$1,767	32	*Thousand squares* 81	$1,965
Millstock:		*Thousand sq ft*			*Thousand sq ft*	
Electrical, structural, and sanitary slate	25	2,657	2,423	26	2,838	2,700
Blackboards and bulletin boards [2]	3	1,066	902	2	985	904
Billiard tabletops	2	222	204	2	215	221
Total	30	3,945	3,529	30	4,038	3,825
Flagstones [3]	61	11,900	1,522	63	12,344	1,635
Miscellaneous uses [4]	30	----------	623	28	----------	630
Grand total	151	----------	7,441	153	----------	8,055

[1] Produced by the following States in 1963 in order of value of output and with number of plants: Pennsylvania 10; Vermont 22; Virginia 2; New York 10; Maine 1; North Carolina 2; and California 2.
[2] Includes a small quantity of school slates.
[3] Includes slate used for walkways and stepping stones.
[4] 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	1962			1963		
	Thousand short tons	Thousand cubic feet	Value (thousands)	Thousand short tons	Thousand cubic feet	Value (thousands)
Building:						
Sawed [2]	102	1,200	$3,677	95	1,118	$3,680
Rubble	32	------------	280	60	------------	446
Flagging	7	82	138	5	59	142
Total	141	------------	4,095	160	------------	4,268

[1] Produced by the following States in 1963 in order of value of output and with number of plants: Virginia 2 plants; California 31; New Jersey 1; Pennsylvania 6; Maryland 2; Hawaii 4; Connecticut 2; Arizona 3; Washington 2; Oregon 1; New Mexico 1; and Colorado 1.
[2] Includes rough and cut stone and stone for refractory use to avoid disclosing individual company confidential data.

FOREIGN TRADE

The bulk of U.S. imports of various types of marble was from Italy although shipments also were reported from Greece, Portugal, Belgium-Luxembourg, Mexico, and other countries. Canada was the principal source of both dressed and unmanufactured granite. Dressed sandstone and slate were imported from Italy. Value of slate imported from Italy increased 108 percent over that of 1962, but imports of marble blocks declined in tonnage and value. Volume of travertine imported from Italy increased as did total value. Some travertine quarries have now been exhausted. Unrubbed marble slabs imported from Greece amounted to 100,000 surficial feet valued at $118,000.

Exports of marble and other building stone to Canada amounted to 414,000 cubic feet valued at $1.6 million.

WORLD REVIEW

Canada.—Deposits of white, gray, and green serpentine marble were developed in Eastern Ontario to meet the increasing demand for varicolored and varitextured aggregate in precast slabs.[3] The Rock of Ages Corp. of Barre, Vt., began operation of the Stanstead Granite Co. quarries and dressing plant of Stanstead, Quebec.

United Arab Republic (Egypt).—Production of 291,000 cubic yards of granite and over 4 million cubic yards of marble was reported.

TECHNOLOGY

Publications describing various types of traprock and sandstone, localities where found, methods of quarrying, and uses were issued.[4]

A report on occurrences of various types of building stones, in Colorado, listed the locations of over 100 active or inactive quarries.[5]

New developments in methods for preparing specimens for research in rock mechanics were reported.[6]

A new process for finishing granite which combined flame stippling and blasting with glass beads was developed. This method highlighted the various minerals composing the granite.[7]

CRUSHED AND BROKEN STONE

The 686 million tons of crushed and broken stone valued at $972 million produced in 1963 represented an increase of 5 percent in tonnage over that of 1962 and set a new production record. The average price was $1.42 per ton. Expenditures for public and private construction amounted to $63 billion, also a new record, and were primarily responsible for maintaining the systematic growth of the crushed stone industry.

Trends in use.—There appears to be a slowly growing tendency to use less tonnages of sand and gravel for concrete and roadstone and more crushed and broken stone. Portable processing units, consisting of conveyors, screens, washers, and classifiers are growing in favor. These units are adapted to automatic or semiautomatic control and require less labor. Large stationary plants have installed bigger crushers to cut down secondary breaking, and the demand by the construction industry for more cubical products has resulted in in-

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[3] Canadian Mining Journal (Gardenvale, Quebec). V. 85, No. 2, p. 125.

[4] Bowles, Oliver, and William R. Barton. Sandstone as Dimension Stone. BuMines Inf. Circ. 8182, 1963, 30 pp.

Bowles, Oliver, and Roger L. Williams. Traprock. BuMines Inf. Circ. 8184, 1963, 19 pp.

[5] Sharps, Thomas I. Dimension Stone in Colorado. Miner. Industries Bull. (Colorado School of Mines), v. 6, No. 1, January 1963, 12 pp.

[6] Hackett, P. Specimen Preparation for Rock Mechanics Research. Mine & Quarry Eng., v. 29, No. 10, October 1963, pp. 438–441.

[7] Stone. New Granite-Finishing Process for CBS Headquarters Building. V. 84, No. 1, January 1964, p. 23.

creasing use of both single- and double-rotor type crushers. Specifications which require a cleaner or better washed product have resulted in shortening of screen life, presumably because of electrolytic action. Research is conducted, by manufacturers, to solve this problem. The problems of multiple land use, rehabilitation of worked out quarries for recreational areas, and restrictive zoning legislation continue to be solved or disputed on a local level.

TABLE 15.—Crushed and broken stone sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1962		1963	
	Quantity	Value	Quantity	Value
Agriculture	23,269	$39,652	26,216	$44,412
Cement	89,651	99,655	93,299	99,688
Concrete and roadstone	414,970	568,267	439,325	598,786
Fill	5,576	6,752	7,736	8,606
Filtration	133	329	70	146
Flux	26,512	38,562	27,630	41,026
Glass	1,646	5,461	1,768	5,745
Lime and dead-burned dolomite	20,797	34,835	22,619	37,687
Mineral food	697	3,873	619	3,796
Poultry grit	946	7,754	896	7,251
Railroad ballast	11,042	13,310	11,727	14,054
Refractory	711	5,692	1,180	6,337
Riprap	36,415	41,835	30,200	35,982
Roofing granules, aggregates, and chips	2,704	12,169	1,965	9,337
Stone sand	2,991	4,111	3,201	4,557
Terrazzo	380	4,869	382	4,913
Other uses[1] and unspecified	15,785	47,884	16,917	49,467
Total	654,225	935,010	685,750	971,790

[1] Includes some uses listed separately in the Limestone and Sandstone sections.

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	1962		1963	
	Quantity	Value	Quantity	Value
Concrete and roadstone	40,832	$51,496	47,214	$57,174
Riprap	20,506	21,462	15,880	16,110
Agricultural (limestone)	300	446	330	495
Other uses	4,208	5,786	3,902	5,532
Total	65,846	79,190	67,326	79,311

[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.

Price.—Average prices for crushed and broken stone were stable, as they have been for many years.

Size of Plants.—Although 3,023 plants reported production the 328 top producers accounted for 51 percent of the total commercial production. New production was reported by 44 plants, the greatest number in the 100,000 to 200,000 class. Average production of the 871 small plants, many portable, was approximately 8,000 tons.

Transportation.—Truck transportation increased 2 percent and rail and waterway transportation each declined 1 percent.

GRANITE

Production and value of crushed and broken granite decreased slightly compared with 1962. The average price was $1.47 per ton. Production was reported from 32 States, but Georgia, North Carolina, Virginia, and South Carolina produced 79 percent of the total.

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	1962		1963	
	Quantity	Value	Quantity	Value
Alabama	6,626	$8,092	[1] 6,318	[1] $7,929
Alaska	([2])	([2])	([2])	([2])
Arizona	1,971	3,042	1,173	1,568
Arkansas	6,699	7,003	8,549	12,548
California	13,061	16,487	14,192	18,348
Colorado	302	774	470	1,119
Connecticut	4,711	7,137	4,937	7,862
Delaware	([2])	([2])	([2])	([2])
Florida	23,393	26,704	27,237	31,761
Georgia	[1] 14,176	[1] 19,684	[1] 14,239	[1] 19,740
Hawaii	3,735	6,440	3,433	5,994
Idaho	986	1,551	768	895
Illinois	32,747	43,398	29,105	37,356
Indiana	13,416	17,365	13,408	17,657
Iowa	16,618	21,321	15,529	20,425
Kansas	9,575	12,639	9,159	12,209
Kentucky	15,810	22,763	20,557	29,231
Louisiana	[1] 4,126	[1] 6,065	[1] 3,870	[1] 6,019
Maine	351	808	318	716
Maryland	8,901	14,729	10,269	17,999
Massachusetts	3,689	5,931	4,294	7,086
Michigan	3,802	4,682	3,882	4,639
Minnesota	2,877	3,354	[1] 2,735	[1] 3,342
Mississippi	([2])	([2])	---	---
Missouri	17,134	23,321	[1] 17,178	[1] 23,296
Montana	([2])	([2])	4,738	4,774
Nebraska	1,758	3,078	1,661	2,834
Nevada	56	37	41	35
New Hampshire	([2])	([2])	([2])	([2])
New Jersey	9,485	19,276	9,714	20,383
New Mexico	1,379	1,874	1,695	2,897
New York	18,183	32,976	17,383	32,066
North Carolina	18,954	27,091	15,349	22,524
North Dakota	([2])	([2])	([2])	([2])
Ohio	[1] 17,991	[1] 23,694	[1] 19,036	[1] 24,611
Oklahoma	10,108	11,257	10,337	10,727
Oregon	9,403	12,246	13,656	17,161
Pennsylvania	26,471	39,185	28,425	41,028
Rhode Island	287	466	332	502
South Carolina	[1] 4,274	[1] 6,432	[1] 5,126	[1] 7,512
South Dakota	1,693	2,477	1,929	3,326
Tennessee	19,344	24,169	[1] 21,741	[1] 26,708
Texas	24,472	28,084	29,033	32,105
Utah	128	127	27	90
Vermont	1,224	1,672	1,746	2,333
Virginia	17,834	26,125	19,670	28,483
Washington	10,504	13,832	8,948	10,271
West Virginia	3,469	5,815	3,691	5,985
Wisconsin	10,739	10,530	10,223	9,763
Wyoming	685	1,168	488	785
Undistributed	1,823	3,366	2,716	4,144
Total	414,970	568,267	439,325	598,786

[1] To avoid disclosing individual company confidential data, total is somewhat incomplete, the portion not included being combined as "Undistributed."
[2] Included with "Undistributed."

TABLE 18.—Number and production of commercial crushed-stone plants in the United States, by size of operation

Annual production (short tons)	1962				1963			
	Number of plants	Production		Cumulative total, thousand short tons	Number of plants	Production		Cumulative total, thousand short tons
		Thousand short tons	Percent of total			Thousand short tons	Percent of total	
Less than 25,000	889	7,462	1.3	7,462	871	7,253	1.2	7,253
25,000 to 50,000	292	10,805	1.8	18,267	307	11,188	1.8	18,441
50,000 to 75,000	241	14,828	2.5	33,095	242	14,994	2.4	33,435
75,000 to 100,000	193	16,899	2.9	49,994	195	16,669	2.7	50,104
100,000 to 200,000	499	71,421	12.1	121,415	535	76,363	12.4	126,467
200,000 to 300,000	248	60,554	10.3	181,969	251	61,290	9.9	187,757
300,000 to 400,000	187	65,654	11.1	247,623	165	57,451	9.3	245,208
400,000 to 500,000	137	61,046	10.4	308,669	129	57,601	9.3	302,809
500,000 to 600,000	94	50,556	8.6	359,225	89	48,777	7.9	351,586
600,000 to 700,000	50	32,325	5.5	391,550	64	41,262	6.7	392,848
700,000 to 800,000	36	26,900	4.6	418,450	46	34,211	5.5	427,059
800,000 to 900,000	21	17,627	3.0	436,077	33	27,985	4.5	455,044
900,000 tons and over	92	152,302	25.9	588,379	96	163,380	26.4	618,424
Total	2,979	588,379	100.0	588,379	3,023	618,424	100.0	618,424

TABLE 19.—Crushed stone sold or used in the United States, by methods of transportation

Method of transportation	1962		1963	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Commercial:				
Truck	388,023	59	416,864	61
Rail	83,221	13	82,578	12
Waterway	53,200	8	51,348	7
Unspecified	63,935	10	67,634	10
Total commercial	588,379	90	618,424	90
Government-and-contractor: Truck [1]	65,846	10	67,326	10
Grand total	654,225	100	685,750	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	1962		1963	
	Quantity	Value	Quantity	Value
Concrete and roadstone	41,784	$60,210	41,756	$60,881
Railroad ballast	1,995	2,262	1,987	2,376
Riprap	2,962	4,759	1,843	3,469
Fill	970	869	520	632
Stone sand	1,161	775	1,138	1,019
Poultry grit	197	1,774	184	2,035
Other uses [1]	87	237	612	425
Total	49,156	70,886	48,040	70,837

[1] Includes stone used for agriculture, filtration, and unspecified uses.

TABLE 21.—Granite (crushed and broken stone) sold or used by producers in the United States in 1963, by States

State	Short tons	Value	State	Short tons	Value
Arizona	20,705	$32,738	Oregon	95,620	$132,400
California	3,752,039	4,533,941	South Carolina	5,878,086	8,780,339
Colorado	72,615	151,384	South Dakota	5,700	8,773
Georgia	14,413,738	20,580,767	Utah	14,704	53,225
Idaho	1,257	1,676	Virginia	6,701,821	10,847,233
Minnesota	561,393	714,615	Washington	834,385	948,279
Missouri	243	1,213	Wyoming	626,448	708,665
Montana	22,895	26,449	Other States [1]	3,196,819	4,941,042
New Hampshire	44,648	40,183			
New Jersey	749,020	1,988,189	Total	48,040,447	70,836,960
New Mexico	900	11,997	Puerto Rico	112,800	277,200
North Carolina	11,047,411	16,333,852			

[1] Includes Alaska, Connecticut, Delaware, Maine, Maryland, Massachusetts, Nevada, New York' Pennsylvania, Rhode Island, Texas, Vermont, and Wisconsin.

BASALT AND RELATED ROCKS (TRAPROCK)

Production of crushed basaltic type rock for concrete and roadstone and for railroad ballast increased 14 percent and 19 percent, respectively; all other uses declined. Total value of output increased 3 percent. Oregon, New Jersey, and Washington accounted for 53 percent of production.

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	1962		1963	
	Quantity	Value	Quantity	Value
Concrete and roadstone	54,077	$85,051	61,661	$93,717
Railroad ballast	1,499	2,302	1,784	2,735
Riprap	9,290	9,374	8,094	9,931
Fill	3,572	5,158	537	346
Stone sand	3	6	(1)	(1)
Other uses [2]	1,224	5,724	789	4,189
Total	69,665	107,615	72,865	110,918

[1] Included with "Other uses."
[2] Includes stone used for filtration, filler, rock wool, roofing granules, and unspecified uses.

TABLE 23.—Basalt and related rocks (traprock) (crushed and broken stone) sold or used by producers in the United States in 1963, by States

State	Short tons	Value	State	Short tons	Value
Arizona	80,816	$208,716	North Carolina	2,348,129	$3,272,051
California	2,022,167	2,798,485	Oregon	18,175,083	21,954,119
Colorado	72,915	83,173	Pennsylvania	3,085,066	6,077,864
Connecticut	4,893,626	7,705,618	Virginia	2,961,972	4,590,415
Hawaii	2,219,086	4,650,886	Washington	10,561,517	12,314,430
Idaho	771,541	897,869	Other States [1]	2,992,159	7,357,234
Maryland	4,090,187	7,547,795			
Massachusetts	3,826,454	6,094,874	Total	72,864,778	110,917,544
Michigan	15,433	14,975			
Montana	4,968,031	5,179,202	American Samoa	994,372	2,351,112
New Jersey	9,773,880	20,161,627	Panama Canal Zone	100,736	196,400
New Mexico	6,716	8,211	Virgin Islands	65,973	328,919

[1] Includes Alaska, Minnesota, Nevada, New York, Texas, and Wisconsin.

MARBLE

Most crushed marble is sold for facing aggregates, terrazzo, and roofing granules. Production increased slightly but value declined.

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	1962		1963	
	Quantity	Value	Quantity	Value
Terrazzo	380	$4,866	367	$4,768
Other uses [2]	1,243	9,512	1,385	8,797
Total	1,623	14,378	1,752	13,565

[1] Produced by the following States in 1963, in order of tonnage: Georgia, Alabama, Missouri, Texas, California, New York, Tennessee, Arizona, North Carolina, Washington, Vermont, Virginia, Colorado, Maryland, New Jersey, Montana, Wisconsin, Utah, Nevada, and Wyoming.
[2] Includes stone used for agriculture, asphalt filler, precast stone, roofing, stone chips, stucco, whiting (excluding marble whiting made by companies that purchase marble), and unspecified uses.

LIMESTONE

Because of its multitudinous uses and nearly universal availability limestone lead all other types of crushed stone both in tonnage and total value, accounting for 71 percent of production and 68 percent of value in 1963. The average price was $1.36 per ton.

Sixty percent of crushed limestone was used in concrete and roadstone and 18 percent for cement. Iron blast furnaces consumed 53 percent of the total amount of fluxstone, and 6,396,791 tons were used in making iron ore agglomerates.[8] An average of 0.284 ton of limestone per ton of pig iron was required compared with the 0.209 ton used by Canadian operators. A 48-percent increase in the amount of lime used in the various basic oxygen processes for steelmaking was reported.[9]

Shell.—With the exception of production for cement and some minor miscellaneous uses, output of shell declined in both tonnage and value. Total output decreased 5 percent and value 6 percent.

[8] American Iron & Steel Institute. Annual Statistical Report 1963, p. 44.
[9] American Iron & Steel Institute. Annual Statistical Report 1962, p. 19; Annual Statistical Report 1963, p. 17.

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	1962		1963	
	Quantity	Value	Quantity	Value
Concrete and roadstone	276,878	$365,098	292,976	$380,893
Flux	26,081	36,821	27,185	39,322
Agriculture	23,029	39,348	25,956	44,195
Railroad ballast	5,065	6,578	4,923	6,410
Riprap	10,016	12,253	10,690	13,229
Alkali manufacture	2,840	3,188	2,955	3,282
Cement—portland and natural	83,318	92,886	86,842	92,646
Coal-mine dusting	400	1,667	539	2,268
Fill material	440	330	383	296
Filler (not whiting substitute):				
Asphalt	3,208	6,955	1,994	5,012
Fertilizer	448	1,132	457	1,133
Other	351	1,567	419	1,921
Filtration	79	141	62	117
Glass manufacture	1,337	4,294	1,492	4,781
Lime and dead-burned dolomite	19,356	32,959	21,450	36,024
Limestone sand	1,706	3,103	1,759	3,234
Limestone whiting [1]	838	9,639	785	9,298
Mineral food	692	3,847	618	3,793
Paper manufacture	271	821	358	1,099
Poultry grit	161	1,333	160	1,342
Refractory (dolomite)	322	563	769	1,297
Sugar refining	623	1,506	646	1,580
Other uses [2]	1,741	4,253	2,125	5,472
Use unspecified	1,753	2,518	2,805	3,282
Total	460,953	632,800	488,348	661,926

[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 and animal sanitation, electrical products, magnesia, magnesite, magnesium, mineral wool, oil-well drilling, patching plaster, roofing granules, stucco, terrazzo, and water treatment.

TABLE 26.—Limestone and dolomite (crushed and broken stone) sold or used by producers in the United States in 1963, by States and uses

State	Riprap		Fluxing stone		Concrete and roadstone	
	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	356,580	$483,599	947,197	$1,601,898	6,318,326	$7,929,287
Alaska	(1)	(1)				
Arizona			(1)	(1)	(1)	(1)
Arkansas	(1)	(1)	(1)	(1)	2,398,326	3,420,918
California	80,653	133,967	(1)	(1)	1,480,482	1,828,434
Colorado	(1)	(1)	284,073	621,230	(1)	(1)
Connecticut			(1)	(1)		
Florida	(1)	(1)			25,461,245	29,576,062
Georgia	(1)	(1)			1,756,738	2,330,217
Hawaii					445,018	645,414
Idaho			(1)	(1)		
Illinois	283,399	403,994	(1)	(1)	29,105,404	37,355,967
Indiana	182,762	277,648	(1)	(1)	13,407,737	17,656,585
Iowa	330,265	414,068	(1)	(1)	15,528,895	20,425,163
Kansas	997,648	1,263,220	(1)	(1)	8,874,031	11,718,011
Kentucky	(1)	(1)	(1)	(1)	20,557,484	29,231,263
Maine	10	58			117,655	210,268
Maryland	(1)	(1)	(1)	(1)	5,109,929	8,727,586
Massachusetts			(1)	(1)	(1)	(1)
Michigan	(1)	(1)	11,194,243	12,785,420	3,859,669	4,615,686
Minnesota	23,934	27,163	(1)	(1)	2,656,308	3,192,465
Mississippi	(1)	(1)				
Missouri	3,213,464	2,845,161	(1)	(1)	17,178,254	23,295,889
Montana	146	110	(1)	(1)	(1)	(1)
Nebraska	851,911	1,171,119			1,661,340	2,833,739
Nevada			(1)	(1)	(1)	(1)
New Jersey			(1)	(1)	(1)	(1)
New Mexico	71,440	297,621	(1)	(1)	565,213	844,315
New York	208,665	312,144	(1)	(1)	14,261,220	25,578,006
North Carolina					(1)	(1)
Ohio	341,524	494,795	4,727,532	7,423,231	19,036,063	24,610,840
Oklahoma	185,316	228,441			9,880,068	10,384,194
Oregon			(1)	(1)	(1)	(1)
Pennsylvania	31,322	45,107	4,788,866	8,791,840	21,956,939	30,806,481
Rhode Island			(1)	(1)		
South Carolina			(1)	(1)	(1)	(1)
South Dakota	18,920	40,375			1,096,364	1,546,420
Tennessee	12,985	14,184	(1)	(1)	21,740,841	26,707,845
Texas	1,025,779	1,449,140	475,641	526,775	21,872,664	21,890,300
Utah			602,605	710,824	(1)	(1)
Vermont	(1)	(1)			(1)	(1)
Virginia	(1)	(1)	1,075,534	1,763,795	10,135,706	13,650,892
Washington			(1)	(1)	(1)	(1)
West Virginia	(1)	(1)	(1)	(1)	2,275,206	3,623,833
Wisconsin	37,073	55,010	(1)	(1)	10,007,196	9,560,482
Wyoming	133,548	97,435	(1)	(1)	387,413	631,389
Undistributed	2,302,979	3,175,116	3,089,302	5,097,483	3,844,637	6,065,110
Total	10,690,323	13,229,475	27,184,993	39,322,496	292,976,371	380,893,066
American Samoa						
Canton Island					1,560	6,000
Guam					214,162	253,169
Puerto Rico	4,682	10,541			1,959,682	3,928,975
Wake Island					8,585	50,500

[1] Figures withheld to avoid disclosing individual company confidential data; included with "Undistributed."

TABLE 26.—Limestone and dolomite (crushed and broken stone) sold or used by producers in the United States in 1963, by States and uses—Continued

State	Railroad ballast		Agriculture		Miscellaneous		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
Alabama	(1)	(1)	498,363	$845,227	(1)	(1)	13,255,474	$15,859,121
Alaska							(1)	(1)
Arizona					1,525,935	$1,915,332	1,771,114	2,307,107
Arkansas	(1)	(1)	339,055	541,133	1,857,102	2,270,562	5,247,501	7,505,961
California			(1)	(1)	(1)	(1)	15,820,032	21,992,720
Colorado					1,622,152	3,143,903	2,139,431	4,170,148
Connecticut			(1)	(1)	(1)	(1)	231,091	1,009,778
Florida	(1)	(1)	481,926	1,642,849	(1)	(1)	30,085,869	35,559,377
Georgia	(1)	(1)	210,336	435,399	(1)	(1)	2,743,949	3,956,769
Hawaii			14,233	33,794	357,406	305,536	816,657	984,744
Idaho			(1)	(1)	(1)	(1)	(1)	(1)
Illinois	343,662	$352,979	4,841,143	7,052,552	(1)	(1)	40,287,761	52,094,256
Indiana	282,768	352,069	2,519,620	3,636,463	(1)	(1)	18,993,190	24,329,327
Iowa	17,445	23,340	1,449,211	2,042,261	(1)	(1)	20,895,756	27,637,432
Kansas	(1)	(1)	439,525	751,862	2,529,310	3,124,524	12,881,648	16,910,271
Kentucky	475,633	522,300	1,824,357	2,497,202	(1)	(1)	24,687,191	34,529,792
Maine	32,471	51,162	(1)	(1)	(1)	(1)	713,465	1,175,150
Maryland	(1)	(1)	(1)	(1)	2,361,767	5,652,849	7,602,738	14,656,338
Massachusetts			177,943	558,632	443,527	1,480,332	650,205	2,083,789
Michigan	(1)	(1)	483,502	838,336	(1)	(1)	30,110,172	31,809,316
Minnesota			425,554	664,820	(1)	(1)	3,166,312	4,240,501
Mississippi			129,528	129,852	(1)	(1)	(1)	(1)
Missouri	(1)	(1)	2,684,423	4,601,017	6,615,874	11,808,291	29,756,401	42,652,004
Montana	(1)	(1)			838,927	1,309,210	900,471	1,398,399
Nebraska			(1)	(1)	(1)	(1)	3,684,013	6,118,290
Nevada					(1)	(1)	(1)	(1)
New Jersey			(1)	(1)	(1)	(1)	(1)	(1)
New Mexico					(1)	(1)	1,264,243	2,017,667
New York	496,855	848,261	399,067	1,250,317	(1)	(1)	23,114,427	35,403,019
North Carolina	(1)	(1)	(1)	(1)	(1)	(1)	2,176,937	3,346,169
Ohio	923,738	1,134,282	2,213,197	3,879,888	9,629,707	16,460,271	36,871,761	54,003,307
Oklahoma	(1)	(1)	(1)	(1)	2,249,892	3,741,623	12,433,841	14,502,445
Oregon			(1)	(1)	787,173	1,078,484	824,155	1,134,494
Pennsylvania	94,567	126,258	1,089,748	3,255,974	14,096,673	19,796,798	42,058,115	62,822,458
Rhode Island			(1)	(1)	(1)	(1)	(1)	(1)
South Carolina			(1)	(1)	(1)	(1)	(1)	(1)
South Dakota	(1)	(1)			(1)	(1)	1,646,071	2,395,016
Tennessee	(1)	(1)	1,631,928	1,873,686	2,928,454	5,156,061	26,541,519	34,042,374
Texas	308,788	275,351	283,182	277,033	7,366,480	9,123,646	31,332,534	33,542,245
Utah	(1)	(1)			1,098,689	2,491,247	1,716,450	3,219,167
Vermont			82,441	282,088	(1)	(1)	1,194,379	3,716,691
Virginia	308,478	390,134	1,071,160	1,969,101	(1)	(1)	16,699,956	24,474,148
Washington			15,299	69,700	(1)	(1)	1,157,575	1,914,666
West Virginia	514,665	678,323	138,848	308,851	1,827,713	3,509,648	6,111,046	10,843,953
Wisconsin			1,591,129	2,044,934	(1)	(1)	11,927,868	12,036,046
Wyoming	(1)	(1)			470,056	1,053,985	1,224,327	2,122,226
Undistributed	1,123,418	1,655,302	920,917	2,711,979	68,010,907	84,453,557	3,611,909	7,408,926
Total	4,922,488	6,409,761	25,955,635	44,194,950	126,617,744	177,875,859	488,347,554	661,925,607
American Samoa								
Canton Island							1,560	6,000
Guam					92,833	184,977	306,995	438,146
Puerto Rico			61,500	188,600	1,892,517	1,177,900	3,918,381	5,306,016
Wake Island							8,585	50,500

[1] Figures 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
1954-58 (average)	27,169	$36,320	6,655	$9,604	1,040	$1,339	340	$532	35,204	$47,795
1959	19,752	28,683	6,439	8,963	965	1,223	1,050	1,573	28,206	40,442
1960	21,627	30,809	7,409	10,958	997	1,311	1,382	2,004	31,415	45,082
1961	18,129	25,891	6,412	10,056	896	1,205	1,761	2,573	27,198	39,725
1962	16,996	23,062	6,411	9,835	646	952	2,028	2,972	26,081	36,821
1963	18,514	26,456	5,772	8,511	741	1,162	2,158	3,193	27,185	39,322

[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	1962		1963	
	Quantity	Value	Quantity	Value
Concrete and road material	12,792	$18,611	11,821	$17,277
Cement	5,117	5,531	5,278	5,847
Lime	1,441	1,876	1,169	1,663
Poultry grit	587	4,635	552	3,874
Mineral food	4	22	(1)	(1)
Other uses [2]	113	566	199	759
Total	20,054	31,241	19,019	29,420

[1] Included with "Other uses."
[2] Includes agriculture, asphalt filler, and whiting.

TABLE 29.—Shell sold or used by producers in the United States in 1963, by States

State	Short tons	Value	State	Short tons	Value
Florida	1,814,036	$2,613,815	Other States [1]	1,993,088	$4,819,262
Louisiana	5,408,182	7,961,135			
Texas	9,803,701	14,025,878	Total	19,019,007	29,420,090

[1] Includes Alabama, California, Maryland, New Jersey, Pennsylvania, and Virginia.

Calcareous Marl.—Production of calcareous marl for cement declined 5 percent in tonnage and value. Marl produced for agricultural uses increased 15 percent in quantity. The average price was $0.68 per ton.

SANDSTONE, QUARTZ, AND QUARTZITE

Use in concrete and roadstone accounted for 60 percent of the production of this type of rock and brought an average price of $1.60 per ton.

CRUSHED AND BROKEN SLATE

Production of crushed slate increased greatly but the lack of a corresponding rise in value indicates that much of the output went into lightweight aggregates.

MISCELLANEOUS STONE

Local use in concrete and roadstone accounted for 55 percent of production. The average price was $1.33 per ton.

TABLE 30.—Calcareous marl sold or used by producers in the United States,[1] by uses

(Thousand short tons and thousand dollars)

Use	1962		1963	
	Quantity	Value	Quantity	Value
Agriculture [2]	226	$156	260	$178
Cement	956	855	904	811
Total	1,182	1,011	1,164	989

[1] Produced by the following States in 1963 in order of tonnage: Mississippi, Virginia, Michigan, Indiana, Minnesota, Wisconsin, West Virginia, Nevada, and Ohio.
[2] Includes marl used in mineral food.

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	1962		1963	
	Quantity	Value	Quantity	Value
Concrete and roadstone	13,514	$19,923	17,239	$27,595
Railroad ballast	754	921	991	1,115
Riprap	9,051	7,316	6,020	5,140
Refractory stone (ganister)	389	5,129	411	5,040
Abrasives	41	253	63	405
Ferrosilicon	56	258	46	254
Filtration	13	71	8	29
Flux	429	1,741	442	1,704
Foundry	60	187	36	159
Glass	309	1,167	276	964
Other uses [2]	1,071	3,249	3,034	4,167
Total	25,687	40,215	28,566	46,572

[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.

TABLE 32.—Sandstone, quartz, and quartzite (crushed and broken stone) sold or used by producers in the United States in 1963, by States

State	Short tons	Value	State	Short tons	Value
Alabama	18,162	$42,158	Oklahoma	135,038	$213,668
Arizona	704,515	1,453,829	Oregon	188,259	427,198
Arkansas	9,132,781	10,221,722	Pennsylvania	2,981,481	6,473,543
California	3,360,239	5,854,536	South Dakota	1,033,749	2,070,837
Colorado	83,588	314,356	Texas	1,411,154	1,752,113
Illinois	600	6,000	Utah	609,856	438,694
Kansas	410,839	741,247	Vermont	62,296	62,296
Massachusetts	174,300	348,600	Virginia	435,965	631,494
Michigan	7,649	8,940	Washington	67,372	417,029
Minnesota	32,503	78,055	West Virginia	3,339,549	3,644,607
Montana	206,755	301,147	Wisconsin	922,355	1,334,106
New York	567,050	1,176,500	Other States [1]	2,067,064	5,087,856
North Carolina	63,076	139,912			
Ohio	550,254	3,331,579	Total	28,566,449	46,572,022

[1] Includes Connecticut, Georgia, Idaho, Indiana, Maine, Maryland, Missouri, Nevada, New Hampshire, Tennessee, and Wyoming.

TABLE 33.—Slate (crushed and broken stone) sold or used by producers in the United States,[1] by uses

(Thousand short tons and thousand dollars)

Use	1962		1963	
	Quantity	Value	Quantity	Value
Granules [2]	268	$2,079	596	$2,638
Flour	110	570	113	639
Other uses	15	10	40	33
Total	393	2,659	749	3,310

[1] Produced by the following States in 1963 in order of tonnage: Virginia, Georgia, Arkansas, Pennsylvania, California, and New York.
[2] Includes crushed slate used for lightweight aggregates to avoid disclosing individual company confidential data.

TABLE 34.—Miscellaneous stone (crushed and broken stone) sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1962		1963	
	Quantity	Value	Quantity	Value
Concrete and roadstone	15,920	$19,372	13,872	$18,423
Railroad ballast	1,728	1,247	2,042	1,418
Riprap	5,096	8,133	3,553	4,213
Fill	593	394	4,402	6,139
Other uses [1]	2,175	5,059	1,378	4,060
Total	25,512	34,205	25,247	34,253

[1] Includes stone used for agriculture, filler, filtration, flux, roofing granules, stone sand, terrazzo, and unspecified uses.

TABLE 35.—Miscellaneous varieties of stone (crushed and broken stone) sold or used by producers in the United States in 1963, by States

State	Short tons	Value	State	Short tons	Value
Arizona	646,047	$653,582	Pennsylvania	922,881	$1,433,365
Arkansas	4,439,419	3,912,725	Rhode Island	356,460	524,910
California	12,199,266	13,894,146	Texas	270,593	251,524
Connecticut	7,611	7,611	Washington	223,788	195,890
Hawaii	795,642	786,389	Wyoming	80,450	149,883
Kansas	243,066	133,164	Other States [1]	1,472,504	3,416,380
Missouri	576,111	483,955			
New Mexico	1,236,238	2,170,130	Total	25,247,166	34,253,049
North Dakota	131,947	131,947	Panama Canal Zone	60,765	84,621
Oklahoma	1,238,377	577,635	Puerto Rico	1,160,360	2,270,560
Oregon	406,766	529,813			

[1] Includes Alaska, Colorado, Louisiana, Maine, Maryland, Massachusetts, Montana, Nevada, New Hampshire, New Jersey, New York, South Dakota, Utah, Vermont, and Virginia.

FOREIGN TRADE

Imports of chalk or whiting from the United Kingdom, France, and Belgium-Luxembourg were 13,837 short tons valued at $286,110.

Crushed limestone exports to Canada were 700,000 short tons valued at $1.5 million, an increase of 21 percent in tonnage and 9 percent in value compared with 1962.

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TABLE 36.—U.S. imports for consumption of stone and whiting, by classes

Class	1962 Quantity	1962 Value	1963 Quantity	1963 Value
Marble, breccia, an onyx:				
Sawed or dressed, over 2 inches thick____cubic feet__	6,152	$52,031	5,331	$35,736
In blocks, rough, etc______do____	151,774	1,069,021	114,256	852,286
Slabs and paving tiles______superficial feet__	5,017,957	4,477,470	5,669,565	5,539,576
All other manufactures______	------------	5,421,769	------------	4,870,859
Total______	------------	11,020,291	------------	11,298,457
Granite:				
Rough______	129,501	557,636	139,282	634,944
Dressed, monumental, paving blocks, manufactured______	------------	1,057,724	------------	1,529,107
Total______	------------	1,615,360	------------	2,164,051
Quartzite______short tons__	105,335	296,029	5,853	90,125
Slate______	------------	581,822	------------	1,069,082
Travertine stone (unmanufactured)______cubic feet__	[1] 120,322	341,615	144,034	426,024
Stone (other):				
Dressed: Travertine, sandstone, limestone, etc. cubic feet__	------------	1,087,690	------------	1,377,724
Rough (monumental or building stone)_cubic feet__	5,219	23,151	6,882	11,172
Rough (other)______short tons__	50,068	650,075	1,141,776	[2] 1,404,787
Marble chip or granito______do____	31,002	287,524	24,173	246,947
Crushed or ground, n.s.p.f______	------------	1,038,712	------------	[2] 573,068
Total______	------------	3,087,152	------------	3,613,698
Whiting:				
Chalk or whiting, precipitated______short tons__	1,334	82,139	2,132	145,680
Whiting, dry, ground, or bolted______short tons__	11,663	179,266	11,256	168,568
Whiting, ground in oil (putty)______short tons__	(3)	136	17	1,907
Total______	------------	261,541	------------	316,155
Grand total______	------------	17,203,810	------------	18,977,592

[1] Revised figure.
[2] Data not comparable with other years.
[3] Less than 1 ton.

Source: Bureau of the Census.

TABLE 37.—U.S. exports of stone

Year	Building and monumental stone		Crushed, ground, or broken				Other manufactures of stone (value)
			Limestone		Other		
	Cubic feet	Value	Short tons	Value	Short tons	Value	
1954–58 (average)______	402,660	$1,080,664	884,620	$1,250,030	157,992	$2,921,166	$423,223
1959______	425,194	1,261,687	1,085,553	1,999,107	157,911	3,388,372	643,102
1960______	431,262	1,250,365	926,197	1,779,799	153,106	2,658,669	477,401
1961______	435,173	1,595,805	790,912	1,596,122	128,149	3,026,785	429,604
1962______	534,919	1,795,048	621,177	1,546,663	114,744	2,166,167	501,389
1963______	452,167	1,669,098	762,658	1,752,930	110,949	2,095,217	584,582

Source: Bureau of the Census.

TABLE 38.—U.S. exports of slate, by uses [1]

(Value)

Use	1954–58 (average)	1959	1960	1961	1962	1963
Roofing	$10,974	(2)	(2)	(2)	$15,096	(2)
Structural (including floors and walkways) and granules and flour	213,363	$89,912	$47,811	$9,154	16,321	$20,081
Other uses [3]	122,693	126,683	100,247	73,918	84,639	56,228
Total	347,030	216,595	148,058	83,072	116,056	76,309

[1] Figures collected by the Bureau of Mines from shippers of products named.
[2] Included with "Other uses" to avoid disclosing individual company confidential data.
[3] Includes electrical slate, school slate, blackboards, and billiard tabletops.

TECHNOLOGY

A series of articles discussed the application of petrographic methods to the selection and processing of various types of natural aggregates and building stone.[10] The factors applying to the selection, operation, and maintenance of rubber-tired front-end loaders were itemized. Particular mention was made of the advantages of four-wheel drive front-end loaders.[11]

Results of tests using the Libu (Swedish) system of loading, under a wide range of materials and sites, in Switzerland, Korea, Australia, and England indicated that this method required a minimum investment per ton of material moved, that the loading cycle was 30 percent faster than conventional methods, and that production in tons per man shift was from 20 to 60 percent greater.[12]

For the second consecutive year underground crushed stone operations worked without a fatality. Ninety-six participants in the National Crushed Stone Association Safety Contest of 1962 completed the year without a disabling injury.[13]

Drilling and Blasting.—A South Carolina limestone company reported that primary drilling costs were reduced by doubling the pressure of air supplied to drills. Increasing the pressure to 200 psi from the customary 100 psi doubled penetration rate and decreased wear on carbide bits [14]

[10] The following articles appeared in the Quarry Manager's Journal (London), v. 47:
Knill, D. C. The Value and Application of Petrology to the Production of Natural Aggregates and Building Stone, No. 1, January 1963, pp. 27–30.
Knill, D. C. A Review of the Petrological Basis of the Trade Classification of Rocks, No. 2, February 1963, pp. 63–70.
Knill, D. C. The Polished-Stone Coefficient: Its Petrological Significance in Relation to Other Physical Tests, No. 4, June 1963, pp. 192–195.
[11] Riding, D. The Application of Front-End Loaders to the Aggregate Industry. Quarry Manager's J. (London), v. 47, No. 9, September 1963, pp. 355–363.
[12] Walter, Leo. Operational Experience With Front-End Loaders Using Three-Way Shovels. Cement, Lime, and Gravel (London), v. 38, No. 9, September 1963, pp. 303–305.
[13] Bureau of Mines. Awards of the 1962 National Crushed Stone Association Safety Contest. Mineral Industry Surveys, Oct. 21, 1963, 20 pp.
[14] Mining World. What's Going on in the Mining World. V. 25, No. 12, November 1963, p. 38.

The techniques of drilling and blasting at the Düsseldorf, Germany operations of the Rheinisch-Westfälische Kalkwerke were described. This operation produces 35,000 tpd of limestone and dolomite from a quarry with a 90-foot face. Boreholes were drilled at a 30-degree angle and to secure low costs a variety of explosives were used.[15]

The history and background of the development of ammonium nitrate explosives were reviewed and the hazards to be avoided in the use of this explosive underground were discussed.[16]

Evaluation of the comparative efficiencies of field-mixed and premixed ammonium nitrate-fuel oil explosive by a North Carolina quarry showed that the premixed nitrate reduced costs through improved breakage.[17]

The operational efficiency and safety aspects of inclined drilling were from the view-point of various types of geological formations. Methods for determining angle and degree of drillhole deviation were described.[18]

A method for drilling blastholes which combined jet piercing and percussion drilling was developed.[19]

A series of articles discussed in detail the fundamentals of quarry blasting.[20]

Mining and Processing.—The factors entering into the selection of abrasion resistant materials in quarrying operations were itemized. Performances of various types of alloy steels, when subjected to grinding, scratching, and gouging abrasion were discussed, and a material selection summary was listed.[21]

Because of the greatly increased demand for washed aggregate, corrosion of screens has intensified, and various methods for increasing screen life were studied. The conditions affecting choice of screens for use under different conditions were discussed.[22]

The Bureau of Mines published reports on the methods used to produce crushed limestone at quarries in Tennessee and Iowa.[23]

A comprehensive report on conveyor belts discussed design of conveyor systems, specifications for pulleys and idlers, motors, fabrics, and maintenance.[24]

A 6,700-foot-long conveyor belt system designed to haul 14 million tons of crushed basalt for the San Luis Dam over a period of 4 years was constructed to feed back power into the construction site's transmission circuit.[25]

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[15] Forsthoff, W. Variety Paces German Blasting Operation. Pit and Quarry, v. 66, No. 10, October 1963, pp. 68-70, 122.

[16] Porter, M. A. New Developments in the Use of Ammonium Nitrate Products in Underground Limestone Mines. Pit and Quarry, v. 55, No. 12, June 1963, pp. 107-109.

[17] Pit and Quarry. Blasting Performance Boosted. V. 55, No. 11, May 1963, pp. 95-97.

[18] Cheshire, M. A. The Advantages of Inclined Holes at Hard Rock Faces. Quarry Manager's J. (London), v. 47, No. 4, May 1963, pp. 177-186.

[19] Pit and Quarry. New Drilling Procedure Born in Extensive Research. V. 56, No. 5, November 1963, pp. 129-131.

[20] Ash, Richard L. Mechanics of Rock Breakage. Pit and Quarry, v. 56, No. 2, August 1963, pp. 98-100, 112; No. 3, September 1963, pp. 118-123; No. 4, October 1963, pp. 126-131.

[21] Pit and Quarry. Selection and Performance of Abrasion-Resistant Materials in the Mining and Quarrying Industries. V. 55, No. 9, March 1963, pp. 114-117, 129.

[22] Reed, Albert E. What's Your Recipe for Screen Cloth? Rock Products, v. 66, No. 4, April 1963, pp. 92, 94, 96.

[23] Marshall, L. G. Mining and Beneficiating Methods and Costs at Two Crushed-Limestone Operations, Madison County, Iowa, BuMines Inf. Circ. 8199, 1963, 18 pp.

Riley, H. L., and H. J. Schroeder. Crushed Limestone Operations, Watauga Quarry, Watauga Stone Co., Carter County, Tenn., BuMines Inf. Circ. 8198, 1963, 21 pp.

[24] Bergstrom, John. Belt Conveyor Roundup. Rock Products, v. 66, No. 2, February 1963, pp. 52-92.

[25] Engineering News Record. Conveyor Hauls Rock, Generates Power. V. 171, No. 9, Aug. 29, 1963, p. 46.

A detailed and fully illustrated report of methods and equipment used to produce crushed aggregate was published. Descriptions of crushers conveying systems, screens, plant layout, control of feed, and control of particle shape were given.[26]

Details of methods and equipment used to quarry and process limestone in Indiana, Kentucky, and Wisconsin were reported.[27]

A room-and-pillar method, with 45-foot rooms and 50-foot-square pillars, was introduced by an underground limestone producer in Iowa.[28]

Portable Plants.—A crawler-mounted, self-propelled mobile crusher unit was devised by Friedrich Krupp of Rheinhausen, Germany, to bring the primary crushing operation nearer the quarry face and to supplement output from fixed quarry installations.[29]

The Cullor Limestone Company, Inc., at Fort Scott, Kans., installation comprising a three-unit portable crushing plant, portable and stationary screening units, and a separate agstone plant enabled them to meet agstone specifications for both Missouri and Kansas as well as aggregate for concrete and roadstone.[30]

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[26] Brown, G. J. Principles and Practice of Crushing and Screening. Quarry Manager's Journal (London). V. 47, No. 3. March 1963, pp. 95–102; No. 4, April 1963, pp. 149–156; No. 5, May 1963, pp. 167–174; No. 6, June 1963, pp. 239–246; No. 7, July 1963, pp. 257–264; No. 8, August 1963, pp. 319–326; No. 9, September 1963, pp. 335–344.

[27] Herod, Buren C. Kentucky Stone's New 300-tph Plant. Pit and Quarry, v. 56, No. 3, September 1963, pp. 98–100, 103, 111.
Lindsay, George C. May Stone Conquers Quarry Problems. Rock Products, v. 66, No. 2. February 1963, pp. 47–52.
Swenson, Arthur. Indiana Limestone Producer Routs Overburden Ogre. Rock Products, v. 66, No. 6, June 1963, pp. 84–87.
Swenson, Arthur. Waukesha Swells into Limestone Supermarket. Rock Products, v. 66, No 8, August 1963, pp. 80, 82, 84.

[28] Rock Products. Midwest Producer Goes Underground. V. 66, No. 4, April 1963, pp. 99–100.

[29] Quarry Manager's Journal. Crawler-Mounted Primary Crushing Plants. V. 47, No. 8, January 1963, pp. 31–32.

[30] Trauffer, Walter E. Kansas Agstone Producer Also Meets Missouri Specifications. Pit and Quarry, v. 55, No. 11, May 1963, pp. 134–138.

Strontium

By Clarence O. Babcock[1]

IMPORTS of strontium from the United Kingdom and Mexico continued to supply consumer needs. Interest centered on the radioisotope strontium 90 and its possible effects on human beings.

LEGISLATION AND GOVERNMENT PROGRAMS

The General Services Administration again offered for sale, at its warehouse in Point Pleasant, W. Va., about 12,500 short tons of celestite ore; 9,632 tons of Spanish origin, and the remainder from Mexico. No acceptable bids were received. The 12,500 tons was part of a below-grade stockpile of 28,816 tons.

Contracts were made for 21,997 tons of stockpile-grade celestite with producers in the United Kingdom and Mexico; deliveries were 8,562 tons and 458 tons, respectively.

DOMESTIC PRODUCTION

King Laboratories, Inc., Syracuse, N.Y., continued to be the only strontium metal producer as well as the the principal consumer.

There was no domestic production of strontium minerals for the fourth consecutive year. Production was last obtained in 1959 from San Diego County, Calif., and Skagit County, Wash.

Strontium chemicals were produced from imported celestite by E. I. du Pont de Nemours & Co., Inc., at Grasselli, N.J.; Foote Mineral Co. at Exton, Pa.; and Inorganic Chemicals Division, FMC Corp., Modesto, Calif.

CONSUMPTION AND USES

Strontium or strontium compounds were used in caustic soda refining, ceramics, chemicals, depilatories, desulfurizing steel, dielectrics, drilling muds, fireworks, getter alloys, greases, luminous paint, marine distress signals, military flares, plastics, purification of electrolytic zinc, rubber filler, scavengers in metallurgy, tracer bullets, warning fuses, and welding rod coatings.

Heat produced by the decay of radioisotope strontium 90 acting on thermocouples has been used to produce electricity. This high cost energy has been used to power unmanned weather stations, navigational aids, and a navigational satellite.

PRICES

Posted prices of various strontium compounds quoted in Oil, Paint and Drug Reporter throughout 1963 were unchanged since 1955.

[1] Commodity specialist, Division of Minerals.

FOREIGN TRADE

Strontium mineral imports in 1963 more than doubled in quantity over 1962. The United Kingdom replaced Mexico as principal source. Strontium chemical imports (carbonate, nitrate, and oxide) were valued at $1,125 for 1963.

Under the new tariff schedule of the United States Annotated, TSUS, No. 421.82, effective August 1963, strontium (celestite) continued to be imported duty free.

TABLE 1.—U.S. imports for consumption of strontium minerals,[1] by countries

Country	1962		1963	
	Short tons	Value	Short tons	Value
Italy	27	$6,750	11	$2,700
Mexico	4,554	98,476	6,476	104,867
United Kingdom	2,908	83,609	9,745	264,457
Total	7,489	188,835	16,232	372,024

[1] Strontianite or mineral strontium carbonate and celestite or mineral strontium sulfate.

Source: Bureau of the Census.

WORLD REVIEW

Free world production of strontium minerals in 1963 increased 95 percent over that for 1962 and 42 percent over the average for the period 1954–62.

An increase in United Kingdom production reflected acquisition of strontium minerals (celestite) for the U.S. stockpile.

TABLE 2.—Free world production of strontium minerals, by countries [1] [2]

(Short tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
Argentina	223	(3)	(3)	(3)	(3)	(3)
Italy	448	353	915	1,179	660	[4] 600
Mexico [5]	2,105	2,182	2,880	2,642	4,554	6,476
Morocco	[6] 893	435				
Pakistan	539	744	1,492	461	262	
United Kingdom	6,395	6,720	7,396	9,720	[5] 2,908	[5] 9,475
United States	[7] 1,404	(8)				
Free world total [1]	12,007	[4] 10,700	[4] 12,900	[4] 14,300	[4] 8,600	[4] 16,800

[1] Strontium minerals are produced in Germany, Poland, and the U.S.S.R., but data on production are not available; no estimates are included in the total for these countries.

[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[3] Data not available; estimate included in total.

[4] Estimate.

[5] U.S. imports.

[6] Average annual production 1957–58.

[7] Average annual production 1954–56.

[8] Figure withheld to avoid disclosing individual company confidential data; included in world total.

TECHNOLOGY

A report was published on the thermodynamic properties of strontium chloride (7° to 300° K) and strontium fluoride (11° to 300° K). Heat capacities were measured with an adiabatic calorimeter and smooth values of heat capacity, entropy, enthalpy function, and free-energy function were calculated.[2]

A method of analysis using photometric determination of strontium in silicates and carbonates using liquid light filters was described.[3]

Strontium oxide single crystals doped with all the rare-earth and transition elements for fluorescent studies and for possible use as laser and maser material were available from Semi-Elements Inc., Saxonburg, Pa.[4]

Ninety percent of the strontium 90 in milk could be removed at a cost of $0.12 per quart by means of a new ion exchange process developed by an Atomic Energy Commission chemist.[5]

Loyola University, New Orleans, La., planned to collect 6,000 discarded baby teeth per year for 5 years from Gulf Coast and Puerto Rican children. Objective of the study was to determine if the strontium 90 content of the teeth was a dependable indicator of the amount of strontium that entered the life cycle during the prenatal period.[6]

Special sensitivity of photoelectric emission from a sprayed SrO cathode at 290° K was studied. Monochromatic illumination in the range 600 to 200 nano meter (2.1 to 6.2 electron volt) was used. A faint blue-green or blue-white luminescence was produced by light in the range 315 to 265 nano meter (4.0 to 4.7 electron volt). One nanometer equals one billionth meter. Results were discussed.[7]

A patent was issued for a method of preparing the beta form of dibasic strontium phosphate. A water-soluble monohydrogen phosphate salt was added to a water-soluble strontium salt solution. Dibasic strontium phosphate was precipitated in the temperature range 0° to 26° C.[8]

A $14.3 million plant to produce multimegacurie quantities of strontium 90, cesium 137, cerium 144, and promethium 147 was considered as one of several ways to diversify the Atomic Energy Commission's (AEC) billion dollar Hanford works in Washington State. AEC asked Hanford and General Electric Co. to make a conceptual design for the plant.[9]

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[2] Smith, D. F., T. E. Gardner, B. B. Letson, and A. R. Taylor, Jr. Thermodynamic Properties of Strontium Chloride and Strontium Fluoride from 0° to 300° K. BuMines Rept. of Inv. 6316, 1963, 8 pp.

[3] Ksandopulo, G. I., and D. P. Shcherbov. (Flame Photometric Determination of Strontium in Silicates and Carbonates Using Liquid Light Filters). Zavodskaya Laboratoriya (U.S.S.R.), v. 24, No. 12, 1958, pp. 1432–1434 (in French).

[4] Chemical Trade Journal and Chemical Engineer (London). Strontium Oxide Single Crystals. V. 153, No. 3980, Sept. 20, 1963, p. 432.

[5] Chemical Week. Nonradioactive Milk. V. 93, No. 11, Sept. 14, 1963, p. 98.

[6] Chemistry. Baby Teeth for Strontium-90 Research. V. 36, No. 9, October 1963, p. 6.

[7] Journal of the American Ceramic Society. V. 46, No. 5, May 1963, p. 135.

[8] Aia, Michael A. (assigned to Sylvania Electric Products, Inc., Wilmington, Del.). Method of Producing Strontium Phosphate. U.S. Pat. 3,113,835, Dec. 10, 1963.

[9] Chemical Week. Heading for Hanford. V. 93, No. 23, Dec. 7, 1963, p. 42.

Sulfur and Pyrites

By Clarence O. Babcock [1]

FOR the first time in several years Free world sulfur production and consumption were nearly in balance as they reached 19.9 million and 19.7 million long tons, respectively. The United States consumed 6.7 million tons. Increases in Mexican Frasch and Canadian recovered sulfur accounted for about one-half of the gain over that of 1962. Mexico and France sold all their production while Canada sold 85 percent of its production.

Eighty-five percent of all elemental sulfur used in the United States was delivered to customers in molten form. Deliveries of molten sulfur to European countries from the United States, Mexico, and France were expected in 1964. Molten sulfur terminals were under construction at Immingham, England; Rotterdam, Holland; and Rouen, France. Molten sulfur tankers were completed or under construction for United States, Mexican, and French producers. The S.S. *Marine Sulphur Queen* was lost off the Florida coast while carrying a cargo of molten sulfur.

Expansion of sulfur markets included shipment of Canadian sulfur to the U.S.S.R. and Japan and French sulfur to Cuba and the United States.

Domestic sulfur prices were stable during the year and became stable overseas near the end of the year.

TABLE 1.—Salient sulfur statistics
(Long tons, sulfur content)

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Production	5,617,448	4,639,816	5,037,292	5,477,493	5,025,418	4,881,927
All forms	6,933,029	6,167,740	6,660,541	7,172,479	[1] 6,757,211	6,643,802
Imports, pyrites and sulfur	430,432	776,888	884,838	966,417	[1] 1,185,073	1,444,216
Exports, sulfur	1,636,244	1,635,607	1,786,543	1,596,043	1,553,986	1,612,637
Stocks Dec. 31: Producer, Frasch and recovered sulfur	3,978,620	3,949,954	3,777,799	4,813,521	4,934,238	4,682,496
Consumption, apparent, all forms [2]	5,419,760	5,917,100	5,862,000	5,893,000	[1] 6,243,600	6,685,100
World: Production:						
Sulfur, elemental	(3)	9,135,000	10,375,000	11,590,000	12,100,000	12,560,000
Pyrites	(3)	7,800,000	8,300,000	8,100,000	8,300,000	8,300,000

[1] Revised figure.
[2] Measured by quantity sold plus import minus exports.
[3] Data not available.

[1] Commodity specialist, Division of Minerals.

Increasing sulfur imports from Canada and Mexico caused political concern. Interstate Commerce Commission hearings on railroad rates for Canadian sulfur to the United States were watched closely by United States and Canadian producers.

Potential production of sulfur from the Athabasca oil sands of Alberta, Canada, said to contain the largest world reserves (1 to 2 billion tons sulfur), was of interest.

DOMESTIC PRODUCTION

Production of sulfur in all forms totaled 6.6 million long tons, 2 percent less than the 6.8 million tons in 1962. Frasch production decreased 103,000 tons (2 percent) to 4,882,000 tons. Recovered sulfur increased 47,000 tons (5 percent) to 947,000 tons. Other sources were burning of pyrites, 344,000 tons; native ore, 415 tons; and various forms from other sources, 472,000 tons.

NATIVE SULFUR

The 10 Frasch-process mines in operation in 1963 were Freeport Sulphur Co. at Grande Ecaille (largest in the world), Garden Island Bay, and Lake Pelto in Louisiana and Grande Isle off the Louisiana coast; Texas Gulf Sulphur Co. at New Gulf (Boling), Spindletop, Moss Bluff, and Fannett in Texas; Jefferson Lake Sulphur Co. at Long Point Dome and Duval Corp. at Orchard Dome, both in Texas.

Production by the Duval Corp. of 174,000 tons from the Orchard Dome, Tex., plant was 9 percent below that for 1962 but average for the 5-year period from 1959 to 1963. Reduction in domestic sales accounted for most of the 11 percent decrease in sales from 1962. The Duval Corp., formerly the Duval Sulphur & Potash Co., changed its name and authorized a capital stock increase from 2 to 3 million shares.[2]

Frasch production by Freeport Sulphur Co. from mines in Louisiana or off the coast was about equal to record sales of 2.5 million tons. This was the largest native sulfur production for a single company in the world. Production increased 12 percent from that of 1962. The largest single market was the Tampa, Fla., area, where sulfuric acid was manufactured to produce fertilizer. Domestic shipments were 85 percent in liquid form. Liquid storage facilities at Port Sulphur, La., were to be increased by 50 percent. A third 10,000-ton liquid sulfur barge tow served customers on inland waterways. Twelve liquid sulfur storage and transshipment terminals were in use in the eastern half of the country with completion of two new facilities in Alabama and one in Georgia.[3]

Frasch production in Louisiana by Freeport Sulphur Co. was greater than Frasch production in Texas for the first time in 40 years.

Jefferson Lake Sulphur Co. informed its shareholders and employees of a pending merger with Occidental Petroleum Corp. The formal merger agreement and other necessary documents were being prepared.

Texas Gulf Sulphur Co. produced 2,375,000 long tons of sulfur; 2,004,000 tons was Frasch sulfur from Texas, and the remainder was

[2] Duval Corp. Annual Report 1963, p. 4.
[3] Freeport Sulphur Co. Annual Report 1963, pp. 4–6.

TABLE 2.—Production of sulfur and sulfur-containing raw materials by producers in the United States

(Long tons)

	1954–58 (average)		1959		1960		1961		1962		1963	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
Native sulfur or sulfur ore:												
Frasch-process mines	5,562,391	5,562,391	4,553,634	4,553,634	4,942,935	4,942,935	5,385,468	5,385,468	4,984,578	4,984,578	4,881,512	4,881,512
Other mines	181,938	55,057	331,237	86,182	379,067	94,357	400,015	92,025	162,186	40,840	1,371	415
Total		5,617,448		4,639,816		5,037,292		5,477,493		5,025,418		4,881,927
Recovered elemental sulfur:												
Brimstone	476,507	474,554	688,487	686,407	769,319	766,566	861,413	858,169	902,124	899,598	949,567	946,753
Paste	281	129										
Total		474,683		686,407		766,566		858,169		899,598		946,753
Pyrites (including coal brasses)	1,005,414	417,242	1,056,617	436,871	1,016,263	416,213	987,309	398,519	915,890	379,046	824,800	343,566
Byproduct sulfuric acid (basis—100 percent) produced at Cu, Zn, and Pb plants	1,028,868	336,250	969,678	316,600	1,056,890	345,075	1,016,731	331,963	1,088,397	355,362	1,089,523	355,730
Other byproduct sulfur compounds [1]	100,474	87,406	104,887	88,046	114,359	95,395	126,923	106,335	115,670	97,787	136,509	115,826
Total		6,933,029		6,167,740		6,660,541		7,172,479		6,757,211		6,643,802

[1] Hydrogen sulfide and liquid sulfur dioxide. In addition, a quantity of acid sludge is converted to H_2SO_4 but it is excluded from the above figures.

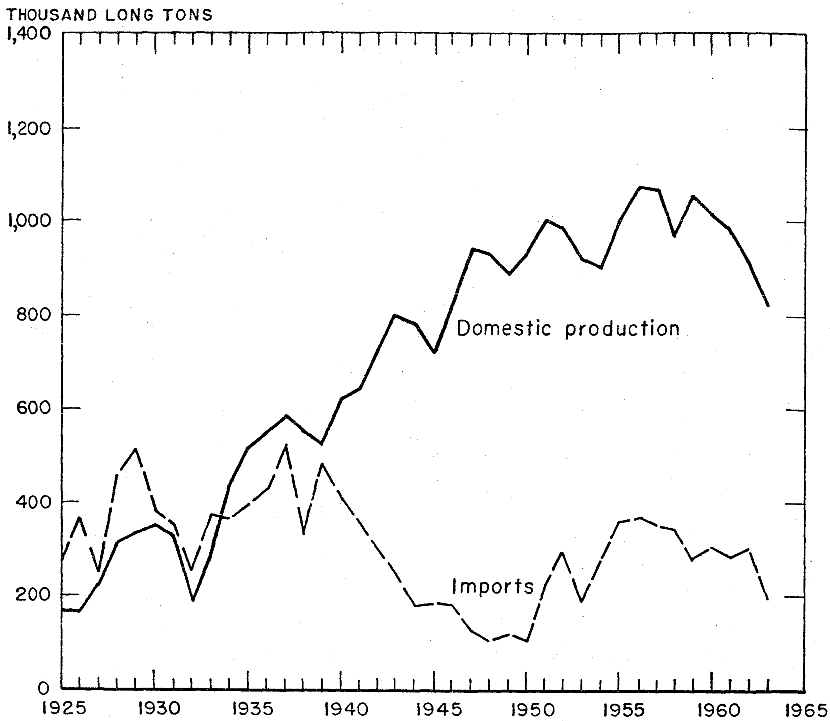

FIGURE 1.—Domestic production, apparent consumption, and exports of native sulfur, 1925–63.

recovered sulfur from sour natural gas at Worland, Wyo., and Okotoks and Windfall, Alberta, Canada. Production was 3 percent less than for 1962. Windfall production of 725 tons per day for 1963 was to be increased to 1,225 tons per day in 1964. Eleven regional liquid sulfur terminals, including two new ones on the Delaware River at Paulsboro, N.J., and on the Monongahela River at Newell, Pa., had a capacity of 169,100 tons. Loss off the Florida coast about February 3 of the 15,000-ton chartered, liquid-sulfur carrier, the S.S. *Marine Sulphur Queen*, increased delivery costs for sulfur and reduced earnings. A new 23,760-ton vessel for domestic service, the S.S. *Marine Texan*, was to enter service in January 1964.[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)
1954–58 (average)	3,422,267	2,140,124	5,562,391	5,304,503	$137,543
1959	2,519,090	2,034,544	4,553,634	5,222,206	121,777
1960	2,678,643	2,264,292	4,942,935	5,002,638	115,494
1961	2,777,674	2,607,794	5,385,468	5,082,585	117,884
1962	2,621,974	2,362,604	4,984,578	4,917,466	107,069
1963	2,412,653	2,468,859	4,881,512	4,995,023	99,014

[4] Texas Gulf Sulphur Co. Annual Report 1963, pp. 1–6.

TABLE 4.—Sulfur ore (10 to 70 percent S) produced and shipped in the United States [1]

Year	Produced (long tons)	Shipped		Year	Produced (long tons)	Shipped	
		Long tons	Value (thousands)			Long tons	Value (thousands)
1954–58 (average)	181,938	179,252	$1,562	1961	400,015	177,549	$1,694
1959	331,237	151,932	1,418	1962	162,186	150,550	1,439
1960	379,067	181,422	1,732	1963	1,371	1,371	15

[1] California and Nevada (except 1954).

RECOVERED SULFUR

Production of recovered sulfur from sour natural and refinery gases increased for the 20th straight year. The 20-year increase, from 5,101 tons in 1943 to 946,753 tons in 1963, averaged 47,082 tons per year. In 1963, 67 sulfur recovery plants were operated by 45 companies in Arkansas, California, Delaware, Illinois, Indiana, Louisiana, Michigan, Minnesota, Mississippi, Montana, New Jersey, New Mexico, North Dakota, Ohio, Oklahoma, Pennsylvania, Texas, Virginia, and Wyoming. Leading producing States in descending order of production were Texas, California, Delaware, and Wyoming. They provided 70 percent of the total.

Four new recovered sulfur plants on-stream in 1963 were: Climax Chemical, Hobbs, New Mex., 10 tons per day; Monsanto-Tidewater, Avon, Calif., 170 tons per day; Pan American Petroleum, West Yantis Field, Wood County, east Texas, 80 tons per day; and Signal Oil & Gas, Houston, Tex., 40 tons per day.

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)
1954–58 (average)	476,507	474,554	437,459	435,571	$12,060
1959	688,487	686,407	711,191	709,074	17,396
1960	769,319	766,566	778,079	775,214	18,163
1961	861,413	858,169	834,046	831,001	18,861
1962	902,124	899,598	909,964	907,340	19,599
1963	949,567	946,753	932,147	929,369	19,401

PYRITES

Production of pyrites, ores and concentrates, was 825,000 long tons, 91,000 less than in 1962. Producing companies sold or consumed 805,000 tons. Of this quantity, 73,000 tons, with a sulfur content of 33,000 tons and valued at $303,000, was sold; and 732,000 tons, having a sulfur content of 299,000 tons and valued at $5,335,000, was consumed.

Tennessee was the leading producer by a wide margin and was followed by Colorado, Pennsylvania, Arizona, and South Carolina.

The Mountain Copper Co., closed its copper pyrite Hornet mine at Iron Mountain early in the year because pyrites could not compete with sulfur from other sources.[5]

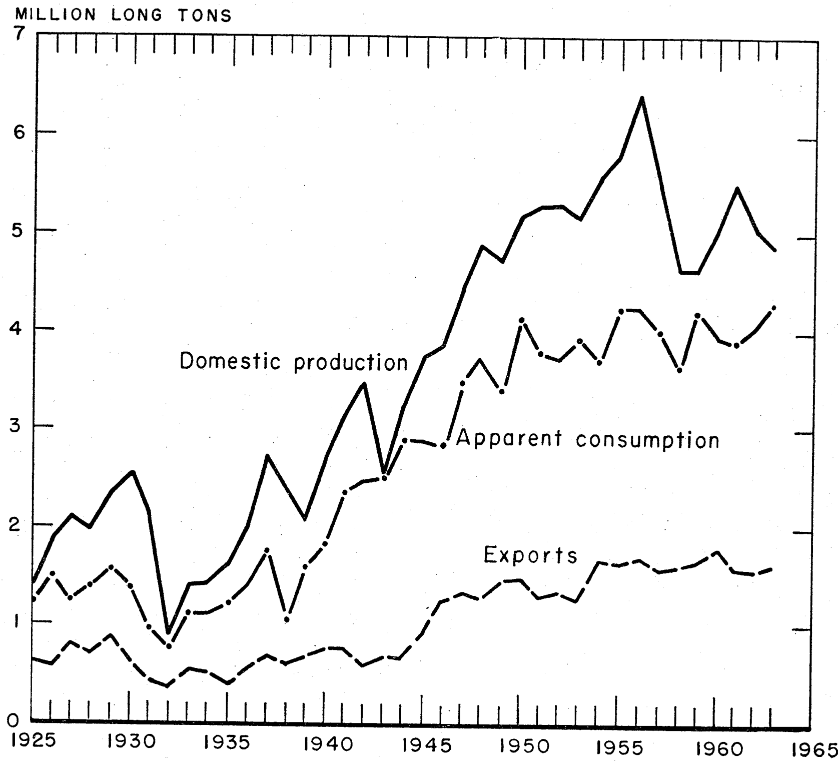

FIGURE 2.—Domestic production and imports of pyrites, 1925–63.

TABLE 6.—Production and shipments of pyrites (ores and concentrates) in the United States

(Long tons)

Year	Production		Value (thousands)	Shipments		Value (thousands)
	Gross weight	Sulfur content		Gross weight	Sulfur content	
1954-58 (average)	1,005,414	417,242	$8,473	148,426	71,176	$1,045
1959	1,056,617	436,871	8,148	131,685	63,456	868
1960	1,016,263	416,213	7,936	150,281	72,205	901
1961	987,309	398,519	7,418	117,957	56,870	816
1962	915,890	379,046	6,809	64,476	31,382	359
1963	824,800	343,566	5,698	72,618	33,449	303

[5] Engineering and Mining Journal. V. 164, No. 4, April 1963, p. 138.

BYPRODUCT SULFUR COMPOUNDS

Copper and zinc plants in the United States produced sulfuric acid from smelting sulfide ores. Either hydrogen sulfide or sulfur dioxide were recovered from 11 plants owned by 10 companies in California, New Jersey, Tennessee, Louisiana, Pennsylvania, and Michigan. The hydrogen sulfide production was from oil refineries, and the sulfur dioxide was from smelter gases.

TABLE 7.—Byproduct sulfuric acid [1] (basis, 100 percent) produced at copper, zinc, and lead plants in the United States

(Short tons)

Plants	1954–58 (average)	1959	1960	1961	1962	1963
Copper [2]	393,051	282,461	412,845	362,630	403,683	358,503
Zinc [3]	759,281	803,578	770,872	776,109	815,322	861,763
Total	1,152,332	1,086,039	1,183,717	1,138,739	1,219,005	1,220,266

[1] Includes acid from foreign materials.
[2] Includes acid produced at a lead smelter. Excludes acid made from pyrite concentrates in Arizona, Montana, Tennessee, and Utah.
[3] Excludes acid made from native sulfur.

CONSUMPTION

U.S. consumption of sulfur in all forms reached a record high of 6,685,000 long tons, 7 percent more than the revised figure of 6,244,000 tons used in 1962. Native sulfur consumption increased 8 percent to 4,380,000 tons. Recovered sulfur consumption, measured by sales and imports, increased 18 percent to 1,417,000 tons. Pyrite consumption decreased 17 percent to 437,000 tons.

Free world consumption reached a new high of 19.7 million tons, an increase of 7 percent more than the 18.4 million tons in 1962. A near balance between demand and production occurred and absorbed nearly all the output. This position was a dramatic contrast to 1962 when production exceeded consumption by nearly 1 million tons. Elemental sulfur again supplied most of the increase in demand.[6]

STOCKS

On December 31, producer stocks of Frasch sulfur totaled 4,594,000 tons, 5 percent less than in 1962 at yearend. This included 4,007,000 tons at the mines and 587,000 tons elsewhere. Producer stocks of recovered sulfur were 89,000 tons, slightly less than in 1962 at yearend. Pyrite stock data were unavailable.

Eighty-five percent of elemental sulfur shipped by domestic producers was in molten form.

[6] Gittinger, L. B. Sulphur—1963. Eng. and Min. J., v. 165, No. 2, February 1964, pp. 150–152.

747-149—64——69

TABLE 8.—Production of new sulfuric acid [1] (100 percent H_2SO_4) by geographic divisions and States

(Short tons)

Division and State	1959	1960	1961	1962	1963
New England [2]	195,614	192,664	179,341	184,142	183,956
Middle Atlantic:					
New York and New Jersey	1,673,150	1,681,302	1,652,868	1,684,590	1,749,165
Pennsylvania	764,239	754,703	770,272	797,207	877,120
Total	2,437,389	2,436,005	2,423,140	2,481,797	2,626,285
North Central:					
Illinois	1,368,644	1,355,647	1,399,349	1,464,064	1,562,320
Indiana	479,064	485,297	456,372	(3)	(3)
Michigan	334,609	324,318	307,979	331,901	355,824
Ohio	767,089	742,287	684,312	661,535	659,090
Other [3]	849,807	715,137	781,046	1,361,113	1,474,984
Total	3,799,213	3,622,686	3,629,058	3,818,613	4,052,218
South:					
Alabama	309,516	312,996	242,996	319,218	350,396
Delaware and Maryland	1,153,071	1,119,452	1,077,644	1,114,025	1,016,809
Florida	2,036,707	2,272,039	2,518,215	[4] 3,087,431	3,822,364
Georgia	345,552	337,140	345,775	384,010	420,765
Kentucky and Tennessee	1,014,735	997,379	1,024,717	(5)	(5)
Louisiana	640,180	595,232	598,534	675,159	699,985
North Carolina	149,774	131,221	133,115	140,591	144,864
South Carolina	152,241	142,652	149,493	143,250	154,281
Texas	1,674,284	1,593,303	1,585,307	1,885,553	1,925,948
Virginia	504,223	460,098	448,839	467,122	495,366
Other [5]	541,565	584,181	606,031	1,759,087	1,802,141
Total	8,521,848	8,545,693	8,730,666	[4] 9,975,446	10,832,919
West [6]	1,950,384	2,288,142	2,095,837	2,322,500	2,342,159
Total United States	16,904,448	17,085,190	17,058,042	[4] 18,782,498	20,037,537

[1] Includes data for Government-owned and privately operated plants.
[2] Includes data for plants located in Maine, Massachusetts, and Rhode Island.
[3] Includes data for plants located in Iowa (1961-63), Indiana, Kansas, Minnesota, Missouri, and Wisconsin. Data for Indiana for prior years were reported separately.
[4] Revised figures.
[5] Includes data for plants located in Arkansas, Kentucky, Mississippi, Oklahoma, Tennessee, and West Virginia. Data for Kentucky and Tennessee for prior years were reported separately.
[6] Includes data for plants located in Arizona, California, Hawaii, Idaho, Montana, Nevada, New Mexico, Utah, Washington, and Wyoming. Also includes data for Colorado for 1960 and 1961. (Data for Hawaii not included for 1959.)

Source: U.S. Department of Commerce.

TABLE 9.—Apparent consumption of native sulfur in the United States

(Long tons)

	1954-58 (average)	1959	1960	1961	1962	1963
Apparent sales to consumers [1] [2]	5,341,045	5,225,245	5,129,300	4,854,809	4,873,021	5,129,008
Imports	267,632	642,488	607,235	648,910	[3] 745,772	863,385
Total	5,608,677	5,867,733	5,736,535	5,503,719	5,618,793	5,992,393
Exports:						
Crude	1,610,707	1,612,158	1,775,526	1,585,531	1,537,419	1,603,438
Refined	25,537	23,449	11,017	10,512	16,567	9,199
Total	1,636,244	1,635,607	1,786,543	1,596,043	1,553,986	1,612,637
Apparent consumption	3,972,433	4,232,126	3,949,992	3,907,676	[3] 4,064,807	4,379,756

[1] Production adjusted for net change in stocks during year.
[2] Includes native sulfur from mines that do not use Frasch process.
[3] Revised figure.

TABLE 10.—Apparent consumption of sulfur in all forms in the United States [1]

(Long tons)

	1954-58 (average)	1959	1960	1961	1962	1963
Native sulfur	3,972,440	4,232,100	3,950,000	3,907,700	[2] 4,064,807	4,379,800
Recovered sulfur:						
Sales	443,640	709,100	775,200	831,000	907,300	929,400
Imports	(3)	(3)	134,100	182,600	[2] 294,700	487,800
Pyrites:						
Domestic production	417,240	436,900	416,200	398,500	379,000	343,600
Imports	162,800	134,400	146,000	134,900	144,600	93,000
Total pyrites	580,040	571,300	562,200	533,400	523,600	436,600
Smelter-acid production	336,260	316,600	345,100	332,000	355,400	335,700
Other productions [4]	87,380	88,000	95,400	106,300	97,800	115,800
Grand total	5,419,760	5,917,100	5,862,000	5,893,000	[2] 6,243,600	6,685,100

[1] Crude sulfur or sulfur content.
[2] Revised figure.
[3] Data included with imports in table 9. Not separately available before 1960.
[4] Hydrogen sulfide and liquid sulfur dioxide. In addition, a quantity of acid sludge is converted to H_2SO_4 but is excluded from the above figure.

TABLE 11.—Liquid sulfur regional storage and transshipment terminals in operation [1] in 1963

Producer controlled terminals	Number of storage tanks	Total storage capacity (thousand long tons)
Freeport Sulphur Co.:		
Baton Rouge, La	1	6.5
Bucksport, Maine	2	20.0
Charleston, S.C	1	10.0
Everett, Mass	1	10.0
Joliet, Ill	3	30.0
Le Moyne, Ala. [2]	2	9.8
Nitro, W. Va	2	18.0
Tampa, Fla	4	40.0
Tuscaloosa, Ala. [2]	1	3.8
Warners, N.J	2	12.5
Wellsville, Ohio	2	20.0
Total	21	180.6
Gulf Sulphur Corp.:		
Baltimore, Md	1	10.0
Tampa, Fla	1	10.0
Total	2	20.0
Pan American Sulphur Co.:		
Baltimore, Md	1	10.0
Newark, N.J	1	10.0
Tampa, Fla	3	30.0
Total	5	50.0
Texas Gulf Sulphur Co.:		
Baltimore, Md	2	24.0
Carteret, N.J	2	26.0
Cincinnati, Ohio	3	16.8
Jacksonville, Fla	1	11.0
Marseilles, Ill	1	10.0
Newell, Pa. [1]	1	10.0
Norfolk, Va	2	20.8
Paulsboro, N.J. [1]	2	24.0
Savannah, Ga	1	11.0
Tampa, Fla	1	7.5
Wilmington, N.C	1	8.0
Total	17	169.1

[1] Completed in 1963 but not in operation.
[2] Began operating in 1963.

PRICES

Posted prices of Frasch sulfur in the United States remained unchanged at $25 per long ton, f.o.b. gulf ports, for bright sulfur with a discount of $1 per ton for off-color material. Prices f.o.b. mine were $1.50 below port prices. Eighty-five percent of the Frasch sales in the United States were in the form of molten sulfur, much of which was delivered from terminals near major consuming areas. Prices for sulfur delivered from such terminals included transportation costs and terminal charges and tended to reflect competitive conditions within the distribution area.

Domestic prices, weak in 1962, were firm in 1963 and increases were expected in 1964. Prices overeseas became stable near the end of the year.

Delivered prices at yearend for bright sulfur to Northwest Europe were $26.50 to $27; to Northern Europe, $30 to $30.50; to the Mediterranean area, $30.50 to $32; to South America, $30 to $34; to Southeast Asia, the Far East, and Australia, $27 to $32.50. Prices for European pyrites decreased about 6 percent. Spanish crude fines pyrites, Rio Tinto, was $7.91 and, Tharsis, $8.05 per ton, 48 percent sulfur, f.o.b. Huelva.[7]

FOREIGN TRADE

Imports.—Elemental sulfur imports increased 30 percent to a record high of 1,351,000 tons. These imports came from Mexico, 64 percent; Canada, 35 percent; France, and West Germany, less than 1 percent. Imports of Mexican sulfur (Frasch) increased 16 percent while imports of Canadian sulfur (recovered) increased 63 percent. Imports of pyrites decreased 36 percent. Canadian recovered sulfur from sweetening sour natural gas, mostly in Alberta, went to the Northwest and Chicago areas. Mexican Frasch sulfur was shipped to Florida and to other East Coast areas.

Exports.—Exports of sulfur by U.S. producers increased 4 percent to 1,612,637 tons.

Major exports went to India, 16 percent; the United Kingdom, 15 percent; Canada, 9 percent; Brazil, 8 percent; Australia, 8 percent; Netherlands, 7 percent; and about 38 other countries, 37 percent. Exports were handled by the Sulfphur Export Corporation (Sulexco) for the four Frasch producers—Duval Corp., Freeport Sulfphur Co., Jefferson Lake Sulphur Co., and Texas Gulf Sulphur Co. Exports to date have been in solid form, but molten sulfur exports were expected in 1964.

TABLE 12.—U.S. imports for consumption and exports of sulfur

Year	Imports		Exports			
			Crude		Crushed, ground, refined, sublimed and flowers	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1954–58 (average)	267,631	[1] $6,407	1,610,707	$46,164	25,536	$1,957
1959	642,488	13,901	1,612,158	39,975	23,449	2,025
1960	741,370	15,453	1,775,526	40,880	11,017	1,413
1961	831,517	17,152	1,585,531	35,370	10,512	1,254
1962	[2] 1,040,473	[2] 20,310	1,537,419	35,496	16,567	1,799
1963	1,351,216	23,942	1,603,438	33,531	9,199	1,057

[1] Data known to be not comparable with other years.
[2] Revised figure.

Source: Bureau of the Census.

[7] Sulfur (London). No. 50, February 1964, p. 3.

TABLE 13.—U.S. imports for consumption of sulfur by countries

Country	1962						1963 [1]	
	Ore		In any forms, n.e.s.[2]		Total		Sulfur	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
North America:								
Canada	[3] 176,420	[3] $2,801	[3] 118,258	[3] $2,181	294,678	$4,982	480,355	$6,650
Mexico	[3] 266,523	[3] 5,632	[3] 479,249	[3] 9,691	745,772	15,323	863,385	17,101
Total	[3] 442,943	[3] 8,433	[3] 597,507	[3] 11,872	1,040,450	20,305	1,343,740	23,751
Europe:								
France	-	-	-	-	-	-	7,431	184
Germany, West	-	-	23	5	23	5	45	7
Total	-	-	23	5	23	5	7,476	191
Grand total	[3] 442,943	[3] 8,433	[3] 597,530	[3] 11,877	1,040,473	20,310	1,351,216	23,942

[1] Effective Sept. 1, 1963, ore and sulfur in any forms, not elsewhere specified, no longer separately classified.
[2] Not elsewhere specified.
[3] Revised figure.

Source: Bureau of the Census.

TABLE 14.—U.S. exports of sulfur by countries

Destination	Crude				Crushed, ground, refined, sublimed, and flowers			
	1962		1963		1962		1963	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
North America:								
Canada	176,646	$4,589	141,710	$3,811	2,612,338	$254	2,090,309	$191
Central America	2,605	62	6,757	159	664,544	29	669,419	32
Mexico	425	14	441	14	420,700	55	324,800	57
West Indies	12,545	287	16,798	360	89,543	3	19,500	1
Total	192,221	4,952	165,706	4,344	3,787,125	341	3,104,028	281
South America:								
Argentina	20,305	469	8,001	147	366,470	56	118,900	27
Bolivia	-	-	-	-	-	-	43,780	2
Brazil	123,232	2,911	134,843	2,855	671,619	128	656,578	94
Chile	5,904	138	2,000	41	103,050	12	22,655	6
Colombia	2,468	58	1,476	32	1,039,601	42	1,956,371	63
Ecuador	-	-	40	1	53,396	2	101,210	8
Paraguay	91	3	-	-	-	-	66,623	1
Peru	10,517	246	13,370	270	180,631	17	268,015	24
Uruguay	5,126	125	4,716	93	33,196	2.	2,700	(1)
Venezuela	9,800	258	5,293	150	625,788	48	744,703	33
Total	177,443	4,208	169,739	3,589	3,073,751	307	3,981,535	258
Europe:								
Austria	19,705	447	16,464	309	44,100	7	-	-
Belgium-Luxembourg	58,452	1,335	49,500	986	3,500	1	3,100	1
Czechoslovakia	44,500	1,012	38,000	776	-	-	-	-
Finland	7,200	166	500	8	-	-	-	-
France	83,539	1,883	53,719	1,079	115,580	4	-	-
Germany, West	39,980	915	72,200	1,460	117,518	16	64,850	6
Greece	-	-	-	-	15,483,369	511	13,002	1
Iceland	-	-	-	-	-	-	3,640	1
Ireland	35,216	820	40,707	838	15,250	1	-	-

[1] Less than $1,000.

TABLE 14.—U.S. exports of sulfur by counties—Continued

Destination	Crude				Crushed, ground, refined, sublimed, and flowers			
	1962		1963		1962		1963	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
Europe—Continued								
Netherlands	87,621	$1,924	116,495	$2,270	----	----	8,718	(1)
Norway	885	21	1,800	35	324,500	$9	42,200	$1
Spain	4,277	98	5,612	117	70,200	14	39,900	9
Sweden	1,800	40	4,627	92	31,910	5	67,200	9
Switzerland	21,815	506	35,600	711	----	----	----	----
United Kingdom	257,233	5,560	247,875	4,844	2,000	(1)	----	----
Yugoslavia	----	----	----	----	151,986	6	22,050	3
Other	----	----	87	2	2,000	(1)	1,000	(1)
Total	662,223	14,727	683,186	13,527	16,361,913	574	265,660	31
Asia:								
Bahrein			130	5	----	----	120,385	12
Ceylon	----	----	----	----	4,500	1	4,400	(1)
India	237,363	5,625	247,755	5,340	5,599,808	222	5,047,680	157
Indonesia	2,500	60	600	14	183,550	9	424,469	14
Iran	----	----	----	----	20,000	1	15,488	2
Iraq	1,507	41	1,833	62	143,600	2	322,000	5
Israel	77	2	55,750	1,089	227,593	19	192,521	12
Japan	498	15	----	----	56,521	10	20,100	5
Jordan	----	----	----	----	781,387	21	1,544,164	35
Korea, Republic of	4,656	118	4,407	102	165,541	4	1,031,109	30
Lebanon	104	2	----	----	396,687	15	305,200	7
Malaya, Federation of	----	----	----	----	9,000	1	4,500	1
Pakistan	4,101	104	3,055	61	72,507	3	148,830	6
Philippines	1,114	28	627	14	1,131,513	38	877,915	32
Saudi Arabia	1,032	34	1,419	55	1,488,605	26	592,797	10
Taiwan	2,387	51	----	----	----	----	----	----
Turkey	----	----	----	----	669,978	16	205,975	15
Other	12	(1)	5,376	100	239,756	10	378,165	9
Total	255,351	6,080	320,952	6,842	11,190,546	398	11,235,698	352
Africa:								
Congo, Republic of the, and Ruanda-Urundi	----	----	----	----	421,514	10	42,000	1
South Africa, Republic of	44,010	966	3,632	86	1,546,240	91	1,258,500	58
Tunisia	----	----	29,250	554	----	----	----	----
United Arab Republic (Egypt)	83	2	----	----	21,800	3	----	----
Other	8,878	191	5,428	103	120,761	8	41,800	2
Total	52,971	1,159	38,310	743	2,110,315	112	1,342,300	61
Oceania:								
Australia	124,266	2,700	129,562	2,545	351,993	42	378,538	48
New Zealand	72,944	1,670	95,983	1,941	233,900	25	298,077	26
Total	197,210	4,370	225,545	4,486	585,893	67	676,615	74
Grand total	1,537,419	35,496	1,603,438	33,531	37,109,543	1,799	20,605,836	1,057

[1] Less than $1,000.

Source: Bureau of the Census.

WORLD REVIEW [8]

The supply of and demand for sulfur were in near balance for the first time in several years. Markets were found for most of the new production resulting from the rapid growth of the Canadian and

[8] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

TABLE 15.—U.S. imports for consumption of pyrites containing more than 25 percent sulfur, by customs districts

(Long tons)

Customs district	1954–58 (average)	1959	1960	1961	1962	1963
Buffalo	304,293	230,606	244,103	249,230	262,580	172,893
Chicago				52		
Connecticut	4	262				154
Maine and New Hampshire						133
Massachusetts					1	
Michigan	17,630	13,182	11,870	12,583	16,379	18,928
Montana and Idaho			37	14		
New York	43					
Pittsburgh	299					
Rochester	41				1	
St. Lawrence	7,899	14,640	21,338			
San Francisco					104	
Vermont	9,676	21,948	28,868	19,725	22,834	2,063
Washington	43					
Total:						
Long tons	339,928	280,638	306,216	281,604	301,899	194,171
Value	$1,197,505	$868,495	$1,075,271	$741,942	$746,644	$487,663

Source: Bureau of the Census.

French recovered sulfur industries and the Mexican Frasch industry. The period since 1950 has been one of sulfur shortage (1950–56), near balance (1957–59), oversupply (1960–62), and near balance (1963). Delivery of sulfur in molten form grew rapidly from 1959, when it began, to 85 percent in 1963. This form of delivery has received approval overseas and new ocean-going molten sulfur tankers and storage facilities were being built for United States, Mexican, and French producers. No new major producing facilities were completed in 1963.

The largest molten sulfur tanker in the world, the 26,400-ton *Naess Texas*, was launched at Haverton Hill, England. Construction was by the Furness Shipbuilding Co., Ltd., for Sulphur Carriers, Ltd. The Vessel, chartered by Sulphur Export Corp. (Sulexco) of the United States, was to be operated by Naess-Denholm Co., Ltd. The tanker, the first for transatlantic shipping of molten sulfur, was 620 feet long, 85 feet wide, and had a draft of 32.5 feet when loaded with 25,000 long tons of sulfur. A 13,800 horsepower engine provided a speed of 16 knots. Waste heat from the engine, transmitted through steam coils, was to keep the sulfur molten at 260° F in four tanks. A sister ship, the *Naess Louisiana* under construction at the Furness shipyard, was to be chartered to Sulexco when completed in late 1964.

NORTH AMERICA

Canada.—Production of sulfur in all forms, measured by shipments, was 1,533,000 long tons in 1963–415,000 tons or 37 percent more than the 1,118,000 tons in 1962. Of this total, 1,037,000 tons was elemental, 278,000 tons was sulfur in smelter gases, and 218,000 tons was sulfur contained in pyrites.

Production of recovered sulfur in Alberta was 1,228,000 tons in 1963.[9] Production of recovered sulfur in British Columbia was 53,900 tons in 1963.[10]

[9] Oil & Gas Conservation Board (Calgary, Alberta, Canada). Alberta Oil & Gas Industry, Annual Statistics. 1963, pp. 99–100.
[10] Department of Mines and Petroleum Resources (Victoria, British Columbia, Canada). Oil and Gas Production Report, December 1963.

TABLE 16.—World production of elemental sulfur by countries [1] [2]

(Long tons)

Country	1959	1960	1961	1962	1963
Native sulfur:					
Frasch:					
Mexico	1,293,181	1,261,574	1,148,494	1,350,375	1,456,656
United States	4,553,634	4,942,935	5,385,468	4,984,578	4,881,512
Total	5,846,815	6,204,509	6,533,962	6,334,953	6,338,168
From sulfur ores:					
Argentina	25,207	39,265	22,183	22,303	[3] 22,300
Bolivia (exports)	------	1,175	4,896	7,247	9,793
Canary Islands	2,900	3,900	4,900	5,900	[3] 5,900
Chile	21,676	30,900	43,994	54,132	57,000
China [3]	100,000	120,000	120,000	120,000	120,000
Colombia	8,824	8,899	9,941	10,046	[3] 10,000
Italy	116,252	79,703	68,668	53,068	41,128
Japan [4]	215,669	243,684	238,456	220,438	217,998
Mexico	[3] 17,700	[3] 17,700	25,116	26,751	28,968
Philippines	------	43	158	926	47
Poland	10,500	25,000	227,000	337,000	303,300
Spain	2,851	1,336	------	------	------
Taiwan	5,533	5,725	5,472	7,462	7,144
Turkey	13,174	16,830	15,506	18,247	19,123
U.S.S.R.[3]	600,000	800,000	900,000	950,000	950,000
United Arab Republic (Egypt)	1,200	3,500	9,000	[3] 6,000	4,675
United States	86,182	94,357	92,025	40,840	415
Total [3] [5]	1,230,000	1,490,000	1,790,000	1,880,000	1,800,000
Total native sulfur	7,075,000	7,700,000	8,320,000	8,220,000	8,140,000
Other elemental:					
Recovered:					
Bulgaria [6]	4,000	5,000	5,000	6,000	[3] 6,000
Canada (sales)[7]	130,050	244,963	352,466	620,623	1,037,190
China [3] [6]	100,000	120,000	120,000	120,000	120,000
Finland	------	------	------	------	50,000
France [8]	419,273	778,157	1,080,013	1,326,000	1,396,000
Germany:					
East	106,153	100,130	115,000	118,000	[3] 118,000
West	78,474	82,807	82,861	90,666	[3] 85,000
Iran [3] [9]	19,000	20,000	20,000	15,000	20,000
Italy [3]	4,000	3,200	2,000	2,000	2,000
Japan [9]	7,829	8,326	8,163	8,549	11,429
Mexico [8]	45,054	33,487	51,086	46,545	43,308
Netherlands [6]	30,700	30,000	38,000	28,000	33,000
Netherlands Antilles: Aruba and Curacao [3]	30,000	40,000	40,000	40,000	30,000
Norway [6]	77,111	71,256	61,156	45,175	------
Portugal [6]	15,888	10,915	8,813	6,637	3,000
South Africa, Republic of [9]	------	------	2,163	1,913	1,981
Spain [6]	25,719	40,194	48,323	41,836	27,519
Sweden [10]	37,576	38,900	30,500	[3] 30,000	25,000
Taiwan [9]	810	875	1,968	2,130	2,310
Trinidad [3] [9]	5,000	5,000	5,000	5,000	7,000
U.S.S.R.[3]	180,000	210,000	275,000	370,000	400,000
United Arab Republic (Egypt)	2,403	2,345	2,545	2,039	[3] 3,000
United Kingdom [11]	53,173	62,402	58,405	51,900	45,000
United States	686,407	766,566	858,169	899,598	946,753
Total other elemental	2,060,000	2,675,000	3,270,000	3,880,000	4,415,000
World total (estimate)[2]	9,135,000	10,375,000	11,590,000	12,100,000	12,560,000

[1] This table incorporates some revisions.
[2] Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Includes sulfur from mixed sulfur-sulfide ore.
[5] In some years Iran produces mine sulfur equivalent to 250–1,500 tons of sulfur. No estimates in total.
[6] From sulfide ore.
[7] Produced from natural gas, includes a small quantity derived from treatment of nickel-sulfide matter at Port Colborne, Ontario.
[8] From natural gas.
[9] From refinery gases.
[10] From shale oil.
[11] Including sulfur recovered from petroleum refineries.

Sales of much of the sulfur produced depended on exports, and these grew rapidly. Exports of 733,000 tons valued at Can$12 million, were received by: United States, 65 percent; U.S.S.R., 7 percent; Taiwan, 7 percent; Australia, 5 percent; India, 4 percent; Republic of South Africa, 4 percent; United Kingdom, 2 percent; Japan, 2 percent; and six other countries, 4 percent.[11]

The Province of Alberta pushed export sales of sulfur to reduce a stockpile of 839,000 tones. Increasing stockpiles were expected to deter natural gas exploration in Western Canada.

In the first half of 1963, sales were 78 percent of production, compared with 59 percent in 1962, 70 percent in 1961, and 60 percent in 1960, according to the Alberta Oil & Gas Conservation Board.[12]

Sulfur would be one of several mined commodities to be pumped through a 740-mile pipeline from Alberta to Vancouver if permission could be obtained. Two and one-half million tons of sulfur were included in the anticipated annual throughput for the 20-inch pipe. Sulfur could be either molten or solid. Water would be the carrier for solids, not oil, and spur lines would feed the main line.[13]

Mexico.—Production of sulfur in all forms totaled 1,528,500 long tons, 8 percent more than the 1,414,000 tons produced in 1962. Production was 1,456,200 tons from two Frasch mines, 43,300 tons from refineries, and 29,000 tons from volcanic sulfur mines. Stocks held by producing companies totaled 517,300 tons.[14]

Pan American Sulphur Co. (PASCO), third largest Frasch sulfur producer in the world, established new company records in 1963 for production, tonnage sold, value of sales, and sales in liquid form. Production was 1,121,000 long tons compared with 983,000 tons for 1962. Sales of 1,175,395 tons were valued at $26,777,063 or $22.78 per ton. PASCO began expansion of hot water facilities to increase production capacity from 1.5 to 2.0 million or more tons per year. Increased capacity was not expected to be used immediately but was to increase operating efficiency and reduce costs. Additional ore was located by drilling. A long-term charter for a new liquid sulfur carrier of about 20,000 ton capacity was negotiated. Liquid sulfur deliveries to Europe to start in 1965 were to be made after terminals were built and the carrier became available late in 1964.[15]

Gulf Sulphur Corp. produced 345,000 long tons of sulfur, a 6 percent decrease from 1962. Gross sales of $8,022,538 for 359,000 tons averaged $22.35 per ton. More than 53 percent of sales were shipped through company terminals at Tampa, Fla., and Baltimore, Md. Shipments were by chartered carrier. A 12,000-ton liquid sulfur storage tank was under construction at Tampa, Fla. Bulk shipments weighed 148,000 tons. Plant capacity was to be increased 25 percent by two boilers to be added in 1964.[16]

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[11] Dominion Bureau of Statistics, External Trade Division (Ottawa, Canada). Exports by Commodities. Catalogue No. 26-202, Annual, December 1963.
[12] Oil, Paint and Drug Reporter. Sulfur Price Outlook Brighter: Trade Views Turn Optimistic As Canada Trims Output Goals. V. 184, No. 12, Sept. 16, 1963, pp. 7, 35.
[13] Chemical Engineering., Chementator., Multipurpose Pipeline is Planned. V. 70, No. 22, Oct. 28, 1963, p. 74.
[14] Bureau of Mines. Mineral Trade Notes. V. 58, No. 6, June 1964, p. 33.
[15] Pan American Sulphur Company. Annual Report, 1963. pp. 2–5.
[16] Gulf Sulphur Corporation. Annual Report, 1963. 12 pp.

TABLE 17.—World production of pyrites (including cupreous pyrites) [1] [2]

(Thousand long tons)

Country [1]	1954–58 (average) Gross weight	1959		1960		1961		1962		1963	
		Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
North America:											
Canada (sales)	887	982	416	922	391	462	223	462	236	439	218
Cuba [3]	76	20	9	18	8	20	9	26	12	33	15
United States	1,005	1,057	437	1,016	416	987	399	916	379	825	344
South America: Venezuela	[4] 18	4	1	------	------	------	------	------	------	------	------
Europe:											
Bulgaria	69	113	47	117	49	120	50	140	59	128	54
Czechoslovakia	340	365	[3] 144	384	148	363	141	395	155	[3] 395	[3] 155
Finland	275	259	109	256	108	270	114	468	215	529	248
France	354	290	121	273	117	281	118	299	126	247	106
Germany:											
East	145	[3] 141	49	[3] 132	46	[3] 115	40	[3] 118	41	[3] 118	[3] 41
West	585	462	189	529	210	524	221	404	173	[3] 384	[3] 168
Greece	213	127	57	161	74	185	86	142	65	[3] 148	[3] 66
Italy	1,363	1,496	682	1,523	694	1,555	708	1,560	711	1,377	628
Norway	813	732	320	820	356	722	319	780	320	700	[3] 280
Poland	171	217	79	223	83	198	76	219	82	[3] 219	[3] 82
Portugal	654	622	286	645	297	643	296	631	290	595	274
Rumania	185	231	92	263	105	259	103	300	120	[3] 300	[3] 120
Spain	2,130	2,086	961	2,217	1,058	2,097	1,001	2,095	997	1,973	[3] 947
Sweden	418	341	168	406	203	431	220	370	189	[3] 369	[3] 187
U.S.S.R.[3]	1,968	2,559	1,358	2,756	1,457	2,756	1,457	2,953	1,565	3,149	1,673
United Kingdom	5	1	(5)	(5)	(5)	(5)	(5)	27	[3] 11	26	[3] 10
Yugoslavia	254	285	114	410	164	358	143	407	163	350	140
Asia:											
China [3]	(6)	837	374	984	443	984	443	1,083	492	1,181	531
Cyprus [7]	989	870	418	914	439	824	396	809	388	[3] 886	[3] 394
Japan [8]	3,001	3,336	1,396	3,634	1,517	3,869	1,624	3,952	1,664	[3] 3,937	[3] 1,575
Korea, North [3]	(6)	197	79	246	98	295	118	344	138	394	157
Philippines	14	25	[3] 11	25	[3] 11	51	[3] 22	8	[3] 3	57	27
Taiwan	29	33	13	42	16	47	20	45	20	46	17
Turkey	40	87	42	42	20	97	46	105	51	96	44
Africa:											
Algeria	21	29	13	38	17	48	22	42	19	37	17
Morocco	6	14	5	13	5	14	5	20	7	23	7
Rhodesia and Nyasalands, Federation of: Southern Rhodesia	31	40	17	49	19	58	23	50	19	65	[3] 27
South Africa, Republic of	378	495	195	492	212	440	176	434	[3] 174	412	[3] 165
Oceania: Australia	212	223	107	239	115	213	102	149	65	[3] 218	[3] 100
World total (estimate) [1] [2]	17,100	18,600	7,800	19,800	8,300	19,300	8,100	19,800	8,300	19,700	8,300

[1] Brazil produces pyrites, but production data are not available; no estimate is included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Estimate.
[4] Average annual production 1956–58.
[5] Less than 500 tons.
[6] Data not available; estimate included in total.
[7] Tons of ore mined containing pyrites in thousand long tons: 1954–58 average, 1,469; 1959, 1,237; 1960, 1,810; 1961, 1,836; 1962, 1,829.
[8] Years 1959–62 include pyrrhotite, cupreous pyrites, sulfur ore, and zinc concentrates. Pyrites data covering pyrites, cupreous pyrites, and pyrrhotite only are as follows: (In thousand long tons) 1959, 2,127; 1960, 2,656; 1961, 2,855; 1962, 2,977; and 1963, 2,509—includes pyrites and pyrrhotite only.

TABLE 18.—Sulfur recovery plants in Western Canada, 1963

Company	Location	Approximate H_2S, percent	Capacity, long tons Daily	Capacity, long tons Annual
British American Oil Co., Ltd	Pincher Creek, Alberta	10	674	236,000
Do	Nevis, Alberta	6	76	27,000
Do	Homeglen-Rimbey, Alberta	4-8	250	87,500
British American Oil Co., Ltd.[1]	Turner Valley, Alberta	4	29	10,300
Canadian Fina, Ltd.[2]	Wildcat Hills, Alberta	4	105	37,000
Home Oil Co., Ltd	Carstairs, Alberta	1	50	17,500
Imperial Oil Ltd	Redwater, Alberta	3	9	3,125
Jefferson Lake Petrochemicals of Canada, Ltd.	Taylor Flats, British Columbia	3	295	103,000
Do	Coleman, Alberta	14	375	131,000
Petrogas Processing, Ltd	Calgary, Alberta	16	862	301,000
Shell Canada, Ltd.[3]	Innisfail, Alberta	14	98	34,000
Shell Oil Company of Canada, Ltd	Waterton, Alberta	22	1,384	484,400
Do	Jumping Pound, Alberta	3	98	34,000
Standard Oil Co. of California and others.	Nevis, Alberta	6	116	40,200
Steelman Gas, Ltd	Steelman, Saskatchewan	1	6	2,143
Texas Gulf Sulphur Co	Windfall, Alberta	15-20	[4] 652	228,000
Texas Gulf Sulphur Co. and others	Okotoks, Alberta	35	371	129,000
Total			5,450	1,906,000

[1] Formerly Royalite Oil Co., Ltd.
[2] Formerly Western Lease Holds, Ltd.
[3] Formerly Canadian Oil Companies, Ltd.
[4] Eventual capacity—1,607 long tons per day or 560,000 long tons per year.

TABLE 19.—Mexico: Exports of sulfur by countries

(Long tons)

Destination	1962	1963	Destination	1962	1963
North America:			Europe—Continued		
Canada	14,803	25,198	Spain	1,999	
El Salvador		3,445	United Kingdom	89,492	130,531
Jamaica	299		Asia:		
Nicaragua	4,179		Israel	59,916	11,505
United States	735,550	821,477	Thailand		1,000
South America:			Africa:		
Brazil	15,831	12,135	South Africa, Republic of	70,901	74,933
Colombia	1,851		Tunisia	30,073	
Venezuela		4,921	Oceania:		
Europe:			Australia	52,452	88,543
Belgium	30,508	32,730	New Caledonia	5,250	
France	57,963	56,536	New Zealand	35,546	44,116
Germany, West	7,082				
Netherlands	118,361	127,365	Total	1,332,056	1,434,435

Source: Compiled from U.S. Embassy, Mexico, D.F., Mexico, State Department Airgram 1243, Mar. 29, 1963, p. 2; and Airgram 1135, Apr. 2, 1964, p. 2.

SOUTH AMERICA

Chile.—Most of the sulfur produced in Chile came from volcanic depostis situated more than 12,000 feet in elevation in the El Loa and Arica Departments of Antofagasta and Tarapacá Provinces, respectively. Production rose in 1962—despite problems of cost, mining, and transportation. The major producer, Sociedad Azufrera Aucanquilcha, S.A., produced 32,852 long tons of refined sulfur from deposits associated with the Aucanquilcha volcano in Antofagasta Province. Other producers in order of size were Compañía Azufrera Nacional, with deposits at the Tacora volcano near the Peruvian border in Tarapacá Province, and Sociedad Azufrera Borlando y Cia., with deposits at the Ollague volcano in Antofagasta Province.[17]

[17] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, pp. 30-31.

EUROPE

France.—Port authorities at Bayonne, prepared to deepen the harbor so that special liquid sulfur tankers could transport sulfur from Lacq. The French Government was to pay one-third of the cost.[18] Competition from liquid U.S. sulfur, handled by Sulexco, was an important factor in this development. Port of Bayonne was to handle 12,000-ton, liquid-sulfur tankers. The Dutch firm, N. V. Frans Swarttouw's Havenbedrijf of Rotterdam has formed Nederlands Zwavel-Overslagbedrijf to erect sulfur unloading facilities at Botlek Port, Holland.[19]

Italy.—The Liaison and Action Committee of the Italian Sulphur Industry submitted its report to the European Economic Community (EEC) Commission and Council and the European Bank. Production of 750,000 tons of sulfur ore per year was expected when outside competition was permitted.[20]

Poland.—Sulfur production from native sulfur ores at the Tarnobrzeg chemical combine was expected to grow rapidly from about 195,000 tons in 1963 to 400,000 tons in 1965. Long-range plans called for 700,000 tons by 1970, 1 million tons by 1975, and more than 1.5 million tons by 1980. A second sulfur recovery unit, to be completed late in 1964, would provide the planned capacity in 1965 of 400,000 tons per year. Most of the sulfur ore for the combine came from the Piaseczno mine where production of 1.7 million tons per year was to increase to 3 million tons per year by 1965. A second sulfur ore mine at Machow was to be developed and was ultimately to produce 8 million tons of ore, equivalent to 1.5 million tons sulfur, per year.[21]

United Kingdom.—The Société Nationale de Pétrolés d'Aquitaine (SNPA) was awarded a contract to supply 250,000 to 300,000 tons of French Lacq sulfur to the United Kingdom in 1964. The Pan American Sulphur Co. was expected to supply 100,000 tons during the same period. The total United Kingdom demand was about 450,000 tons per year. Both SNPA and Pan American Sulphur Co. planned to construct liquid terminals at Immingham. The Sulphur Export Corp. (Sulexco), representing the four U.S. producers, cancelled plans for an Immingham terminal.[22]

ASIA

Cyprus.—The Income Tax Law of 1961 (Foreign Persons), which granted greater concessions, stimulated prospecting for iron pyrites in 1962.[23]

India.—Sulfur imports continued to supply requirements. Imports of 246,600 long tons in 1962 were up 29 percent from 191,000 tons in 1961. Eighty percent of the sulfur was consumed in 50 sulfuric

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[18] European Chemical News (London). Bayonne Gets Ready for Liquid Sulphur. V. 4, No. 78, July 12, 1963, p. 5.

[19] Chemical Age (London). France to Export Liquid Sulphur Through Bayonne. V. 90, No. 2301, Aug. 17, 1963, p. 234.

[20] European Chemical News (London). Italian Sulphur Report Ready. V. 4, No. 98, Nov. 29, 1963, p. 8.

[21] Chemical Age (London). V. 89, No. 2292, June 15, 1963, p. 881.

[22] Oil, Paint and Drug Reporter. Sulfur: French Pick Up a Huge Contract in the UK. V. 184, No. 17, Oct. 21, 1963, p. 61.

[23] Mining Journal (London). The Mining Industry of Cyprus. V. 261, No. 6686, Oct. 11, 1963, pp. 335–336.

acid plants of 450,000-tons-per-year capacity. The Indian Bureau of Mines revealed that iron pyrite deposits at Amjore, Bihar, contained about 400 million tons of ore, averaging 40 percent sulfur. The Government-owned Pyrites & Chemicals Development Co., founded in 1960 to exploit the deposits, had reported no progress in negotiations with foreign firms for technical help.[24]

Sulfur consumption was expected to grow to 535,000 tons in 1965.[25]

Iraq.—The Government of Iraq invited tenders for the construction of a recovered sulfur plant near Kirkuk, having a 100,000-ton-per-year capacity. Eighty million cubic feet of sour natural gas per day, containing 13 percent sulfur, was to be used to supply the plant. The sweet gas was to be piped to Baghdad.[26]

Japan.—Canadian sulfur shipments to Japan, totaling 22,600 tons, were the first to enter Japan from any foreign source for many years. The shipments were allowed by the Japanese Ministry of International Trade and Industry to offset expected production shortages. Japanese domestic production costing about twice that of the imports has been protected by a complete ban on imports of sulfur. Cost of the sulfur shipped was about $18 per ton f.o.b. Vancouver, British Columbia, the same as for domestic sales.[27]

In an attempt to become self-sufficient in sulfur, the Japanese Government has appointed a Sulfur Commission under the chairmanship of Prof. R. Kiyoura of the Tokyo Institute of Technology. The Commission will advise the Government on how to increase production and use of domestic sulfur and pyrites so that imports will eventually cease.[28]

Taiwan.—Demand for sulfur and pyrites was expected to exceed supply in 1963, despite completion of a new beneficiation plant. Construction of another beneficiation plant was under discussion. Late in 1963 the Central Trust of China announced invitations to bid on the supply of 40,000 tons of imported sulfur for the Kaohsiung Ammonium Sulphate Corp. and 15,000 tons for the Taiwan Fertilizer Co. (TFC). TFC was to import a sulfur-burning unit from Japan and to add a pyrite roaster as part of a new ammonium sulfate plant in the Miaoli area. The plant was to begin operation in the spring of 1964. Sulfur imports were valued at $454,880 for 1962.

OCEANIA

Australia.—Some refineries, now operating, recover sulfur. Two sulfur plants, each of 14,000-tons-per-year capacity, are part of the Altona petrochemical complex with headquarters in Melbourne. One of these units is part of a refinery started in 1955, and the second was to become part of a refinery started in 1963.

Imports of 75,000 tons of sulfur from Canada were to be delivered by the Canadian Sulphur Export Corp. (Cansulex) during a 1-year period.[29]

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[24] Bureau of Mines. Mineral Trade Notes. V. 57, No. 6, December 1963, pp. 40–41.
[25] European Chemical News (London). V. 3, No. 54, Jan. 25, 1963, p. 5.
[26] Chemical Trade Journal and Chemical Engineer (London). Sulphur Plant Tenders Invited. V. 153, No. 3989, Nov. 22, 1963, p. 794.
[27] Chemical Age (London). Japan Sulphur Import Ban Lifted for Canadian Supplies. V. 90, No. 2297 July 20, 1963, p. 98.
[28] Chemical Trade Journal and Chemical Engineer (London). Sulphur Independence Sought. V. 153, No. 3977, Aug. 30, 1963, p. 311.
[29] Bureau of Mines. Mineral Trade Notes. V. 57, No. 4, October 1963, p. 51.

TECHNOLOGY

Elemental sulfur deposits in the Kara Kum sulfur hills of the U.S.S.R. were shown to be produced initially by a process of microbiological reduction of sulfates. The important role of *T. thiooxidans* in the oxidation of sulfur to sulfuric acid was established. The oxidation processes were particularly vigorous in the lower, moistened parts of the hills where the number of *T. thiooxidans* reached 10,000 to 100,000 cells per gram of ore. Sulfuric acid decomposition of the bedrock caused migration of aluminum and iron to a neutral pH location.[30]

A special type of bacteria have been shown to be responsible for the destruction of sulfur deposits in the Kurile Islands. Near 30° C the bacteria rapidly convert sulfur into sulfuric acid. The new concept replaces one in which chemical reactions connected to volcanic activity were thought responsible for the conversion. The bacteria probably are involved in the secondary formation of metal deposits. Absence of life in two lakes on Kunashir Island may be due to presence of sulfuric acid borne in by streams.[31]

Scientists of the British Columbia Research Council performed tests during the last 8 years in which bacteria were used to decompose sulfide ores and bring metals into solution. These tests were successful when used with iron sulfide.[32]

A patent was issued for a process in which finely divided native ore in a fluidized bed was heated by an inert gas to volatilize the sulfur.[33]

Elemental sulfur was produced by passing hydrogen sulfide-containing gas through a solution of a nitrogen dioxide complex consisting of nitrogen dioxide and another compound other than water. The hydrogen sulfide was oxidized to elemental sulfur and water with nitric oxide as a byproduct. Precipitated sulfur was recovered.[34]

A small, completely automatic plant at Sinclair Oil and Gas Co., Tatum, N. Mex., which removed sulfur from weak acid gas, was believed to be the smallest system of its type in existence. The plant used a process developed by the Pan American Petroleum Corp., Tulsa, Okla., to recover 4 tons per day of sulfur. The plant, designed and built by Austin Rankin Corp., Houston, Tex., was shipped completely assembled on a single 12 by 23 foot skid.[35]

The grade of insoluble sulfur was increased from 85 to 90 percent insoluble. The insoluble form was especially important as a curing agent for rubber. Advantages over the normal form of sulfur for this purpose included reduction in staining of the surface of the rubber article. This helped the production of whitewall tires, light colored floor tiles, and shoe stocks.[36]

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30 Karavaiko, G. I., M. V. Ivanov, and L. B. Pomerants. (Microbiological Investigations of a Kara Kum Sulfur Deposit.) Akad. Nauk SSSR, Izvestiya, Ser. Biologicheskaya, v. 28, No. 2, 1963, pp. 249–260 abs. in Tech. Transl., U.S. Dept. of Commerce, OTS, V. 10, No. 6, Sept. 30, 1963, p. 655.

31 Mining Journal (London). Bacteria Destroy Sulphur. V. 261, No. 6695, Dec. 13, 1963, p. 567.

32 Canadian Mining Journal (Quebec, Canada). Bacterial Mining. V. 84, No. 8, August 1963, p. 50.

33 Eads, David K., and Harry W. Haines, Jr. (assigned to Texas Gulf Sulphur Co., New York). Recovery of Sulfur from Native Ores. U.S. Pat. 3,102,792, Sept. 3, 1963.

34 Fierce, William L., and Roger L. Weichman (assigned to the Pure Oil Co., Chicago, Ill.). Preparation of Elemental Sulfur from Hydrogen Sulfide. U.S. Pat. 3,095,275, June 25, 1963.

35 Chemical Engineering. Plant Recovers Sulfur from Lean Acid Gas. V. 70, No. 7, Apr. 1, 1963, pp. 38, 40.

36 Oil, Paint and Drug Reporter. Stauffer Boosts Content of Insolubles in Sulfur. V. 183, No. 5, Feb. 4, 1963, p. 30.

Pyrites ore with a high content of other metal compounds was selectively roasted in a fluidization process. By closely controlling temperature and feed-air ratio certain constituents were made soluble in leach liquor, while the others remained insoluble. The following reactions occurred: FeS_2 or $FeS_{1.18}$ or mixtures of the two became Fe_3O_4 and SO_2; Cu_2S became $CuSO_4$ and CuO; FeAsS became As_2O_3, Fe_3O_4, and SO_2; PbS became PbO and SO_2; ZnS became ZnO and SO_2. Theoretical quantities of oxygen produced partial oxidation, and an excess of 5 to 10 percent was needed. Two-stage roasting offered another alternative.[37]

Sulfur could be kept molten in pipes by means of an induction heating coil, which used less current than required by conventional resistance heaters. The heating unit remained at a relatively low temperature and was expected to have an extremely long life.[38]

A report on a study of explosion dangers of molten sulfur storage undertaken by the Bureau of Mines in cooperation with the Texas Gulf Sulphur Co. was published. Hydrocarbon impurities present in some sulfur combined with the molten sulfur to form vapors of hydrogen sulfide and carbon disulfide. Both gases could be ignited in air; carbon disulfide, by contact with steam pipes in storage tanks.[39]

Metal sulfides acting as lubricants on molybdenum surfaces increased bearing life several hundred percent in tests conducted at the Naval Air Engineering Center, Philadelphia, Pa. Reservoirs in the sliding parts held the lubricants. Failure occurred at sliding contacts after the solid film lubricant was depleted.[40]

The Appellate Division of Superior Court, climaxing legal procedure that began in 1957, ruled that a New York firm be awarded $300,000 damages resulting from sulfur dust damage to structural steel in an adjacent storage yard at Port Newark, N.J.[41]

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[37] Pattison, J. R., and D. W. Beeken. Ore Reduction in Gas Stream and Fluidised Roasting of Pyrites. Min. J. (London), v. 260, No. 6662, Apr. 26, 1963, pp. 391–392.
[38] Chemical Engineering. V. 70, No. 3, Feb. 4, 1963, p. 64.
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Talc, Soapstone, and Pyrophyllite

By James D. Cooper [1]

DOMESTIC production of talc, soapstone, and pyrophyllite in 1963 was 5 percent greater in quantity and 4 percent greater in value than in 1962. Sales of talc increased 2 percent in quantity and 3 percent in value in 1963.

World production of talc, soapstone, and pyrophyllite increased by about 5 percent, establishing a record high of more than 3 million short tons.

TABLE 1.—Salient talc, soapstone, and pyrophyllite statistics

(Thousand short tons and thousand dollars)

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Mine production	697	792	734	762	772	804
Value	$4,477	$5,641	$5,378	$5,277	$5,278	$5,505
Sold by producers	688	782	722	727	777	794
Value	$14,300	$17,068	$16,073	$16,022	$17,882	$18,420
Imports for consumption	23	25	24	27	26	26
Value	$780	$861	$849	$1,055	$1,069	$1,088
Exports [1]	40	59	60	48	47	57
Value [1]	$1,123	$1,707	$1,893	$1,805	$2,230	$2,778
World: Production	2,020	2,580	2,770	2,990	2,990	3,150

[1] Excludes powders—talcum (in package), face, and compact.

DOMESTIC PRODUCTION

Production of talc, soapstone, and pyrophyllite in the United States exceeded 800,000 tons for the first time. Sales were also at a record high. The leading producing States were New York, California, and North Carolina. Talc and soapstone were produced from 65 mines in 13 States. Pyrophyllite was produced from 11 mines in 3 States. North Carolina led in production of pyrophyllite, followed by Pennsylvania (sericite schist) and California.

Western Talc Co., of Los Angeles was purchased by R. T. Vanderbilt Co., Inc., of New York City, in November 1963. Vanderbilt also owns Gouverneur Talc Co., Inc., Gouverneur, N.Y.

[1] Commodity specialist, Division of Minerals.

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TABLE 2.—Crude talc, soapstone, and pyrophyllite produced in the United States, by States

State	1962		1963	
	Short tons	Value	Short tons	Value
California	117,912	$1,339	120,452	$1,427
Georgia	45,940	96	42,000	93
Nevada	6,157	55	4,243	50
North Carolina	100,298	433	106,652	446
Texas	73,635	387	72,658	368
Virginia	(1)	(1)	3,696	9
Washington	2,835	11	2,969	18
Other States [2]	424,951	2,957	451,688	3,094
Total	771,728	5,278	804,358	5,505

[1] Included with "Other States" to avoid disclosing individual company confidential data.
[2] Includes States indicated by footnote 2 and Alabama, Arkansas, Maryland, Montana, New York, Pennsylvania, and Vermont.

TABLE 3.—Talc, soapstone, and pyrophyllite sold by producers in the United States, by classes

Year	Crude			Sawed and manufactured		
	Short tons	Value at shipping point		Short tons	Value at shipping point	
		Total	Average per ton		Total	Average per ton
1954-58 (average)	45,368	$295,232	$6.51	1,078	$410,028	$380.36
1959	64,856	349,484	5.39	710	416,144	586.12
1960	44,477	240,077	5.40	860	410,194	476.97
1961	65,705	344,660	5.25	695	407,000	585.61
1962	58,699	302,841	5.16	660	416,000	630.30
1963	63,924	310,752	4.86	(1)	(1)	(1)

Year	Ground [2]			Total		
	Short tons	Value at shipping point		Short tons	Value at shipping point	
		Total	Average per ton		Total	Average per ton
1954-58 (average)	641,554	$13,595,170	$21.19	688,000	$14,300,430	$20.79
1959	716,837	16,302,657	22.74	782,403	17,068,285	21.80
1960	676,344	15,423,193	22.80	721,681	16,073,464	22.27
1961	661,053	15,270,294	23.10	727,453	16,021,954	22.02
1962	717,559	17,162,912	23.92	776,918	17,881,753	23.02
1963	[1] 730,087	[1] 18,109,581	[1] 24.80	794,011	18,420,333	23.20

[1] Included with "Ground" to avoid disclosing individual company confidential data.
[2] Includes some crushed material.

CONSUMPTION AND USES

Consumption of talc, soapstone, and pyrophyllite increased about 2 percent in 1963. The ceramic industry accounted for approximately 34 percent, the paint industry 17 percent, and the insecticide industry 8 percent of total talc and pyrophyllite consumption. The largest increases were for ceramics, rubber, and paint, more than offsetting a significant decrease in the use of talc and pyrophyllite in insecticides.

TABLE 4.—Pyrophyllite[1] produced and sold by producers in the United States

Year	Production (short tons)	Sales					
		Crude		Ground		Total	
		Short tons	Value	Short tons	Value	Short tons	Value
1954–58 (average)	153,786	18,168	$105,722	[2] 129,886	$1,854,082	148,054	$1,959,804
1959	151,175	31,615	186,090	123,236	1,936,397	154,851	2,122,487
1960	124,631	9,849	57,269	122,508	1,792,387	132,357	1,849,656
1961	157,421	14,544	86,314	115,163	1,712,502	129,707	1,798,816
1962	125,247	(3)	(3)	(3)	(3)	133,336	1,779,075
1963	129,018	(3)	(3)	(3)	(3)	132,719	1,664,329

[1] Includes sericite schist.
[2] Includes a small quantity of sawed material for 1955 only.
[3] Included with "Total" to avoid disclosing individual company confidential data.

TABLE 5.—Talc, soapstone, and pyrophyllite sold or used by producers in the United States, by uses

(Short tons)

Use	Talc and soapstone		Pyrophyllite	
	1962	1963	1962	1963
Ceramics	223,849	236,893	31,706	34,294
Foundry facings	4,116	4,391		
Insecticides	48,045	39,826	31,297	25,408
Paint	125,133	130,596	3,280	(1)
Paper	26,239	29,159		
Rice polishing	2,064	1,847		
Roofing	55,504	52,639	(1)	(1)
Rubber	25,466	31,032	(1)	(1)
Textile	8,447	8,341		
Toilet preparations	9,671	10,504		
Other	[2] 115,048	[2] 116,064	[3] 67,053	[3] 73,017
Total	643,582	661,292	133,336	132,719

[1] Included with "Other" to avoid disclosing individual company confidential data.
[2] Includes adhesive, asphalt filler, composition floor and wall tile, crayons, exports, fertilizer, grease manufacture, instrument wire and cable, joint cement, refractories, stucco, vault manufacturing, and miscellaneous products.
[3] Includes uses indicated by footnote 1 and asphalt filler, battery boxes, exports, joint cement, plaster products, refractories, stucco, and related products.

PRICES

Price quotations for talc appearing in trade journals were unchanged throughout 1963. The quotations are indicative of the range in talc prices; however, as with many other nonmetallic minerals actual prices are negotiated and depend on quantities purchased and on a wide range of specifications.

TABLE 6.—Prices quoted on ground talc, in bags, carlots, in 1963

(Per short ton)

Grade	1963
Domestic, f.o.b. works:	
Ordinary:	
California	$34.00 to $39.50.
Vermont	$19.40.
Fibrous, New York	$28.00.
325-mesh	$31.00.
400-mesh, micronized	$38.00.
625-mesh, micronized	$80.00.
Imported (Canadian), f.o.b. mines	$20.00 to $35.00.

Source: Oil, Paint and Drug Reporter.

TABLE 7.—Prices quoted on talc, carlots, f.o.b. works, in 1963

(Per short ton)

Grade [1]	1963
Georgia: 98 percent minus 200-mesh:	
Gray, packed in paper bags	$10.50 to $11.00.
White, packed in paper bags	$12.50 to $15.00.
New Jersey: Mineral pulp, ground, bags extra	$10.50 to $12.50.
Vermont:	
100 percent through 200-mesh, extra white, bulk basis [2]	$12.50.
99.5 percent through 200-mesh, medium white, bulk basis [2]	$11.50 to $12.50.
Virginia:	
200-mesh	$10.00 to $12.00.
325-mesh	$12.00 to $14.00.
Crude	$5.50.

[1] Containers included unless otherwise specified.
[2] Packed in paper bags, $1.75 per ton extra.

Source: E&MJ Metal and Mineral Markets.

FOREIGN TRADE

Imports.—Imports of talc in 1963 were slightly less in quantity but slightly higher in total value than those of 1962. Italy was the principal supplier of talc, accounting for 70 percent, followed by France with 19 percent and Canada with 8 percent.

Exports.—Exports of talc and pyrophyllite increased in quantity in 1963 after 2 years of decline. The unit value of talc exports has increased greatly in recent years, reflecting the higher quality materials which have become available.

TABLE 8.—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	Short tons	Value	Short tons	Value	Short tons	Value
1954–58 (average)	117	$18,478	23,376	$727,034	81	$34,401	23,574	[1] $779,913
1959	499	18,453	24,778	807,816	74	34,272	25,351	860,541
1960	74	3,376	23,850	821,054	51	24,416	23,975	848,846
1961	40	4,859	[2] 27,238	[2] 1,012,358	84	37,527	27,362	1,054,744
1962:								
Canada			2,152	45,601			2,152	45,601
France			3,993	92,258			3,993	92,258
India	27	3,536	505	18,286			532	21,822
Italy			18,978	857,341	5	1,875	18,983	859,216
Japan					95	48,702	95	48,702
Mexico			10	200			10	200
Norway			12	1,445			12	1,445
Total	27	3,536	25,650	1,015,131	100	50,577	25,777	1,069,244
1963:								
Canada			2,100	39,055			2,100	39,055
France			4,932	108,302			4,932	108,302
India	16	2,250	632	18,469			648	20,719
Italy	929	45,465	16,737	797,182	228	14,073	17,894	856,720
Japan					105	62,919	105	62,919
Taiwan					2	504	2	504
Total	945	47,715	24,401	963,008	335	77,496	25,681	1,088,219

[1] Data known to be not comparable with other years.
[2] Data adjusted by Bureau of Mines to exclude less than 1 ton ($930) of ground, washed, powdered, or pulverized, valued not over $14 per ton from Hong Kong.

Source: Bureau of the Census.

TABLE 9.—U.S. exports of talc, pyrophyllite, and talcum powders

Year	Talc, steatite, soapstone, and pyrophyllite				Powders—talcum (in packages), face, and compact (value, thousands)
	Crude and ground		Manufactures, n.e.c.[1]		
	Short tons	Value (thousands)	Short tons	Value (thousands)	
1954–58 (average)	39,909	$1,020	193	$103	$1,271
1959	58,751	1,532	197	175	1,276
1960	59,457	1,801	158	92	1,378
1961	47,912	1,721	134	84	1,396
1962	46,939	2,133	122	97	1,286
1963	56,483	2,690	107	88	1,140

[1] Not elsewhere classified.

Source: Bureau of the Census.

WORLD REVIEW

World production exceeded 3 million tons for the first time as a result of increased output in many countries.

Austria.—Talc output in Austria decreased by 13 percent in 1963, the second drop in 2 years following the record high of over 93,000 tons achieved in 1961. Nearly 80 percent of the Austrian material was exported to other European countries.

Brazil.—Equipment from an abandoned gold mining venture has been converted by Minas Talco Ltda. for use in production of talc in the Santa Rita region of Minas Gerais.[2]

TABLE 10.—World production of talc, soapstone, and pyrophyllite by countries [1] [2]
(Short tons)

Country [1]	1954-58 (average)	1959	1960	1961	1962	1963
North America:						
Canada (shipments)	30,952	39,176	41,636	48,116	46,161	54,641
Mexico	[3] 4,174	4,060	4,819	4,616	[4] 4,400	[4] 4,400
United States	697,272	791,558	734,473	762,380	771,728	804,358
Total	732,398	834,794	780,928	815,112	822,289	863,399
South America:						
Argentina	31,361	29,938	[4] 25,000	[4] 25,000	[4] 21,000	[4] 21,000
Brazil	26,861	23,400	21,956	26,209	42,200	[4] 42,200
Colombia	------	------	390	600	720	[4] 720
Paraguay [4]	110	110	110	110	110	110
Peru	2,526	1,694	1,732	3,236	1,896	3,620
Uruguay	1,510	2,335	3,297	1,857	1,890	1,890
Total	62,368	57,477	52,485	57,012	67,816	[4] 69,500
Europe:						
Austria	75,603	56,475	90,695	93,639	83,523	72,360
Finland	7,646	8,261	11,008	6,967	7,088	5,500
France	144,560	193,528	206,997	245,427	231,378	213,800
Germany, West (marketable)	35,553	30,364	32,277	32,696	30,411	[4] 30,000
Greece	1,992	2,277	2,008	2,044	[4] 2,200	[4] 2,800
Italy	108,206	120,436	137,117	145,638	140,171	149,385
Norway	95,463	123,959	113,628	[4] 120,000	142,000	[4] 142,000
Portugal	22	243	750	794	359	[4] 359
Spain	29,465	30,661	30,853	30,498	30,562	[4] 30,000
Sweden	14,275	15,910	17,466	17,306	[4] 17,600	[4] 17,600
U.S.S.R.[4]	([5])	275,000	300,000	330,000	340,000	385,000
United Kingdom	4,652	6,365	7,244	7,761	[4] 7,700	[4] 7,700
Yugoslavia	[6] 731	------	------	------	------	------
Total [1] [4]	660,000	860,000	950,000	1,035,000	1,035,000	1,060,000
Asia:						
China [4]	([5])	165,000	165,000	165,000	165,000	165,000
India	49,504	71,082	102,947	102,370	114,117	130,044
Japan	338,125	535,140	652,953	699,510	649,651	720,195
Korea:						
North [4]	([5])	2,200	4,400	16,500	22,000	22,000
Republic of	15,752	19,272	24,889	50,330	51,235	70,772
Taiwan	6,199	7,079	11,637	13,685	14,781	16,300
Total [4]	540,000	800,000	960,000	1,050,000	1,020,000	1,125,000
Africa:						
Kenya	22	------	------	------	------	------
South Africa, Republic of	2,920	1,412	1,975	3,279	13,921	7,566
Swaziland	[3] 89	1,008	1,714	2,955	3,902	3,052
United Arab Republic (Egypt)	6,138	6,708	6,614	6,565	6,753	5,280
Total	9,169	9,128	10,303	12,799	24,576	15,898
Oceania: Australia	15,573	18,729	18,112	16,613	16,790	[4] 14,300
World total (estimate) [1] [2]	2,020,000	2,580,000	2,770,000	2,990,000	2,990,000	3,150,000

[1] Talc or pyrophyllite is reported in Rumania, but data are not available; estimates are included in total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Average annual production 1957-58.
[4] Estimate.
[5] Data not available; estimate included in total except for North Korea.
[6] Average annual production 1955-58.

[2] Engineering and Mining Journal. V. 164, No. 8, August 1963, p. 176.

TABLE 11.—Austria, France, and Italy: Exports of talc and soapstone by countries [1]

(Short tons)

Destination	Austria 1962	Austria 1963	France 1962	France 1963	Italy 1962	Italy 1963
Algeria			2,201	2,723		
Belgium-Luxembourg	3,698	3,441	5,526	5,301	[2] 5,575	(3)
Denmark	373	351	274	210		
Finland			265	224		
France	1,593	1,949			[2] 4,623	[2] 5,570
Germany:						
East	4,004	4,132				
West	21,915	27,527	11,584	12,563	6,745	5,854
Hungary	1,934	2,443				
Israel	71	91	397	562		
Italy	6,031	9,561	702	735		
Ivory Coast			307	348		
Morocco			1,472	1,497		
Netherlands	1,267	1,738	1,655	1,670	[2] 272	[2] 471
Poland	16,007	810				
Portugal		1	560	699	[2] 212	(3)
Rumania	115	209				
Sweden	71	60	959	978	[2] 142	(3)
Switzerland	3,953	3,657	9,550	10,019	[2] 1,893	[2] 1,467
Tunisia			741	707		
United Kingdom	487	603	7,845	9,611	8,610	7,210
United States			3,926	5,212	19,309	17,305
Vietnam			288			
Other countries	90	327	1,155	1,642	9,500	14,122
Total	61,609	56,900	49,407	54,701	56,881	51,999

[1] This table incorporates some revisions.
[2] From import detail of Trade Returns of the respective country.
[3] Data not available.

South Africa, Republic of.—Wonderstone (pyrophyllite) from Ottosdal, Transvaal, has found increased application as a pressure-transmitting medium for ultra-high-pressure work, including the production of manufactured diamond, and for electrical and chemical uses. The two main deposits contain about 5 million tons of crude rock, and about 200,000 tons has been mined from the area since 1937. Approximately 5 percent of the rock is usable wonderstone. Five Europeans and over 100 Africans were employed.[3]

TABLE 12.—Republic of South Africa: Salient statistics of pyrophyllite (wonderstone)

	1962	1963
Production short tons	1,848	2,045
Exports do	1,142	1,538
Value	$109,143	$148,975
Local sales short tons	664	296
Value	$55,709	$26,611

TECHNOLOGY

Evidence was found that the properties of steatite bodies are optimum at vitrification temperature, and less than optimum if under-

[3] Bureau of Mines. Mineral Trade Notes. V. 56, No. 4, April 1963, pp. 35–36.

fired or overfired. Protoenstatite was found to be the stable high-temperature phase of $MgSiO_3$, and clinoenstatite the low-temperature phase. Desirable properties were consistently associated with protoenstatite. The tests were conducted on ceramic items made from raw materials ranging from a composition containing 82.1 percent talc and no synthetic $MgSiO_3$, to one containing 99 percent synthetic $MgSiO_3$.[4]

Data were published on the effects of reinforcing ethylene propylene copolymers and terpolymers with ultrafine talc.[5]

A bibliography of references on talc available at the Department of the Interior Libraries in Washington, D.C., was published.[6]

The Johnson Mine, Johnson, Vt., was the subject of a publication describing geology and mining and milling practices, including available data on costs and performance.[7]

Improvements in product uniformity attained by pnuematic handling of ground talc were described. Better mixing of stored talc was possible, and the problem of segregation by particle size was essentially eliminated by filling the storage silos from the bottom rather than from the top.[8] A British patent was issued on the improved method of maintaining particle size during pneumatic conveying of the material.[9]

Processes were patented for production of plus 15-micron platy talc by froth flotation of a ground talc-water slurry from which most of the minus 15-micron material was removed prior to flotation. Approximately 0.01 pound of synthetic wetting agent is required per ton of solids treated.[10]

Other U.S. patents were issued on use of pyrophyllite in making lightweight castable refractories,[11] and for use of talc in manufacturing fire-retardant acoustical tile [12] and wood-filling compound.[13] Canadian patents were issued on use of talc in a dry fire-extinguishing compound,[14] and on a heat treatment process to improve pyrophyllite and wonderstone for use as pressure-transmitting media or as insulation.[15]

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[4] Haertling, Gene H., and Ralph L. Cook. Physical Properties vs. Crystalline Phases in Low-Loss Steatite. Ceram. Age, v. 79, No. 1, January 1963, pp. 47–52.

[5] Lamar, R. S., H. T. Mulryan, and M. F. Warner. Reinforcing EPR and EPT With Ultra-Fine Talc. Rubber World, v. 147, No. 5, February 1963, pp. 60–64.

[6] Merrill, Celine W. Selected Bibliography of Talc in the United States. Geol. Survey Bull. 1182–C, 1963, 26 pp.

[7] Burmeister, H. L. Mining and Milling Methods and Costs, Eastern Magnesia Talc Co., Johnson Mine, Johnson, Vt. BuMines Inf. Cir. 8142, 1963, 42 pp.

[8] McClellan, R. S. Vanderbilt's New Storage Method Improves Talc Uniformity by 50% Ceram. Ind., v. 80, No. 3, March 1963, pp. 54–57.

[9] Gouverneur Talc Co. (assigned to Gouverneur, N.Y.), Improvement in Pneumatic Conveying and Blending Method of Apparatus. British Pat. 940,235, Oct. 11, 1963.

[10] Brown, Whitman E., and Robert D. Macdonald (assigned to Johnson & Johnson, New Brunswick, N.J.). Talc Beneficiation. U.S. Pat. 3,102,855, Sept. 3, 1963.

Chase, Walter Eugene (assigned to Johnson & Johnson, New Brunswick, N.J.). Platy Talc Beneficiation. U.S. Pat. 3,102,856, Sept. 3, 1963.

[11] Konrad, H. E., and W. L. Stafford (assigned to Johns-Manville Corp., New York). Lightweight Castable Refractories. U.S. Pat. 3,079,267, Feb. 26, 1963.

[12] Cotts, R. F. (assigned to The Celotex Corp., Chicago, Ill.). Fire Retardant Acoustical Tile. U.S. Pat. 3,103,444, Sept. 10, 1963.

[13] Halloquist, E. G. (assigned to MacMillan & Bloedel Ltd., Vancouver, British Columbia. Canada). Wood Patching Composition Containing Acrylic Ester Polymer and Method of Use. U.S. Pat. 3,098,053, July 16, 1963.

[14] Steppe, V. (assigned to Chemische Fabrik Grunau G. m.b.H.). Canadian Pat. 655,687, Jan. 8, 1963.

[15] Custers, J. F. H., A. B. Dyer, B. W. Senior, and P. T. Wedepohl (assigned to Adamant Laboratories (Prop.) Ltd., Johannesburg, Republic of South Africa). Canadian Pat. 655, 693, Jan. 8, 1963.

Thorium

By Charles T. Baroch [1]

DOMESTIC mine production of monazite dropped 25 percent in 1963. Free world production also fell appreciably, mainly owing to the closing of a South African monazite mine that had been one of the world's largest producers since 1954. Ample supplies of thoria were available from Canada. Consumption demands for both nonenergy uses increased moderately and were mainly met by the large imports of 1962.

LEGISLATION AND GOVERNMENT PROGRAMS

The U.S. Atomic Energy Commission (AEC) distributed drafts to interested persons for comment on a licensing guide entitled "Fabrication of Thorium-Magnesium Alloys Containing Not More Than 4 Percent Thorium." The AEC exempted from licensing the possession and use of finished optical lenses containing not more than 30 percent thorium, except for contact lenses or eyepieces. A license will still be required for processing the glass into finished lenses.

Although the Office of Minerals Exploration (OME) continued to include thorium in the list of minerals eligible for financial assistance, no exploration contracts for thorium were made in 1963.

The AEC continued its thorium-utilization program at Oak Ridge (Tenn.) National Laboratory and a study of the use of thorium in a seed-blanket reactor concept at the Bettis Atomic Power Laboratory, Pittsburgh, Pa. Authorization was also received for a relatively large joint AEC-industry demonstration prototype of the spectral shift reactor, which uses the thorium-uranium 233 fuel cycle.

Thorium has no maximum objective as a strategic and critical material but inventories on December 31, 1963, consisted of 848,354 pounds under the Defense Production Act (DPA) and 8,620,525 pounds of thorium nitrate in the supplemental and Commodity Credit Corporation (CCC) stockpiles.

DOMESTIC PRODUCTION

Mine Production.—Domestic production consisted of a small tonnage of monazite recovered as a byproduct from Florida beach sands by Titanium Alloy Manufacturing Division, National Lead Co. No production of thorite ore was reported from the Northwest.

[1] Commodity specialist, Division of Minerals.

Refinery Production.—The principal domestic processors of thorium-bearing ores and concentrates were American Potash & Chemical Corp., West Chicago, Ill.; W. R. Grace & Co., Davison Chemical Division, Pompton Plains, N.J., and Erwin, Tenn.; and Vitro Chemical Co., Chattanooga, Tenn. All of these reported the production of thorium oxide or hydroxide, American Potash and Vitro produced thorium nitrate and other compounds, Davison produced metal, and Vitro produced thorium-magnesium alloy. Other firms capable of producing thorium metal powder or ingots included The Dow Chemical Co., Midland, Mich.; Metal Hydrides, Inc., Beverly, Mass.; National Lead Co., Albany, N.Y.; Nuclear Materials & Equipment Corp., Apollo, Pa.; and United Nuclear Corp., Hematite, Mo. Thorium oxide pellets and powder were offered by United Nuclear; Westinghouse Electric Corp., Cheswick, Pa.; and Zirconium Corporation of America, Solon, Ohio. Refractory-grade and high-purity thorium oxide was offered by Coors Porcelain Co., Golden, Colo.; National Beryllia Corp., Haskell, N.J.; and Norton Co., Worcester, Mass.

CONSUMPTION AND USES

Nonenergy Uses.—Apparent consumption of thorium, reported by shipments of compounds, totaled about 50 tons of equivalent ThO_2. The major uses continued to be in magnesium alloys and gas mantles. Magnesium containing up to 3 percent of thorium retains a much higher strength between 400° and 600° F. The popularity of thorium alloys increased during 1963, and AEC proposed amending its regulations to exempt such alloys from licensing. The new dispersion-strengthened nickel, containing 2 percent ThO_2 and known as TD Nickel, increased in use as its properties became known. After 7 years of research by E. I. du Pont de Nemours & Co., Inc., it was introduced in bar form in 1962 and in 1963 it became available in sheet, wire, and tubing. Significant amounts of thorium were also used as refractories, and in chemical products and electronics.

Energy Uses.—Thorium was used as a reactor fuel in research and development facilities. Orders for thorium metal powder and ingots increased in 1963. The AEC at Oak Ridge, Tenn., provided leadership in thorium utilization as a backup to the plutonium breeder program. The Babcock & Wilcox Co. was constructing a fuels development center at Lynchburg, Va. Allis-Chalmers Manufacturing Co. worked on a thorium-reprocessing facility being built in Italy for Comitato Nazionale per l'Energia Nucleare (CNEN), a counterpart of AEC; and assisted in developing a rapid thorium-uranium-sodium reactor (RAPTUS) scheduled for operation in 1968. The reprocessing facility will also reprocess and refabricate fuel from the Elk River reactor located in Minnesota.

Powerplant prototype reactors using thorium presently in operation or in an advanced stage of construction are—

1. The Indian Point, N.Y., reactor of Consolidated Edison Co., built by The Babcock & Wilcox Co., achieved full power on January 25, 1963. It has an electrical capacity of 255 megawatts, of which

about 151 megawatts is nuclear and the balance is from an oil-fired superheater. The reactor core contains about 38,000 pounds of thorium and 2,600 pounds of enriched uranium as ThO_2–UO_2 pellets in stainless steel tubes.

2. The Elk River, Minn., reactor, sponsored cooperatively by the AEC and Rural Cooperative Power Association, operated at 15 megawatts nuclear and 7 megawatts of coal-fired superheat. Its core consists of about 8,500 pounds of thorium and 800 pounds of enriched uranium.

3. The Peach Bottom, Pa., reactor of Philadelphia Electric Co. was under construction by General Dynamics Corp. and was expected to be in operation in 1964. It was designed for 40 megawatts and is an advanced design of the high-temperature gas-cooled reactor, using helium as coolant. It will be the first nuclear reactor to produce commercial electric power at modern steam conditions of 1,000° F. and 1,450 pounds per square inch.[2]

PRICES

Monazite quotations made by mineral brokers were listed in E&MJ Metal and Mineral Markets and have shown little change for many years. Massive material, 55 percent rare-earth oxide including thoria, was quoted at $0.14 per pound, and the sand ranged from $0.10 to $0.15; 66 percent sand was $0.18 and 68 percent sand was $0.20 per pound.

Domestic thorium oxide, ceramic-grade, 99 percent was offered at $7 per pound in lots of 10 to 49 pounds, and the high-density grade, 99 percent, was $10 per pound. Thorium nitrate, wire-grade, ranged from $2.50 to $3 per pound, and the mantle grade ranged from $2.65 to $3.15 per pound. Thorium-magnesium hardener alloy containing 30 to 40 percent thorium was quoted at $9.18 to $10 per pound of contained thorium plus the contained magnesium at $0.3625 per pound. All prices were quoted f.o.b. destination, continental United States, and the range in prices depended on the quantity per shipment.

Canadian metallurgical-grade thorium oxide was quoted at the U.S. equivalent of $4.63 per pound, and metallurgical-grade thorium fluoride was $3.93 per pound.

Thorium metal, 99.9+ percent Th, was $20 per pound, and metal in pellets was quoted at $15 per pound.

The new refractory, TD Nickel, containing about 2 percent ThO_2 dispersed in the nickel, was offered at $30 per pound in sheet form and $20 per pound in bars.

FOREIGN TRADE

Imports for consumption of monazite and other thorium ore from the Federation of Malaya, the Republic of South Africa, and another country totaled 6,430 tons valued at $771,120, compared with 7,650 tons in 1962. Most of the decrease was caused by a 25-percent reduction in South African imports. Slightly over 9,400 pounds of thorium

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[2] Atomics. High Performance Expected From Peach Bottom, Pa. V. 16, No. 4, July–August 1963, pp. 45–50.

metal was imported from Canada, and about 800 pounds of thorium nitrate came from the United Kingdom and 500 pounds came from Canada.

Thorium ores, concentrates, and compounds totaling 46,000 pounds, valued at $322,140, were exported to 22 countries, and 1,320 pounds of thorium metal and thorium-bearing alloys, except special nuclear materials, valued at $50,500, went to 8 countries.

WORLD REVIEW

With the closing of the monazite mine at Steenkampskraal, Republic of South Africa, possibly permanently, ascendancy in thorium production shifted to Canada, where thorium is recovered as a byproduct of uranium production. World supply far exceeded world demand.

Canada.—The principal products of the Elliot Lake plant of Rio Tinto Dow, Ltd., were crude sludge or thorium cake, mainly thorium sulfate, and thoria. Most of the sludge was exported to the United States, and the oxide was shipped to Dominion Magnesium, Ltd., at Haley, Ontario, where it was made into sintered thorium pellets (97 percent thorium), thorium-magnesium master alloy (40 percent thorium), and some thorium powder (99.5 percent thorium).[3]

Malagasy Republic.—Uranothorianite, first exploited in 1954, was the most valuable mineral export, exceeded only by graphite. The Commissariat a l'Énergie Atomique (CEA, the French Atomic Energy Commission) purchased the output of four minor operators and had its own large-scale operations. In 1962, exports of uranothorianite reached 600 short tons, containing about 20 percent U_3O_8 and 62 percent ThO_2, valued at about $1.6 million. CEA paid small producers $6 per pound of U_3O_8 and $0.74 per pound of ThO_2 contained in ore high in thorium. It was estimated that 948 tons of monazite was produced, compared with 702 tons in 1962.

South Africa, Republic of.—The monazite mine of Anglo-American Corporation of South Africa, Ltd., at Steenkampskraal, Cape Province, closed after completing a contract with American Potash & Chemical Corp. for 8,000 short tons of monazite containing a minimum of 5 percent ThO_2. Estimated reserves in the mine are small and it may not reopen.[4]

TECHNOLOGY

The production history of thorium and rare-earth minerals in the Rocky Mountain region was discussed, together with their occurrence, mining, processing, and other economic factors.[5] A geologic study of thorium-bearing deposits of the Lemhi Pass area included basic exploratory data on the three major deposits.[6] The area surveyed covered about 80 square miles, and the detailed geology of the vein

[3] Northern Miner (Toronto, Canada). Canadian Thorium in Abundance If Demand Improves. No. 39, Dec. 19, 1963, p. 18.
[4] Metal Bulletin (London). Anglo-American's Monazite. No. 4873, Feb. 18, 1964, p. 19.
[5] Kelly, Francis J. Technological and Economic Problems of Rare-Earth-Metal and Thorium Resources in Colorado, New Mexico, and Wyoming. BuMines Inf. Circ. 8124, 1962, 38 pp.
[6] Sharp, William N., and Wayne S. Cavender. Geology and Thorium-Bearing Deposits of the Lemhi Pass Area, Lemhi County, Idaho, and Beaverhead County, Montana. Geol. Survey Bull. 1126, 1963, 76 pp.

deposits is shown on six maps. ThO_2 content ranged from 0.05 to 2.1 percent. AEC estimated in 1962 that the Lemhi Pass area may contain approximately 100,000 tons of ThO_2. The uranium-thorium deposits in southeastern Alaska were described.[7] Included was the Ross-Adams mine, the only uranium ore producer in Alaska and which has produced since 1957. The ore has a high thorium content, but only the uranium has been recovered.

Unanothorianite occurs in the Malagasy Republic as an accessory mineral in pyroxenite lenses in Precambrian rocks about 50 miles northwest of Fort Dauphin. Uranothorianite content ranges from 0.3 to 0.4 percent, and the uranothorianite mineral itself ranges from 57 to 83 percent ThO_2 and from 7.7 to 26.0 percent U_3O_8. Mining is by open-pit using trucks. The concentrating plant consists of crushers, rodmills, jigs, tables, and spiral concentrators. Capacity is about 25 tons per hour, possible annual production is over 500 tons of uranothorite averaging 18 to 23 percent U_3O_8 and 82 percent combined U_3O_8 and ThO_2. Concentrate is shipped to the CEA extraction plant at Le Bouchet, near Paris. Ore reserves at Belafa, the principal deposit, were estimated to contain 2,000 to 5,000 short tons of uranothorianite.[8] Black sands containing monazite, ilmenite, and zircon are found in dune and beach sand deposits along the southeastern coast of the Malagasy Republic. Société de Traitment des Sables du Sud de Madagascar has been mining a dune deposit at Antete since 1959 where 4 million short tons of sands have been proven. Average ore contains about 50 percent heavy minerals, of which 2 to 2.25 percent is monazite. About 100 tons of sand daily is hand-mined and hand-trammed about 200 yards to the concentrating plant, consisting of spirals, shaking tables, and magnetic separators. Société d'Exploitation des Monazites recovers monazite from beach sands at Fort Dauphin in a plant using a table, an electromagnetic separator, and a dryer. Monazite was shipped to the CEA in France for processing.

Fifteen monazite samples, taken from areas being actively mined for tin in Malaya, ranged in thoria content from 4.33 to 7.51 percent, averaging 6.10 percent. A 16th sample analyzed only 2.00 percent ThO_2.[9] A detailed study was made of the crystalline rocks in the Shelby Quadrangle, N.C., which consist of biotite schists, gneisses, monzonite, and pegmatite dikes. Panning concentrates from 1,241 samples, averaging 0.004 to 0.02 volume-percent of the original rock, were studied microscopically to determine the amounts of monazite and other minerals present in the heavy-mineral concentrate. Monazite portions of the concentrates averaged 4.8 to 6.4 percent ThO_2, being richest in the monzonites.[10]

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[7] MacKevett, E. M., Jr. Geology and Ore Deposits of the Bokan Mountain Uranium-Thorium Area, Southeastern Alaska. Geol. Survey Bull. 1154, 1963, 125 pp.

[8] Mining Journal (London). Mining in Madagascar. V. 261, No. 6693, Nov. 29, 1963, pp. 517–518.
Murdock, Thomas G. Mineral Resources of the Malagasy Republic. BuMines Inf. Circ. 8196, 1963, pp. 102–107.

[9] Flinter, B. H., J. R. Butler, and G. M. Harral. A Study of Alluvial Monazite From Malaya. Am. Mineralogist, v. 48, Nos. 11–12, November–December 1963, pp. 1210–1226.

[10] Overstreet, William C., Robert G. Yates, and Wallace R. Griffitts. Heavy Minerals in the Saprolite of the Crystalline Rocks in the Shelby Quadrangle, North Carolina. Geol. Survey Bull. 1162–F, 1963, 31 pp.

A handbook of methods for determining uranium and thorium, intended to meet the requirements of the practical analyst, was published. The methods ranged from the determination of microgram quantities to the estimation of either element in high-grade materials, and a colorimetric method for thorium was stated to be quicker and more accurate than the spectrographic method.[11]

The recently developed superalloy material called TD Nickel was shown to be a simple, two-phased alloy, consisting of 2 percent of thoria (ThO_2) particles dispersed in high-purity nickel. The thoria dispersion appeared to be in the order of 0.01 to 0.5 micron in diameter and the interparticle spacing was about 0.1 micron. For time-temperature exposure up to 2,000 hours at 2,000° F. the thoria particles were thermally stable, and they did not react, agglomerate, or diffuse significantly. Also, no nickel grain growth occurred. This very great stability is an indication of strength for exceptionally long periods at elevated temperatures.[12] Sintering is a key process in powder metallurgy, and the high temperatures and special atmospheres required in sintering furnaces create difficult engineering design problems. A new mesh belt traveling through a furnace used for continuous-process sintering of stainless steel parts was made of TD Nickel and will operate up to 2,400° F., whereas the limit on other high-temperature alloys has been 2,100° F.[13]

Alloy systems of thorium were studied over the full range of compositions, and phase diagrams were prepared for the thorium-germanium and the thorium-ruthenium system.[14]

Development of the thorium-uranium 233 fuel cycle was continued at Oak Ridge National Laboratory with the thorium-uranium Fuel Cycle Development Facility under construction and scheduled for completion by mid-1966. The Babcock & Wilcox Co. was building a major fuels development center for studying the spectral-shift reactor concept which is especially well suited for thorium fuel.[15] The Indian Point (N.Y.) Nuclear Power Station of Consolidated Edison Co., which uses fuel elements made from ThO_2 and enriched UO_2 pellets, achieved its designed power level of 255 megawatts in January.[16]

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[11] National Chemical Laboratory (Teddington, Middlesex, England). The Determination of Uranium and Thorium. H. M. Sta. Off., London, 1963, 43 pp.

[12] Sims, Chester T. Structural Stability in Ni–2ThO_2 Alloy. Trans. AIME (Met. Soc.), v. 227, No. 6, 1963, pp. 1455–1457.

[13] Steel. Powder Metallurgy: A Way To Make Almost Any Part. V. 153, No. 3, Dec. 2, 1963, pp. 49–64.

[14] Brown, Allan, and J. J. Norreys. The System Thorium-Germanium. J. Less-Common Metals (Amsterdam, Netherlands), v. 5, No. 4, August 1963, pp. 302–313.

Thomson, J. R. Alloys of Thorium With Certain Transition Metals: I. The Systems Thorium-Ruthenium and Thorium-Rhodium. J. Less-Common Metals (Amsterdam, Netherlands), v. 5, No. 6, December 1963, pp. 437–442.

[15] Nucleonics. Thorium Fuel Cycle Development Emerging From Shadow. V. 21, No. 2, February 1963, p. 24.

[16] Nucleonics. Indian Point on the Line. V. 21, No. 4, April 1963, pp. 47–52.

Tin

By John E. Shelton [1]

CONSUMPTION of primary tin rose 1 percent to the highest level since 1956; however, consumption of secondary tin dropped 6 percent to the lowest level since 1939. Tin concentrate was received for smelting at the Texas City smelter under contract with the Bolivian Government. The average price of Straits tin in the United States was the highest since 1951.

Predominant factors in the market were sales of tin by the Buffer Stock manager of the International Tin Council in an attempt to halt the rise in price and sales of tin from the U.S. national stockpile. Free world consumption exceeded free world production. Sales of tin from various Government stockpiles and drawdown of commercial stocks helped meet consumer requirements.

The United States continued to be the leading free world consumer of tin. The United Kingdom was second and Japan third.

TABLE 1.—Salient tin statistics

(Long tons)

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Production:						
Mine	60.78	50	10	(1)	(1)	(1)
Smelter	[2] 13,786	(1)	(1)	(1)	(1)	(1)
Secondary	26,208	23,700	22,050	21,690	21,040	22,332
Imports for consumption:						
Metal	58,062	43,578	39,538	39,893	[3] 41,401	43,601
Ore (tin content)	12,895	10,773	14,026	8,917	5,364	(4)
Exports (exports and reexports)	1,139	1,371	857	800	435	1,625
Consumption:						
Primary	55,430	45,833	51,530	50,288	54,602	55,209
Secondary	28,328	31,540	29,030	27,962	24,483	23,094
Price: Straits tin, New York, average cents per pound	95.81	102.01	101.40	113.27	114.61	116.64
World:						
Production:						
Mine	187,900	161,500	[3] 180,400	[3] 184,100	[3] 187,000	190,300
Smelter	189,500	[3] 155,400	[3] 189,300	[3] 184,000	[3] 189,600	191,700

[1] Figure withheld to avoid disclosing individual company confidential data.
[2] Includes tin content of alloys made directly from ores.
[3] Revised figure.
[4] Includes 793 long tons (tin content) January-August and 2,140 tons (gross weight) September-December.

[1] Commodity specialist, Division of Minerals.

LEGISLATION AND GOVERNMENT PROGRAMS

The Export Control Act of 1949, extended to June 30, 1965, governed the destination of tin shipments. Exports were under general license except to China, Cuba, North Korea, the Communist-controlled area of Viet-Nam, and the Pacific region of the U.S.S.R. Regulations administered by the Office of Export Control, U.S. Department of Commerce, required a license (except to Canada) for exports of detinned tinplate, terneplate scrap, and detinned cans. Exports of tinplate, terneplate scrap, and old cans were exempted from licensing except to the Sino-Soviet bloc, Hong Kong, and Macao.

The foreign assets control regulations of the U.S. Treasury Department prohibited the entry of Chinese tin. Soviet tin could enter the United States but required a license (none was issued) on the presumption that it might be of Chinese origin. Alloys that might include Chinese and/or Soviet tin also were prohibited.

The General Services Administration (GSA) continued to dispose of pig tin from the 50,000 long tons that was declared excess of the national stockpile needs. Tin was offered for sale at the rate of 200 tons, 1 day each week, from January 3 to June 19. The weekly rate was raised to 400 tons beginning June 26. On July 19, GSA inaugurated a program of daily sales. The weekly offerings were raised to 600 tons per week beginning December 23. Sales for 1963 totaled 9,325 tons.

The Office of Minerals Exploration offered financial assistance, to the extent of 50 percent of the total allowable costs, for exploration of eligible domestic tin deposits.

GSA administered the production payment provisions of the Texas City, Tex., tin smelter sales contract.

DOMESTIC PRODUCTION

MINE PRODUCTION

A small tonnage of tin-in-concentrate was produced in California, the first since 1944. Production was from the Meeke-Hogan Mine, Kern County. Some tin concentrate was recovered as a byproduct of molybdenum mining in Colorado.

SMELTER PRODUCTION

Tin smelting was continued on a small scale by Wah Chang Corp., Texas City, Tex. The production payment provisions of the sales contract were administered by GSA. Under this program in fiscal year 1963, GSA received $3,662 as payment on smelter production of 5,055 long tons of tin produced during the year ending April 23, 1963. The accounting period for payments on smelter production was changed to a calendar year basis. In addition, a prorated payment of $936.50 was received on metal production of 1,317 tons for the balance of the 1963 calendar year. Payments on the mortgage and mortgage interest due in fiscal year 1963 were deferred until fiscal year 1968. On June 30, GSA held a note with a balance of $800,000 bearing interest at 4 percent per year, obtained from the sale of the tin smelter.

Originally the sales contract with Wah Chang Corp. provided for payment of $10 per ton on all production of tin metal in excess of 2,000 short tons per year, up to 4,000 tons; another $2.50 per ton was to be paid for each of the next 1,000 tons, and another $2.50 per ton (a total of $15) for production over 5,000 tons. Before tin production began at Texas City (April 23, 1958) the payment terms were reduced and continued at $5 per ton on all metal produced in excess of 2,000 tons. The terms were further reduced to $1 per ton for a 2-year period originally ending April 22, 1962, but extended to April 22, 1963. After this date the payment arrangements reverted to the original provisions.

A contract between the Bolivian Government and Wah Chang Corp. completed on December 4, 1962, calls for the delivery from Bolivia of 5,000 metric tons (4,920 long tons) of metallic tin contained in 12,000 tons of concentrate each year for a 3-year period ending December 31, 1965. A second phase calls for the delivery of 10,000 tons of tin-in-concentrate per year for 3 years beginning January 1966.

SECONDARY TIN

Production of secondary tin increased 6 percent. Almost 84 percent was recovered from seven scrap items—drosses, composition of red brass, tinplate, bronze, railroad-car boxes, auto radiators, and solder. Tin recovered from old scrap increased 8 percent, reversing a 7-year downward trend. New scrap supplied 310 tons more than in 1962. The largest tonnage of tin was recovered in bronze and brass, which increased 14 percent. Next in rank was tin reclaimed in solder.

The tonnage of tinplate scrap treated in 1963 decreased 4 percent. The tin recovered at detinning plants decreased for the 17th consecutive year.

M & T Chemicals Inc. opened a new detinning plant at Seattle, Wash., in June. The plant is designed to treat 12,000 tons of tinplate annually and to produce 12,000 pounds of premium-grade tin monthly.

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TABLE 2.—Stocks, receipts and consumption of new and old scrap and tin recovered in the United States in 1963

(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)	2,840	45,755	------	45,425	45,425	3,170	------	1,953	1,953
Brass, composition or red	4,314	74,938	23,942	50,672	74,614	4,638	1,032	1,907	2,939
Brass, low (silicon bronze)	278	2,413	1,406	971	2,377	314	------	3	3
Brass, yellow	5,241	50,602	6,489	44,220	50,709	5,134	15	411	426
Bronze	1,467	26,627	6,879	19,638	26,517	1,577	542	1,550	2,092
Low-grade scrap and residues	3,838	30,243	23,194	6,945	30,139	3,942	20	------	20
Nickel silver	572	3,370	280	3,015	3,295	647	3	22	25
Railroad-car boxes	238	925	------	963	963	200	------	46	46
Total	18,788	234,873	62,190	171,849	234,039	19,622	1,612	5,892	7,504
Brass mills: [1]									
Brass, low (silicon bronze)	2,537	18,980	18,980	------	18,980	3,913	------	------	------
Brass, yellow	13,623	173,842	173,842	------	173,842	16,305	5	------	5
Bronze	925	2,217	2,217	------	2,217	1,006	107	------	107
Mixed alloy scrap	13,101	10,879	10,879	------	10,879	12,886	20	------	20
Nickel silver	3,210	7,262	7,262	------	7,262	2,940	------	------	------
Total	33,396	213,180	213,180	------	213,180	37,050	132	------	132
Foundries and other plants: [2]									
Auto radiators (unsweated)	344	6,337	------	6,023	6,023	1,189	------	271	271
Brass, composition or red	1,532	3,379	1,547	2,257	3,804	1,364	72	107	179
Brass, low (silicon bronze)	418	586	42	184	226	402	------	------	------
Brass, yellow	1,105	8,279	3,275	3,790	7,065	1,483	5	35	40
Bronze	935	2,607	1,186	1,031	2,217	1,197	93	81	174
Low-grade scrap and residues	1,333	11,005	1,889	8,547	10,436	1,934	------	------	------
Nickel silver	31	72	------	75	75	18	------	1	1
Railroad-car boxes	1,837	37,038	------	36,992	36,992	1,920	------	1,757	1,757
Total	7,535	69,303	7,939	58,899	66,838	9,507	170	2,252	2,422
Total tin from copper-base scrap	------	------	------	------	------	------	1,914	8,144	10,058
Lead-base scrap:									
Smelters, refiners, and others:									
Babbitt	321	15,395	------	15,274	15,274	442	------	740	740
Battery lead plates	[3]20,891	374,443	------	363,837	363,837	31,497	------	382	382
Drosses and residues	[3]13,166	82,541	75,453	------	75,453	20,254	2,031	------	2,031
Solder and tinny lead	296	8,305	51	8,160	8,211	390	9	1,425	1,434
Type metals	954	23,237	------	22,774	22,774	1,417	------	1,082	1,082
Total	[3]35,628	503,921	75,504	410,045	485,549	54,000	2,040	3,629	5,669
Tin-base scrap:									
Smelters, refiners, and others:									
Babbitt	73	461	8	484	492	42	7	405	412
Block-tin pipe	47	413	2	440	442	18	2	436	438
Drosses and residues	691	4,424	4,445	------	4,445	670	2,789	------	2,789
Pewter	15	31	------	41	41	5	------	35	35
Total	826	5,329	4,455	965	5,420	735	2,798	876	3,674
Tinplate scrap: Detinning plants	------	------	673,323	------	673,323	------	2,931	------	2,931
Total tin recovered	------	------	------	------	------	------	9,683	12,649	22,332

[1] Lines in brass mills and total sections do not balance as stocks include home scrap and purchased scrap assumed to equal receipts.
[2] Omits "machine shop scrap."
[3] Revised figure.

TABLE 3.—Secondary tin recovered from scrap processed at detinning plants in the United States

	1962	1963
Tinplate scrap treated [1] ... long tons	706,188	673,323
Tin recovered in the form of—		
Metal ... do	2,521	2,342
Compounds (tin content) ... do	650	589
Total [2] ... do	3,171	2,931
Weight of tin compounds produced ... do	1,389	1,168
Average quantity of tin recovered per long ton of tinplate scrap used ... pounds	10.06	9.75
Average delivered cost of tinplate scrap ... per long ton	$21.86	$21.48

[1] Tinplate clippings and old tin-coated containers have been combined to avoid disclosing individual company confidental data.
[2] Recovery from tinplate scrap treated only. In addition, detinners recovered 405 long tons (287 tons in 1962) of tin as metal and in compounds from tin-base scrap and residues in 1963.

TABLE 4.—Tin recovered from scrap processed in the United States, by form of recovery
(Long tons)

Form of recovery	1962	1963	Form of recovery	1962	1963
Tin metal:			Solder	4,764	4,845
At detinning plants	2,664	2,693	Type metal	1,555	1,496
At other plants	313	368	Babbitt	1,070	1,105
			Antimonial lead	344	315
Total	2,977	3,061	Chemical compounds	868	717
			Miscellaneous [1]	62	99
Bronze and brass:					
From copper-base scrap	8,770	10,243	Total	8,663	8,577
From lead and tin-base scrap	630	451	Grand total	21,040	22,332
			Value ... thousands	$54,015	$58,350
Total	9,400	10,694			

[1] Includes foil, cable lead and terne metal.

CONSUMPTION

Total tin consumption in the United States decreased 780 long tons in 1963. The use of primary tin rose 610 tons, whereas the consumption of secondary tin dropped 1,390 tons. More than 80 percent of the tin was used in three items—tinplate, solder, and bronze and brass. Consumption of tin in tinplate, the leading user of primary tin, which accounted for 51 percent of the total, decreased 2 percent.

Tinplate production was 7 percent less than in 1962. The mills featured lightweight tinplate. Electrolytic tinplate comprised 96 percent (96 percent in 1962), and hot-dipped tinplate comprised 4 percent of the total output. The United States used 41 percent of the world's total consumption of tin for tinplate. Almost 90 percent of the U.S. production of tinplate was used for making cans, of which 62 percent was for food pack and 38 percent for nonfood products. The tonnage of tinplate shipments to canmakers decreased 3 percent. Shipments of cans for packing food decreased 6 percent and for nonfood products, 2 percent. Beer ranked first among products packed, and the production of beer cans rose 8 percent. Cans for vegetables and vegetable juice, in second place, decreased 11 percent, and cans for fruit and fruit juices decreased 13 percent.

Cans for soft drinks increased for the seventh consecutive year to an alltime high. Cans for pressure packing and meat increased. Use of cans for fish and seafoods, coffee, pet foods, and oil decreased.

TABLE 5.—Consumption of primary and secondary tin in the United States

(Long tons)

	1954–58 (average)	1959	1960	1961	1962	1963
Stocks January 1 [1]	27,217	30,003	35,521	33,459	36,209	30,876
Net receipts during year:						
Primary	57,017	51,269	50,661	53,565	50,694	54,411
Secondary	2,424	2,471	2,217	2,897	2,409	2,290
Terne	45					
Scrap	27,660	30,814	27,448	26,344	22,542	22,041
Total	87,146	84,554	80,326	82,806	75,645	78,742
Available	114,363	114,557	115,847	116,265	111,854	109,618
Stocks December 31 [1]	28,313	35,521	33,459	36,209	30,876	29,548
Total processed during year	86,050	79,036	82,388	80,056	80,978	80,070
Intercompany transactions in scrap	2,292	1,663	1,828	1,806	1,893	1,767
Tin consumed in manufactured products	83,758	77,373	80,560	78,250	79,085	78,303
Primary	55,430	45,833	51,530	50,288	54,602	55,209
Secondary	28,328	31,540	29,030	27,962	24,483	23,094

[1] Stocks shown exclude tin in transit or in other warehouses on Jan. 1, as follows: 1954–58 (average), 1,342 tons; 1959, 1,940 tons; 1960, 1,900 tons; 1961, 2,570 tons; 1962, 425 tons; 1963, 115 tons; 1964. 175 tons.

TABLE 6.—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)
1954–58 (average)	914,394	11,301	27.7	4,183,537	21,002	11.2	[2]344,312	5,442,243	[3]32,504	13.4
1959	396,739	4,685	26.5	3,997,171	20,590	11.5	374,130	4,768,040	25,275	11.9
1960	454,808	5,443	26.8	5,300,277	27,795	11.8	495,536	6,250,621	33,238	11.9
1961	296,919	3,610	27.2	5,143,839	27,575	12.0	499,258	5,940,016	31,185	11.8
1962	212,525	2,291	24.1	4,989,463	26,417	11.9	545,623	5,747,611	28,708	11.2
1963	174,618	2,188	28.1	4,671,358	26,163	12.6	515,042	5,361,018	28,351	11.9

[1] Includes small tonnage of secondary pig tin and tin acquired in chemicals.
[2] Not reported during January–June 1954.
[3] Includes 201 long tons in tinplate waste-waste, strips, and cobbles through June 1954; thereafter not separately reported.

TABLE 7.—Consumer receipts of primary tin, by brands

(Long tons)

Year	Banka	English	Katanga	Longhorn	Straits	Others	Total
1954–58 (average)	5,471	4,096	4,699	57	39,511	3,183	57,017
1959	8,369	10,537	595		24,496	7,272	51,269
1960	10,065	1,635	1,546		31,355	6,060	50,661
1961	7,763	2,074	579	2,234	37,420	4,084	54,154
1962	8,978	1,448	1,369	1,113	34,341	3,445	50,694
1963	3,393	2,708	1,027	(1)	36,413	[2] 10,870	54,411

[1] Included with "Others."
[2] Incudes GSA tin not reported under specific brands.

TABLE 8.—Consumption of tin in the United States, by finished products

(Long tons of contained tin)

Product	1962			1963		
	Primary	Secondary [1]	Total	Primary	Secondary [1]	Total
Alloys (miscellaneous)	322	106	428	290	144	434
Babbitt	2,186	1,477	3,663	2,225	1,439	3,664
Bar tin	1,439	110	1,549	1,580	88	1,668
Bronze and brass	3,959	12,428	16,387	4,128	11,784	15,912
Chemicals including tin oxide	824	1,486	2,310	1,088	1,350	2,438
Collapsible tubes and foil	1,010	79	1,089	992	72	1,064
Pipe and tubing	30	14	44	28	33	61
Solder	12,349	7,220	19,569	12,856	6,739	19,595
Terne metal	166	182	348	298	263	561
Tinning	2,180	59	2,239	2,142	55	2,197
Tinplate [2]	28,708		28,708	28,351		28,351
Type metal	104	1,212	1,316	116	986	1,102
White metal	1,215	85	1,300	1,044	95	1,139
Other	110	25	135	71	46	117
Total	54,602	24,483	79,085	55,209	23,094	78,303

[1] Includes 285 long tons of tin contained in imported 94/6 tin-base alloys in 1962. Also includes tin content of alloys imported in 1962 and through August 1963 under the category of "babbitt metal and solder;" thereafter not separately reported.
[2] Includes secondary pig tin and tin acquired in chemicals.

STOCKS

Tinplate mills, holding nearly 85 percent of the plant stocks of pig tin in the United States, decreased their inventories by 1,195 long tons. Tin in process at tin mills dropped to 6,100 tons. Pig tin stocks at other plants were depleted by 145 tons to the lowest yearend level recorded.

On December 31, there was 337,356 tons of tin in Government stockpiles; of this, 329,851 tons was in the national (strategic) stockpile and 7,505 tons, obtained largely through the Commodity Credit Corporation barter program, was in the supplemental stockpile.

TABLE 9.—U.S. industry tin stocks

(Long tons)

	1954–58 (average)	1959	1960	1961	1962	1963
Plant raw materials:						
Pig tin:						
Virgin	16,591	22,830	20,881	23,679	19,201	17,834
Secondary	287	270	257	249	193	220
In process [1]	11,434	12,421	12,321	12,281	11,482	11,494
Total	28,312	35,521	33,459	36,209	30,876	29,548
Additional pig tin:						
In transit in United States	1,682	1,900	2,570	425	115	175
Jobbers-importers	758	1,945	1,090	2,675	[2] 2,145	[3] 11,135
Afloat to United States	3,887	1,855	2,990	3,170	4,140	5,060
Total	6,327	5,700	6,650	6,270	6,400	16,370
Grand total	34,639	41,221	40,109	42,479	37,276	45,918

[1] Tin content, including scrap.
[2] Includes 1,600 tons, representing bids rejected by GSA, from tin offered by Defense Materials Services of GSA in DMS-MET-20, Aug. 31 (1,600 tons), and in DEM-MET-25, Oct. 19 (14,000 tons). Does not include 1,000 tons representing total of weekly tin offerings in January 1963 (DMS-MET-25, Dec. 31).
[3] Includes GSA tin as follows: 10,780 tons end of December (bids rejected plus tonnage to be offered through Mar. 27, 1964).

PRICES

The tin market in 1963 reflected the offerings and sales by GSA and the shortfall of world mine production below consumption. The highest price of Straits tin for prompt delivery in New York was 133 cents per pound on December 31, the highest since June 1951. The lowest price during the year was 108.125 cents per pound on February 20 and 21.

The average cash price on the London market was £907.7 per long ton, compared with £896.5 in 1962. The highest price in 1963 was £1,035 on December 31. The lowest price was £849.75 on January 14 and February 27.

The average price of Straits tin ex-works on the Penang market, was £892.6 per long ton (£880.4 for 1962). The highest quotation was £1,011.2 on December 31 and the lowest was £833.0 on January 21.

TABLE 10.—Monthly prices of Straits tin for prompt delivery in New York

(Cents per pound)

Month	1962			1963		
	High	Low	Average	High	Low	Average
January	120.875	119.500	120.301	111.500	109.750	111.062
February	121.375	120.750	121.056	109.500	108.125	108.542
March	124.250	121.125	123.085	110.000	108.750	109.220
April	123.250	120.875	122.119	115.125	109.500	113.018
May	120.375	115.750	117.187	117.250	115.125	116.648
June	115.625	111.000	113.018	120.625	114.500	117.725
July	113.375	109.250	111.446	116.750	113.500	115.335
August	109.250	107.875	108.457	115.250	114.250	114.841
September	108.875	108.250	108.461	117.375	114.750	116.106
October	111.250	107.375	108.761	124.625	117.000	119.973
November	111.625	109.875	110.776	130.250	124.375	127.037
December	111.250	109.250	110.637	133.000	126.625	130.196
Total	124.250	107.375	114.609	133.000	108.125	116.642

Source: American Metal Market.

FOREIGN TRADE

The principal tin items in the foreign trade of the United States were imports of metallic tin and tin concentrate and exports of tinplate and tin cans. There was some trade in tin scrap including tin-alloy scrap, tinplate scrap, and tinplate circles, cobbles, strip, and scroll. Significant quantities of tin ingot, miscellaneous tin manufactures, and tin compounds were exported. Tin contained in babbitt, solder, type metal, and bronze imported and exported is shown in the Lead and Copper chapters. Ferrous scrap exports included tinplate and terneplate scrap not separately classified.

TABLE 11.—U.S. imports for consumption of tin concentrate, by countries

Country	1962		1963		
	Long tons (tin content)	Value	Long tons (tin content)[1]	Long tons (gross weight)[2]	Value
Bolivia	930	$1,799,383	790	2,130	$3,069,038
Burma	100	127,156			
Canada				10	205
Indonesia	4,321	11,630,857			
Mexico	13	37,249			
Netherlands				(3)	347
Thailand			3		7,603
Total	5,364	13,594,645	793	2,140	3,077,193

1 Data reported as tin content January-August.
2 Data reported as gross weight September-December.
3 Less than 1 ton.

Source: Bureau of the Census.

The deficit of free world mine production of tin below consumption, increasing prices, and disposal of surplus tin by the U.S. Government has caused increased need for statistical data on tin. In keeping with this need, historical data for U.S. imports for consumption and exports of tin and exports of tinplate and terneplate are shown in tables 13, 14, and 15. Data on U.S. imports of tin concentrate, mine production and smelter production for 1910 through 1961, inclusive, were shown in Minerals Yearbook 1961, and consumption of primary and secondary tin and tin content of tinplate data for 1935 through 1962, inclusive, and tin content of terneplate data for 1935 through 1954, inclusive, were shown in Minerals Yearbook 1962.

TABLE 12.—U.S. imports for consumption of tin,[1] by countries

Country	1962		1963	
	Long tons	Value (thousands)	Long tons	Value (thousands)
Belgium-Luxembourg	1,826	$4,605	383	$945
Bolivia	1,850	4,464	1,867	4,503
Canada	(2)	4	(2)	6
Congo, Republic of the, and Ruanda-Urundi			103	28
Indonesia	50	120	1,023	2,473
Japan			(2)	(3)
Malagasy Republic			20	62
Malaya, Federation of, and Singapore	4 34,808	4 86,674	36,410	89,362
Netherlands	(2)	1	25	70
Nigeria	1,176	2,908	2,066	5,085
Peru			4	11
Portugal	345	903	105	265
Rhodesia and Nyasaland, Federation of			5	12
United Kingdom	1,346	3,424	1,590	3,878
Total	4 41,401	4 103,103	43,601	106,700

1 Bars, blocks, pigs, grain, or granulated.
2 Less than 1 ton.
3 Less than $1,000.
4 Revised figure.

Source: Bureau of the Census.

TABLE 13.—U.S. imports for consumption of tin [1] by countries

(Long tons)

Country	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951
Australia	711	250										
Belgium-Luxembourg	40							3,500	6,874	7,579	8,137	5,501
Bolivia									49	246	183	20
Brazil			(2)									
Burma										6		
Canada	7	5	4	1	(2)	53						
China	3,889	2,845	3,625		3,338	1,946	984	2,639	1,615	3,689	1,665	55
Congo, Republic of the (formerly Belgian)	4,899	11,030	11,225	11,550	10,000	6,494	627	1,050	2,046	3,735	1,506	915
Denmark												
France												
Germany, West											162	49
Hong Kong	480	4										
India				(2)								
Indonesia (formerly Netherlands Indies)	12,101	17,739	3,922				7,495	39		8		
Italy												
Japan										4	542	
Laos (formerly Indochina)	1,241	487								50		
Lebanon												
Malagasy Republic												
Malaya, Federation of, and Singapore	96,454	104,872	7,791	5	(2)		2,061	13,432	34,176	34,374	54,019	6,986
Mexico	23						24					(2)
Netherlands	10								843	7,616	7,667	12,837
New Zealand				110								
Nigeria												
Panama	(2)		(2)									
Peru												
Portugal	104		99	364			9	(2)	95		1	
Rhodesia and Nyasaland												
Spain												
Switzerland												
Syria												
Thailand							87	4,031	2,978		500	46
United Kingdom	4,851	3,641	87		(2)		4,272	208	520	2,917	8,456	1,846
Total	124,810	140,873	26,753	12,030	13,338	8,493	15,559	24,899	49,196	60,224	82,838	28,255

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Australia	30	5										
Belgium-Luxembourg	7,029	8,152	6,505	7,064	6,275	3,730	3,005	705	1,601	680	1,826	383
Bolivia	105	66			333	214	148	325	939	1,672	1,850	1,867
Brazil												
Burma												
Canada								(2)	(2)	7	(2)	(2)
China												
Congo, Republic of the (formerly Belgian)	1,275	1,605	545	320	240		564	850	336	4		103
Denmark		76	19	5								
France			8									
Germany, West	155	161	264	94	439	263	43	40	10			
Hong Kong												
India												
Indonesia (formerly Netherlands Indies)				10	925			200	550	150	50	1,023
Italy				10								
Japan				19								(2)
Laos (formerly Indochina)												
Lebanon												
Malagasy Republic												20
Malaya, Federation of, and Singapore	45,992	42,969	42,943	47,199	42,479	39,026	23,325	22,404	29,521	32,955	[3] 34,808	36,410
Mexico												
Netherlands	16,861	13,613	10,601	5,894	7,109	7,992	7,292	2,820	432	55	(2)	25
New Zealand												
Nigeria										544	1,176	2,066
Panama												
Peru												4
Portugal	151	20	216	49	90	20	482	541	225	1,016	345	105
Rhodesia and Nyasaland												5
Spain				5								
Switzerland				75								
Syria	15											
Thailand												
United Kingdom	8,930	7,903	4,498	4,071	4,700	4,913	6,290	15,693	5,924	2,810	1,346	1,590
Total	80,543	74,570	65,599	64,815	62,590	56,158	41,149	43,578	39,538	39,893	[3] 41,401	43,601

[1] Bars, pigs, blocks, grain, granulated. (Scrap, and alloys, chief value tin, not specifically provided for included through 1943).
[2] Less than 1 ton.
[3] Revised figure.

TABLE 14.—U.S. exports of tin; imports for consumption and exports of tinplate and terneplate in various forms

Year	Ingots, pigs, and bars				Tinplate and terneplate		Tinplate scrap		Tinplate, circles, strips, and cobbles	Terneplate clippings and scrap	Waste-waste tinplate
	Exports		Reexports		Imports	Exports	Imports	Exports	Exports	Exports	Exports
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Long tons	Long tons	Long tons	Long tons	Long tons	Long tons
1940	(1)	(1)	2,664	$2,887	137	383,328	16,615	3,536	4,590	15,153	6,091
1941	(1)	(1)	1,094	1,283	109	354,940	22,600	180	4,952	751	8,321
1942	244	$291	165	230	134	593,776	24,082	----------	1,333	76	3,230
1943	398	464	1,372	1,567	101	396,550	19,591	27	1,607	56	50
1944	405	489	438	533	112	436,632	17,323	112	1,294	161	3,103
1945	708	891	174	224	147	471,080	18,072	433	1,684	378	12,215
1946	859	1,154	22	32	298	355,794	24,530	141	4,030	590	6,690
1947	415	650	5	10	585	553,748	30,797	54	5,340	9	21,209
1948	78	163	13	28	184	548,021	41,084	----------	3,247	278	28,121
1949	76	177	78	145	12,218	498,371	41,028	----------	3,018	227	41,865
1950	287	595	512	990	3,829	442,851	42,394	562	6,981	144	54,622
1951	264	763	1,249	3,979	398	498,808	51,571	810	12,995	144	55,955
1952	301	581	79	210	2,277	[2] 534,964	42,659	3,570	9,945	----------	(3)
1953	128	298	75	142	374	[2] 459,639	37,582	5,195	11,445	----------	----------
1954	271	467	551	1,125	127	[2] 635,969	29,214	944	11,831	----------	----------
1955	254	504	853	1,748	40	[2] 747,682	28,721	144	14,798	----------	----------
1956	439	821	451	1,018	586	648,517	29,137	3,377	21,858	10	----------
1957	1,112	1,526	419	919	40	625,666	31,431	3,628	19,531	----------	----------
1958	917	1,336	424	899	51	331,813	32,824	(4)	15,728	(4)	----------
1959	943	1,890	428	970	59,811	328,888	37,151	----------	15,082	----------	----------
1960	608	1,294	249	549	17,612	504,942	36,352	----------	20,491	----------	----------
1961	543	1,264	257	626	13,527	358,707	29,499	----------	20,960	----------	----------
1962	335	840	100	267	46,857	294,510	18,832	----------	21,994	----------	----------
1963	1,544	4,225	81	207	74,055	305,682	19,486	----------	20,853	----------	----------

1 Not separately classified before 1942.
2 Owing to changes in classifications, data for 1952-63 not strictly comparable with earlier years.
3 Beginning Jan. 1, 1952, not separately classified; included with "tinplate."
4 Beginning Jan. 1, 1958, not separately classified.

TABLE 15.—U.S. imports for consumption and exports of miscellaneous tin, tin manufactures, and tin compounds

Year	Miscellaneous tin and manufactures						Tin compounds	
	Imports			Exports				
	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 cans, finished or unfinished		Tin scrap and other tin-bearing material except tinplate scrap, value (thousands)	Imports (long tons)	Exports (long tons)
		Long tons	Value (thousands)	Long tons	Value (thousands)			
1940	$12	(1)	(1)	8,397	$2,015	(1)	(2)	58
1941	2	(1)	(1)	13,018	3,064	(1)	3	61
1942	1	226	$64	9,177	2,209	$301	-------	52
1943	4	132	12	7,809	2,331	202	-------	11
1944	4	51	12	5,938	1,589	654	-------	12
1945	1	57	(3)	12,346	3,153	454	(2)	16
1946	[4] 141	1	(3)	13,815	3,791	483	(2)	(1)
1947	162	104	27	26,061	8,160	829	14	(1)
1948	119	750	659	36,450	11,209	1,684	5	(1)
1949	190	520	425	31,087	10,264	2,245	(2)	18
1950	215	2,810	2,146	28,946	10,449	869	34	55
1951	366	1,146	1,898	33,171	14,048	2,403	46	61
1952	448	8,192	17,454	41,624	16,843	[5] 2,087	1	33
1953	606	7,109	11,895	29,841	12,917	2,418	2	82
1954	[6] 785	5,878	9,358	23,878	11,022	3,341	1	153
1955	[6] 559	6,117	[6] 10,383	26,490	11,517	2,441	5	139
1956	[6] 605	5,073	[6] 9,430	30,502	13,245	2,324	10	167
1957	[6] 561	5,077	9,485	30,166	14,309	3,911	10	218
1958	610	3,208	5,771	35,849	18,322	992	11	(1)
1959	1,008	3,350	6,469	36,320	19,027	1,231	6	(1)
1960	839	809	1,642	32,875	17,362	1,355	3	(1)
1961	676	612	1,299	30,929	15,093	3,352	22	(1)
1962	819	2,185	913	25,531	13,927	2,111	58	(1)
1963	731	2,816	2,067	21,595	12,169	2,423	81	(1)

[1] Not separately classified.
[2] Less than 1 ton.
[3] Less than $1,000.
[4] Data include tinplate manufactures, not specially provided for elsewhere.
[5] Due to changes in classifications data, not strictly comparable with earlier years.
[6] Data known to be not comparable with other years.

WORLD REVIEW

INTERNATIONAL TIN AGREEMENT

The International Tin Council held several meetings in 1963. In March, the percentages and votes of the producing countries were revised, effective July 1, 1963; at the June meeting the votes of the consuming countries were revised, also effective July 1, 1963. The Council periodically reviewed the sales of tin from the U.S. national stockpile and discussed future problems of disposal. A delegation from the Council met with representatives of various U.S. Government agencies in Washington, D.C., in November to discuss the policy of surplus tin disposals. The delegation was informed that the U.S. Government was preparing a long-range tin disposal plan. On December 5, the Council raised the tin agreement floor price from £790 (98.75 cents per pound) to £850 (106.25 cents per pound); the ceiling was raised from £965 (120.625 cents per pound) to £1,000 (125 cents per pound); the middle sector in the new range was fixed at £900 (112.50 cents per pound) and £950 (118.75 cents per pound). The buffer stock held 3,275 tons at the end of March and none on December 31.

TABLE 16.—Second International Tin Agreement: Percentages and voting powers of producing countries [1]

Country	Percentage	Votes allocated	Country	Percentage	Votes allocated
Bolivia	16.141	162	Nigeria	6.141	65
Congo, Republic of the	7.362	76	Thailand	10.455	106
Indonesia	15.981	160			
Malaya, Federation of	43.920	431	Total	100.000	1,000

[1] Effective from July 1, 1963, through June 30, 1964. Established at ninth meeting of the Second International Tin Council, Mar. 12-14, 1963.

TABLE 17.—Second International Tin Agreement: Voting power and tonnage of consuming countries [1]

Country	Tonnage	Votes	Country	Tonnage	Votes
Australia	3,893	53	Korea	170	7
Austria	746	14	Mexico	1,083	18
Belgium	2,765	39	Netherlands	3,329	46
Canada	4,113	55	Spain	1,533	24
Denmark	2,106	31	Turkey	833	15
France	10,807	137	United Kingdom	21,157	264
India	4,333	58			
Italy	5,050	67	Total	75,608	1,000
Japan	13,690	172			

[1] Effective from July 1, 1963, through June 30, 1964. Established at the 10th meeting of the Second International Tin Council, June 11-13, 1963.

TABLE 18.—Authority of the tin buffer stock manager

Provisions	From Jan. 12, 1962, to Dec. 4, 1963	Revised Dec. 5, 1963
Must sell [1]	£965 or higher per long ton (120.625 cents or higher per pound).	£1,000 or higher per long ton (125.0 cents or higher per pound).
Upper range—may sell	£910 to £965 per long ton (113.75 to 120.625 cents per pound).	£950 to £1,000 per long ton (118.75 to 125.0 cents per pound).
Midrange—abstains from buying or selling.	£850 to £910 per long ton (106.25 to 113.75 cents per pound).	£900 to £950 per long ton (112.50 to 118.75 cents per pound).
Lower range—may buy	£790 to £850 per long ton (98.75 to 106.25 cents per pound).	£850 to £900 per long ton (106.25 to 112.50 cents per pound).
Must buy [2]	£790 or lower per long ton (98.75 cents or lower per pound).	£850 or lower per long ton (106.25 cents or lower per pound).

[1] If the buffer stock manager has tin.
[2] If the buffer stock manager has money.

TABLE 19.—World mine production of tin (content of ore), by countries [1]

(Long tons)

Country	1954-58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	276	334	278	500	291	474
Mexico	494	378	372	530	576	1,056
United States	61	50	10	(2)	(2)	(2)
Total	831	762	660	(2)	(2)	(2)
South America:						
Argentina	131	225	238	515	571	529
Bolivia (exports)	25,823	23,811	19,407	20,409	21,492	22,752
Brazil [3]	238	367	1,556	582	732	1,000
Peru (recoverable)	9	43	6	14	11	12
Total	26,201	24,446	21,207	21,519	22,806	24,293
Europe:						
Czechoslovakia [4]	200	200	200	200	200	200
France	371	-------	21	156	281	274
Germany, East [3]	678	720	720	720	720	720
Portugal [5]	1,255	1,129	772	729	679	634
Spain	671	326	196	230	231	167
U.S.S.R. [6] [7]	11,700	15,000	16,000	17,000	17,000	20,000
United Kingdom	1,027	1,252	1,199	1,210	1,181	1,226
Total [3] [7]	15,900	18,600	19,100	20,200	20,300	23,200
Asia:						
Burma [5]	1,146	1,200	1,200	1,130	1,041	1,000
China [6]	18,700	26,000	28,000	30,000	28,000	28,000
Indonesia	30,041	21,613	22,596	18,574	17,310	12,947
Japan	920	998	842	853	859	858
Laos	238	294	383	335	367	326
Malaya, Federation of	56,396	37,525	51,979	56,028	58,603	59,947
Thailand	10,905	9,684	12,080	13,270	14,679	15,587
Total [3] [7]	118,300	97,300	117,100	120,200	120,900	118,700
Africa:						
Cameroon, Republic of	80	62	65	65	21	60
Congo, Republic of the (formerly Belgian)	12,240	9,194	8,636	6,314	6,875	6,488
Congo, Republic of	27	32	34	46	46	[3] 43
Morocco	8	9	10	11	10	10
Niger, Republic of	57	57	53	47	41	54
Nigeria	8,177	5,541	7,675	7,779	8,210	8,723
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	278	605	642	716	677	498
Ruanda-Urundi	1,827	1,124	1,277	1,474	[3] 1,440	[3] 1,250
South Africa, Republic of	1,384	1,273	1,276	1,430	1,408	1,530
South-West Africa	409	4	261	302	369	444
Swaziland	26	5	6	5	5	3
Tanganyika (exports)	25	65	138	163	206	236
Uganda	53	36	32	33	67	163
Total	24,591	18,007	20,105	18,385	19,375	19,502
Oceania: Australia	2,072	2,351	2,202	2,745	2,714	3,085
World total (estimate)	187,900	161,500	180,400	184,100	187,000	190,300

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Figure withheld to avoid disclosing individual company confidential data; included in world total.
[3] Estimated by authors of the chapter and in a few instances from the Statistical Bulletin of the International Tin Council, London, England.
[4] Estimate, according to the 49th annual issue of Metal Statistics (Metallgesellschaft) through 1962.
[5] Includes tin content of mixed concentrates.
[6] Estimated smelter production.
[7] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

TABLE 20.—World smelter production of tin, by countries [1]

(Long tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Mexico	293	377	365	559	520	1,055
United States [2]	[3] 14,874	[4] 10,773	[4] 14,026	[4] 8,917	[4] 5,364	[4] 1,650
Total	15,167	11,150	14,391	9,476	5,884	2,705
South America:						
Argentina	52					
Bolivia (exports)[5]	339	916	1,069	2,016	2,024	2,467
Brazil	1,322	1,227	1,311	1,525	2,317	[5] 2,000
Total	1,713	2,143	2,380	3,541	4,341	4,467
Europe:						
Belgium	10,023	5,945	7,947	6,002	8,607	7,044
Germany:						
East [5]	600	600	600	600	600	600
West	513	1,010	769	947	1,309	1,052
Netherlands	25,912	9,592	6,393	2,729	4,282	5,762
Portugal	1,028	1,167	601	784	766	630
Spain	617	328	464	731	905	1,613
U.S.S.R.[5 6 7]	11,700	15,000	16,000	17,000	17,000	20,000
United Kingdom	29,330	26,614	26,286	24,449	18,749	17,411
Total [5 6]	79,700	60,300	59,100	53,200	52,200	54,100
Asia:						
China [5]	18,700	26,000	28,000	30,000	28,000	28,000
Indonesia	1,023	1,971	1,977	[5] 2,000	[5] 2,000	[5] 1,800
Japan	1,103	1,308	1,260	1,644	1,903	1,976
Malaya, Federation of	66,337	45,729	76,130	79,114	82,073	84,001
Total [5 6]	87,200	75,000	107,400	112,800	114,000	115,800
Africa:						
Congo, Republic of the (formerly Belgian)	2,802	3,291	2,532	275	945	1,441
Morocco	10	[5] 10	[5] 10	[5] 10	[5] 10	[5] 10
Nigeria				623	8,024	9,051
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	162	572	611	673	679	544
South Africa, Republic of	803	726	622	870	821	938
Total	3,777	4,599	3,775	2,451	10,479	11,984
Oceania: Australia	1,970	2,226	2,254	2,546	2,704	2,626
World total (estimate)	189,500	155,400	189,300	184,000	189,600	191,700

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Includes tin content of alloys made directly from ores.
[3] Includes imports of tin concentrates (tin content) into United States for 1958.
[4] Imports into the United States of tin concentrates (tin content). 1963 tin content estimated for September through December.
[5] Estimated by authors of the chapter and in a few instances from the Statistical Bulletin of the International Tin Council, London, England.
[6] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.
[7] Includes secondary.

REVIEW BY COUNTRIES

SOUTH AMERICA

Bolivia.—Exports of tin, mostly in concentrate, totaled 22,752 long tons valued at US$57 million, an increase of 6 percent in tonnage and value. Tin production in nationalized mines increased 1 percent. The Bolivian Government began a rehabilitation program in the nationalized mines to improve efficiency and lower costs. The mining unions, in protest to interference in union affairs, called a strike in August that lasted 14 days. Workers at the Catavi mine went on strike in December, protesting the arrest of two union members. The miners took 19 hostages, including 4 U.S. citizens. The hostages were released, unharmed, after several days and the strike was suspended.

TABLE 21.—Bolivia: Tin production by nationalized mines

(Long tons of contained tin)

Mine	1962	1963	Mine	1962	1963
Caracoles	776	1,001	Santa Ana	----------	30
Catavi	4,076	3,492	San Jose	1,058	923
Chorolque	673	812	Santa Fe	614	664
Colquechaca	34	43	Tasna	447	510
Colavi	210	206	Unificada	1,293	1,556
Colquiri	2,314	2,164	Viloco	674	696
Huanuni	2,414	2,586	Other countries	79	188
Japo	90	92			
Morococala	241	163	Total	14,993	15,126

Source: U.S. Embassy, La Paz, Bolivia, from data furnished by Corporation Minera de Bolivia.

TABLE 22.—Bolivia: Exports of tin, by groups

(Long tons of contained tin)

Group	1956–60 (average)	1961	1962	1963
Corporation Minera de Bolivia [1]	17,726	12,622	13,219	15,694
Banco Minero:				
Medium mines	4,639	2,475	2,731	3,223
Small mines		3,297	3,521	3,835
Smelter (tin metal)	752	2,015	[2] 2,021	(3)
Total	23,117	20,409	21,492	22,752

[1] Decree of Oct. 31, 1952, nationalized the major producers of tin included in this group; namely, Patino Mines & Enterprises Inc., Compagnie Aramayo de Mines en Bolivia, and Maurico Hocschild, S.A.M.I.
[2] Includes tin content of alloys made directly from ore.
[3] Not available separately; included in total.

Source: U.S. Embassy, La Paz, Bolivia, from data furnished by Corporation Minera de Bolivia.

TABLE 23.—Bolivia: Exports of tin, by countries

(Long tons of contained tin)

Destination	1962	1963	Destination	1962	1963
Germany, West	1,588	1,666	United States	3,522	4,292
Netherlands	859	1,282	Others	----------	13
United Kingdom	15,523	15,499	Total	21,492	22,752

Source: Statistical Bulletin of the International Tin Council.

EUROPE

U.S.S.R.—Imports from China were 8,000 long tons (estimated), compared with 8,500 tons (revised) in 1962. Tin imports from Malaysian and Western Europe markets were 3,500 tons. Free Europe imported virtually no tin from the U.S.S.R. in 1963. Tin consumption was estimated at 25,000 tons. Tinplate imports from Western Europe were estimated at 40,000 tons (43,290 tons in 1962). Exports of tinplate were 76,000 tons (estimated), compared with

75,200 tons in 1962. Cuba was the largest market. Tinplate production was estimated at 380,000 tons (381,600 tons in 1962).

TABLE 24.—Sino-Soviet bloc: Shipments of tin metal
(Long tons)

Source and destination	1962	1963
From U.S.S.R. to—		
Finland	67	----------
From Viet-Nam (North) to—		
Japan	44	150
Netherlands	----------	10
Total	44	160
From China to—		
Austria	21	96
Belgium	4	----------
Colombia	----------	3
Denmark	75	395
Finland	218	146
France	500	1,019
From China to—Continued		
Germany, West	886	990
Hong Kong	56	60
Japan	820	995
Netherlands	1,351	1,469
Norway	----------	116
Sweden	96	266
Switzerland	120	160
Syria	26	29
United Arab Republic	580	----------
United Kingdom	1,409	1,157
Total	6,162	6,901
Grand total	6,273	7,061

Source: Statistical Bulletin of the International Tin Council.

United Kingdom.—Mine production of tin in Cornwall, England, was 1,226 long tons.

The United Kingdom ranked second as a free world smelter of tin ore, as a consumer of pig tin, and as a producer of tinplate. Most of the concentrate treated came from Bolivia. Primary tin consumption was 20,640 tons, compared with 21,440 tons in 1962. About 46 percent was used for making tinplate. Tinplate production was 1,181,700 tons, 1 percent greater than in 1962 (1,173,900 tons). Of the tinplate produced, 79 percent was electrolytic and 21 percent hot-dipped. Tinplate exports were 454,500 tons, compared with 455,500 tons (revised) in 1962. Tinplate shipments to China, Italy, Republic of South Africa, Spain, Sweden, the United States, and other countries increased, offsetting drops in shipments to Czechoslovakia, Hong Kong, Malaya, the Netherlands, Portugal, and West Germany. The United States received 53,375 tons of tinplate, compared with 36,115 tons in 1962, and was the largest buyer of tinplate from the United Kingdom.

The total imports of tin metal, mainly from Nigeria and China, were 7,925 tons (9,230 tons in 1962). Exports of tin metal, chiefly to France, the Netherlands, the United States, and the U.S.S.R., were 8,455 tons.

Pig tin stocks totaled 5,920 tons at the beginning of 1963 and 3,110 tons at yearend. Stocks of tin in concentrate were 1,411 tons at the beginning of 1963 and 989 tons at yearend. Stocks of tin in concentrate afloat at yearend were 1,447 tons (695 tons at the beginning of 1963).

ASIA

Indonesia.—Mine production of tin in 1963 dropped 25 percent to the lowest since 1946. The islands of Banka, Billiton, and Singkep furnished 49, 37, and 14 percent, respectively, of the total. All of these operations are owned by the Indonesian Government.

Tin in concentrate exports totaled 10,600 tons (estimated) in 1963, of which 9,100 tons went to Malaya and 1,500 tons to the Netherlands. Indonesia, in its dispute with the newly formed Federation of Malaysia, cancelled the contract for smelting tin. A contract between Dutch N.V. Billiton Maatschappij and the Indonesia State Mining Co. to smelt tin at Arnhem, Netherlands, was signed in September.

Malaya, Federation of.—Mine production was 59,947 long tons. Of the total, 60 percent came from European-operated mines (mostly dredges) and 40 percent from Asian-operated mines (mostly by gravel pumps but including 3 percent from dulang washing). European mines produced 35,860 tons (35,988 tons in 1962), and Asian mines produced 24,087 tons (22,615 tons in 1962). Output increased 1,670 tons at gravel pump mines and 400 tons at open pit mines, while output by dredges decreased 975 tons.

There were 704 active mines at the beginning of 1963 and 709 at yearend. The number of dredges remained at 66, gravel pump mines increased from 582 to 593, and other mines decreased from 56 to 50.

The principal world source of tin continued to be the large plants of the Eastern Smelting Co., Ltd., on the island of Penang; the Straits Trading Co., Ltd., at Pulau Brani, Singapore; and the Butterworth Smelter, Wellesley Province. The concentrate treated was derived mostly from Malaya, Indonesia (until September), and Thailand. Total tin in concentrate available for smelters was 80,430 tons (82,120 tons in 1962). Exports of tin metal, mostly from Penang, were the highest since 1941.

Stocks of tin metal decreased from 4,607 tons at the beginning of 1963 to 2,582 tons at yearend. Tin in concentrate (including mine stocks) dropped to 4,593 tons.

TABLE 25.—Federation of Malaya: Exports of tin in metal, by countries

(Long tons)

Destination	1962	1963	Destination	1962	1963
Argentina	935	1,291	Japan	10,319	13,524
Australia-New Zealand	2,218	2,097	Netherlands	2,395	1,901
Belgium	5,855	4,815	United Kingdom	1,955	1,012
Canada	1,862	3,851	United States	34,481	35,579
Denmark	184	28	Yugoslavia	1,155	1,850
France	4,388	3,423	Other countries	5,773	6,578
Germany, West	655	702			
India	4,478	3,958	Total	81,393	86,094
Italy	4,740	5,485			

Source: Federation of Malaya, Department of Statistics, Monthly Statistical Bulletin, March 1964.

TABLE 26.—Federation of Malaya: Imports of tin in concentrate, by countries

(Long tons)

Country	1962		1963	
	Gross weight	Tin content	Gross weight	Tin content
Burma	1,982	1,427	1,996	1,441
Indonesia	17,635	12,706	12,671	9,133
Laos	715	514	554	402
Thailand	12,801	9,225	12,288	8,868
Other countries	180	129	456	328
Total	33,313	24,001	27,965	20,172

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Thailand.—Tin was the most important mineral resource of Thailand and ranked as the fourth major export, exceeded in value only by rice, rubber, and maize. Production and exports of tin concentrate in 1963 were the largest since 1941.

TABLE 27.—Thailand: Exports of tin in concentrate, by countries

(Long tons)

Destination	1961	1962	1963	Destination	1961	1962	1963
Brazil	607	1,311	1,895	Spain	1,021	186	760
Japan	503	440	780	United Kingdom	14	66	80
Malaya	9,089	9,385	9,050	United States			5
Mexico	96		15				
Netherlands	1,616	2,856	2,835	Total	12,946	14,244	15,420

AFRICA

Congo, Republic of the.—Production of tin in concentrate in 1963 decreased 6 percent from 1962. Exports of tin concentrate in 1963 to Belgium decreased about 15 percent from 1962. Production of tin metal at the Manono smelter increased 38 percent.

Nigeria.—Of the 11,800 long tons of tin concentrate produced in 1963, 65 percent was from mechanized mines and 35 percent was from mines worked primarily by manual labor. Almost all of the output was retained for local smelting, and small tonnages were shipped to Portugal and the United Kingdom. Most of the smelter output went to the United Kingdom and the United States, while minor quantities went to France and the Netherlands. Stocks of tin in concentrate at mines and smelters dropped from 810 tons at the beginning of 1963 to 643 tons at yearend.

In the year that ended March 31, 1963, Nigeria's largest producer, Amalgamated Tin Mines of Nigeria, Ltd., reported treating about 15.4 million cubic yards, compared with 13.4 million in the period ending March 31, 1962.

The output (in long tons) was obtained by the following methods:

Method:	*Cassiterite*	*Columbite*
Jig plants	325	202
Dragline washing plants	1,095	70
Gravel pumps and elevators	2,404	182
Dredge	177	28
Contractors	700	52
Mill-tailing treatment	96	90
Total	4,797	624

OCEANIA

Australia.—Tin production increased about 14 percent in 1963. Queensland was the principal source. Test drilling by Aberfoyle Tin Development on the Greenbushes tin and tantalite field in Western Australia indicated proved and possible reserves of 36,760,000 cubic yards of ore estimated at 0.62 pound of tin oxide and 0.063 pound tantalum oxide per cubic yard.

Tin consumption in 1963 was estimated at 4,600 long tons, compared with 4,480 tons in 1962. Tinplate required 2,725 tons in 1963 and 2,255 tons (revised) in 1962. Total tinplate production was 209,430 tons in 1963 (171,875 tons in 1962). Tinplate production exceeded domestic requirements, and most of the surplus was exported to New Zealand. Imports from the United States were less than 200 tons.

TECHNOLOGY

The regional geology of Mount Pleasant in Canada was described as consisting essentially of metasediments and igneous rocks of Lower Ordovician age overlain to the north by Carboniferous sediments. The southern margin abuts a granitic mass of Devonian age. The Mount Pleasant volcanics are a red feldspar-quartz porphyry rhyolite.[2]

The tin deposits of the Rooiberg-Leeuwpoort, Transvaal, South Africa, occur in arkosites and shales of the Precambrian Transvaal system.[3]

The cassiterite-bearing deposit at the South Crofty Mine, Cornwall, consists of semiparallel stringers transversing a porphyry dike. Cassiterite distribution shows a relationship to structural conditions, indicating some type of impounding mechanism.[4]

The use of a dredge for mining tin in France solved a difficult economic problem at Europe's first alluvial tin mining operation.[5] A hydraulic pipeline cutterhead dredge was the most suitable device for excavating and transporting the material.

A flowsheet that combined gravity and magnetic separation for the recovery of tin was published.[6] After hydraulic classification the tin-bearing fraction was concentrated on shaking tables. The gravity concentrate was treated by flotation to remove sulfide and by magnetic separation to remove magnetic waste, resulting in a high-grade tin concentrate.

The extraction of about 90 percent of the tin at grades of 55 to 60 percent from a feed material containing 3 to 4 percent tin was reported.[7] The tin was distilled during reducing-sulfidizing roasting in a fluid bed.

The kinetics of the electrodeposition of tin from acid solutions containing various nonionic additives were studied.[8] Many nonionic organic additives caused large increases in cathodic polarization. Evidence was presented for the absorption of the organic molecules on the electrode surfaces. The rate-determining step for polarization is probably the transfer of cations through the barrier of absorbed organic molecules on the electrode surface.

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[2] Hosking, K. F. G. Geology, Mineralogy and Paragenesis of the Mount Pleasant Tin Deposits Canadian Min. J. (Quebec, Canada), v. 84, No. 4, April 1963, pp. 95–102.

[3] Leube, A., and E. F. Stumpel. The Rooiberg and Leeuwpoort Tin Mines, Transvaal, South Africa. Part I, General and Structural Geology, Econ. Geol., v. 58, No. 3, May 1963, pp. 391–418; Part II, Petrology, Mineralogy and Geochemistry, Econ. Geol., v. 58, No. 4, June-July 1963, pp. 527–557.

[4] Taylor, R. G. An Occurrence of Cassiterite Within a Porphyry Dyke at South Crofty Mine, Cornwall. Inst. Min. and Met. Bull. (London), v. 72, No. 681, August 1962, pp. 749–758.

[5] Canadian Mining Journal (Quebec, Canada). Alluvial Tin Mining. V. 84, No. 6, June 1963, pp. 56–57.

[6] Deco Trefoil. Flowsheet for Recovery of Tin. August-September-October 1963, pp. 19–20.

[7] Klushir, D. N., A. A. Benuni, and P. I. Selivokhin. (Extracting Tin From Low-Grade Ores by Distillation During Reducing-Sulfidizing Roasting in a Fluidized Bed.) Tsventnye Metally, May 1962, pp. 35–40.

[8] Meibuhr, Stuart, Ernest Yeager, Akiya Kozawa, and Frank Hovorka. Effects of Nonionic Addition Agents on Electrodeposition From Stannous Sulfate Solutions. J. Electrochem. Soc., v. 110, No. 3, March 1963, pp. 190–202.

Small quantities of certain alloying elements change the oxidation rate of tin.[9] If the formation of tin oxide (SnO) is thermodynamically favored, elements with a valence greater than tin increase the rate of formation of SnO. When the formation of SnO is not favored, the alloying element is oxidized preferentially.

Stannic oxide was found to be a broadband semiconductor, and the antimony-doped specimens showed n-type behavior.[10]

Tributyl tin oxide additions to preparations for treating hospital floors and walls and in laundry rinse solutions was effective in the control of staphylococcus in hospitals.[11]

The manufacture of tinplate and tin coating, thickness of the tin coating, composition of the steel base, and production of tinplate in various countries was described.[12]

A corrosion test for tinplate was described.[13] The polarization resistance and corrosion current, both related to corrosion rate, are determined from graphs of voltage versus current and of voltage versus the log of the current, respectively.

A new, short-cycle continuous heat-treating process to anneal mild steel strip in 15 seconds is being developed.[14] The strip is perheated in a duct of molten lead-bismuth alloy, annealed in an electric heating section, quenched to 200°–300° C in a second duct of lead-bismuth alloy, and air-cooled in storage.

A small continuous hot-tinning line on which copper or steel strips or wire could be tinned under any desired conditions was constructed by the Tin Research Institute, London.[15] Oil well drill pipe couplings were tinplated, enabling faster makeup or breaking of a string of pipe by reducing friction and sealing joints.[16]

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[9] Boggs, W. E., R. H. Kachik, and G. E. Pellissier. The Effect of Alloying Elements on the Oxidation of Tin. J. Electrochem. Soc., v. 110, No. 1, January 1963, pp. 4–11.

[10] Loch, L. D. The Semiconducting Nature of Stannic Oxide. J. Electrochem. Soc., v. 110, No. 10, October 1963, pp. 1081–1083.

[11] Rees, Glyn. A Possible Solution to the Problem of the Ubiquitous Hospital Infection. Tin and Its Uses, No. 60, Tin Research Institute (Middlesex, England) 1963, pp. 1–3.

[12] Hoare, W. E. Tinplate Handbook. 4th ed., Tin Research Institute (Middlesex, England) March 1963, 58 pp.

[13] Butler, T. J., and P. R. Carter. A Polarization Method for Determining the Corrosion Rate of Tinplate. Electrochem. Tech., v. 1, No. 1–2, January–February 1963, pp. 22–27.

[14] Iron Age. Tinplate Gets "Instant" Anneal. V. 191, No. 17, Apr. 25, 1963, p. 129.

[15] Thwaites, C. J. The Continuous Hot-Tinning of Strip and Wire. Metallurgia (Manchester, England), v. 67, No. 406, August 1963, pp. 69–80.

[16] American Metal Market. Tinplate Finds New Use in Drill Pipe Couplings. V. 70, No. 231, Dec. 4, 1963, p. 6.

Titanium

By John W. Stamper [1]

PRODUCTION and consumption of titanium sponge metal were the second highest on record. Ilmenite output reached a new peak of 888,000 tons and rutile production was the highest since 1956. Production of titanium pigments was down 4 percent; however, consumption was up 3 percent over that of 1962.

Owing to the increased demand for rutile in making titanium dioxide by the chloride process, world output of rutile concentrate jumped 47 percent over that of 1962. Ilmenite production, used chiefly for making titanium dioxide by the sulfate process, increased 3 percent.

A titanium sponge metal plant in the United Kingdom was expected to resume production in 1964. New titanium dioxide plants and expansions of existing facilities were completed in the United States, Australia, Canada, and West Germany. Additional expansions, which included two 25,000-ton-per-year plants, utilizing the chloride process, were planned in France, Spain, India, and Japan. A new 20,000-ton-per-year plant was built in the United States to utilize the chloride process.

LEGISLATION AND GOVERNMENT PROGRAMS

Under the Antidumping Act of 1921, as amended, the U.S. Treasury Department investigated charges by domestic companies of dumping of titanium dioxide pigment in the United States by producers from Finland, France, Japan, and the United Kingdom. The Treasury Department found no evidence of dumping of imports from Finland and the United Kingdom; however, imports from Japan and France were held to be dumping under the act. The case was referred to the U.S. Tariff Commission for a decision on whether the practice was injurious to the domestic industry. The Tariff Commission ruled that imports from France were not injuring the domestic industry. Imports from Japan were to be studied by the Tariff Commission early in 1964.

A total of 85 short tons of titanium sponge metal above 140 Brinell hardness was sold by General Services Administration at an average price of $1.18 per pound.

[1] Commodity specialist, Division of Minerals.

TABLE 1.—Salient titanium statistics

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Ilmenite concentrate:[1]						
Mine shipments short tons	637,723	637,263	789,237	782,629	809,037	890,071
Value thousands	$12,960	$12,106	$14,655	$13,320	$13,974	$16,529
Imports[2] short tons	359,227	371,687	265,645	207,151	166,434	200,880
Consumption do	771,741	917,747	868,080	929,147	944,797	874,986
Titanium slag: Consumption do	126,452	143,329	120,492	130,184	138,205	152,416
Rutile concentrate:						
Mine shipments do	8,212	8,648	[4] 9,226	7,664	8,033	11,311
Value thousands	$1,099	$877	[4] $957	$778	$933	$1,262
Imports short tons	40,959	23,228	29,235	27,497	35,966	71,990
Consumption[3] do	34,270	23,741	24,229	29,548	31,749	35,189
Sponge metal:						
Production do	9,839	3,898	5,311	6,727	6,730	7,879
Imports for consumption do	1,683	1,563	2,231	2,490	925	1,468
Consumption do	5,957	3,953	5,487	6,991	7,136	8,865
Price: Grade A-1, Dec. 31 per pound	$2.72	$1.60	$1.60	$1.60	$1.50	$1.50
World production:						
Ilmenite concentrate short tons	1,623,300	1,937,900	[4] 2,207,000	[4] 2,305,900	[4] 2,168,000	2,222,000
Rutile concentrate do	103,200	106,400	114,200	128,600	150,000	220,100
Sponge metal do	13,460	[4] 7,000	[4] 7,900	[4] 9,300	[4] 8,500	9,800

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite.
[2] Includes titanium slag.
[3] Excludes use for making titanium dioxide pigment, 1960-63, inclusive.
[4] Revised figure.

DOMESTIC PRODUCTION

Concentrates.—A record 888,000 tons of ilmenite was produced in New York, Florida, New Jersey, and Virginia. Production of 11,900 tons of rutile in Florida and Virginia was the highest since 1956.

Ilmenite production was reported by American Cyanamid Co., Piney River, Va.; E. I. du Pont de Nemours & Co., Inc., Starke and Lawtey, Fla.; M & T Chemicals, Inc., Hanover County, Va.; National Lead Co., Tahawus, N.Y.; The Glidden Co., Lakehurst, N.J.; Titanium Alloy Manufacturing Division, National Lead Co., Skinner, Fla.; and The Florida Minerals Co., Vero Beach, Fla. Porter Brothers Corp. shipped ilmenite from stockpiles at Boise, Idaho.

Rutile producers were as follows: M & T Chemicals, Inc., Beaver Dam, Va.; Titanium Alloy Manufacturing Division, National Lead Co., Skinner, Fla.; and The Florida Minerals Co., Vero Beach, Fla.

The town of Tahawus, N.Y., was moved 10 miles to the southwest to permit extending the open pit mine of the Titanium Alloy Manufacturing Division.[2]

Metal.—Titanium sponge metal production rose 17 percent above that of 1962. Consumption of sponge metal also was at high level and output of titanium ingot was the second highest on record.

Commercial producers of titanium sponge metal were E. I. du Pont de Nemours & Co., Inc., Newport, Del.; U.S. Industrial Chemicals Co., Ashtabula, Ohio; and Titanium Metals Corp. of America (TMCA), Henderson, Nev.

[2] Skillings' Mining Review. Tahawus Mining Town Moved to New Site. V. 52, No. 49, Dec. 7, 1963, p. 12.

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]				
1954–58 (average)	627,246	637,723	331,834	$12,960
1959	634,886	637,263	342,746	12,106
1960	786,372	789,237	417,202	14,655
1961	782,412	782,629	410,191	[2] 13,320
1962	807,725	809,037	420,606	13,974
1963	888,400	890,071	470,271	16,529
RUTILE				
1954–58 (average)	9,206	8,212	7,723	1,099
1959	9,466	8,648	8,148	877
1960	8,808	[2] 9,226	9,065	[2] 957
1961	9,045	7,664	7,251	778
1962	9,981	8,033	7,617	933
1963	11,915	11,311	10,839	1,262

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite.
[2] Revised figure.

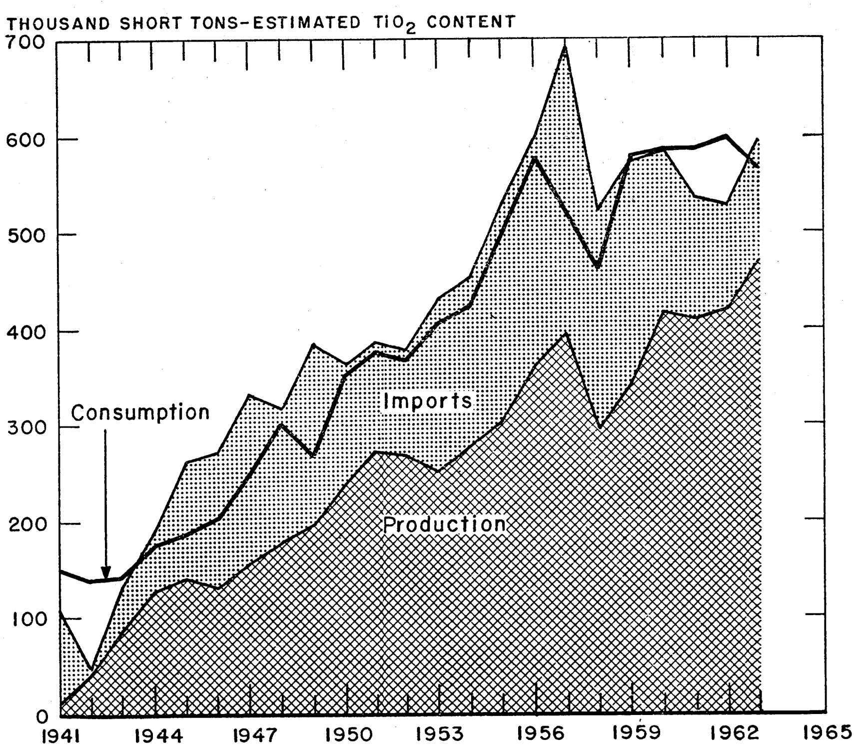

FIGURE 1.—Domestic production, imports, and consumption of ilmenite (includes titanium slags and mixed product), 1941–63.

Titanium melters were Harvey Aluminum, Inc., Torrance, Calif.; Bridgeport Brass Co. (Reactive Metals Products), Niles, Ohio; Oregon Metallurgical Corp., Albany, Oreg.; Crucible Steel Co. of America, Midland, Pa.; Republic Steel Corp., Massillon and Canton, Ohio; and TMCA, Henderson, Nev.

Oregon Metallurgical Corp. produced ingots and castings. The other companies produced and processed ingots into mill products such as sheet, strip, plate, forging billets, and bars. Harvey Aluminum, Inc., produced titanium castings in addition to other mill products. Ladish Co., Cudahy, Wis., processed ingots into forged products.

The Babcock & Wilcox Co., Beaver Falls, Pa., and the Wolverine Tube Division of Calumet & Hecla, Inc., Allen Park, Mich., produced titanium pipe, tubing, and extrusions. Titanium Products Corp. produced seamless titanium pipe at Grosse Point, Mich.

TABLE 3.—Titanium-metal data

(Short tons)

	1959	1960	1961	1962	1963
Sponge metal:					
Production	3, 898	5, 311	6, 727	6, 730	7, 879
Imports for consumption	1, 563	2, 231	2, 490	925	1, 468
Industry stocks	1, 100	1, 100	1, 200	1, 300	1, 400
Government stocks (DPA inventories)	22, 474	22, 474	22, 461	22, 461	22, 371
Consumption	3, 953	5, 487	6, 991	7, 136	8, 865
Scrap-metal consumption	1, 690	2, 527	2, 501	3, 160	2, 235
Ingot: [1]					
Production	6, 017	8, 297	9, 371	10, 400	11, 138
Consumption	5, 964	7, 978	8, 878	9, 773	10, 506
Mill shape production [2]	3, 211	5, 071	5, 647	[3] 6, 507	[3] 6, 112

[1] Includes alloy constituents.
[2] Bureau of the Census and Business and Defense Services Administration, Current Industrial Reports Series BDSAF-263 (63).
[3] 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 previous years.

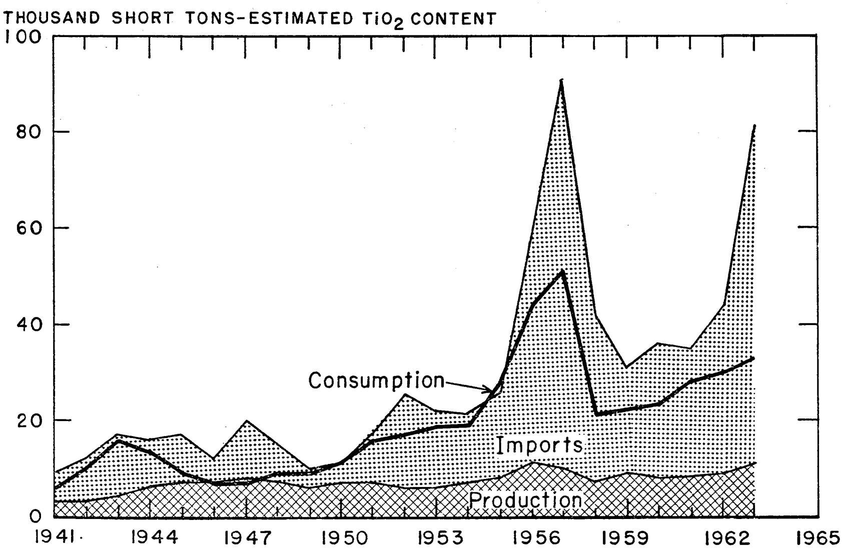

FIGURE 2.—Domestic production, imports, and consumption of rutile (excluding that used in 1961 through 1963 for making TiO_2 pigment), 1941–63.

Pigments.—On a gross-weight basis, production of titanium dioxide pigments decreased 4 percent and shipments increased 3 percent above the levels of 1962. Data on domestic production and shipments in table 4 are based on TiO_2 content.

Titanium pigments were produced by the following companies: American Cyanamid Co., Piney River, Va., and Savannah, Ga.; The Glidden Co., Baltimore, Md.; E. I. du Pont de Nemours & Co., Inc., Edge Moor, Del., Baltimore, Md., and New Johnsonville, Tenn.; National Lead Co., St. Louis, Mo., and Sayreville, N.J.; and The New Jersey Zinc Co., Gloucester City, N.J.

Cabot Titanium Corp. completed construction of its 20,000-ton-per-year plant at Ashtabula, Ohio, for producing titanium pigment via the chloride process.

American Potash & Chemical Corp. announced that its 25,000-ton-per-year chloride process titanium pigment plant would be built in Aberdeen, Miss.

Welding-Rod Coating.—A total of 265,000 tons of welding rods, containing titaniferous materials in their coatings, was produced. Of the total output, 45 percent contained rutile; 18 percent, ilmenite; 22 percent, a mixture of rutile and manufactured titanium dioxide; 9 percent, manufactured titanium dioxide; 3 percent slag; and 3 percent, miscellaneous mixtures.

TABLE 4.—Titanium pigment data (TiO_2 content)

Year	Production (short tons)	Shipments [1]	
		Quantity (short tons)	Value, f.o.b. (thousands)
1954–58 (average)	421,584	413,121	$211,962
1959	506,334	481,930	259,944
1960	455,583	468,228	252,835
1961	502,879	491,122	262,255
1962	523,201	513,822	270,438
1963	519,458	(2)	(2)

[1] Includes interplant transfers.
[2] Data not available.

Source: Facts for Industry and Current Industrial Reports series, M19A and M28A, Inorganic Chemicals, published jointly by the Bureau of the Census and Business and Defense Services Administration, U.S. Department of Commerce.

CONSUMPTION AND USES

Concentrates.—Consumption of ilmenite, which was used chiefly for making titanium dioxide pigment by the sulfate process, decreased 7 percent; however, titanium slag consumption, which is used cheifly for the same purpose, increased 10 percent. Rutile consumption, exclusive of that used for making titanium pigment and other uses not reported in table 5, was 11 percent more than in 1962. The use of rutile in producing titanium pigments was substantially higher than in 1962.

Metal.—Consumption of 8,900 tons of titanium sponge metal was 24 percent higher than in 1962. About one-fourth ton of titanium scrap was used for each ton of titanium consumed and a near record output of 11,000 tons of ingot was produced. Using shipments as a gage, titanium mill products consumption was 6 percent less than in 1962.

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
1954-58 (average)	771,741	406,429	126,452	89,251	34,270	32,505
1959	914,747	476,660	143,329	101,106	23,741	22,462
1960	868,080	464,614	120,492	85,095	24,229	22,942
1961	929,147	497,514	130,184	92,011	29,548	28,016
1962:						
Pigments	[2] 941,954	[2] 499,471	137,576	98,195	(3)	(3)
Titanium metal	(4)	(4)			13,633	13,126
Welding-rod coatings	503	298	453	318	15,492	14,627
Alloys and carbide	2,282	1,391	(5)	(5)	223	211
Ceramics	50	31			330	309
Fiber glass					1,018	993
Miscellaneous [6]	8	5	176	119	1,053	969
Total	944,797	501,196	138,205	98,632	31,749	30,235
1963:						
Pigments	[2] 872,747	[2] 458,128	152,151	108,458	(3)	(3)
Titanium metal	(4)	(4)			14,734	14,021
Welding-rod coating	523	307	207	146	17,444	16,465
Alloys and carbide	1,659	1,036	(5)	(5)	329	314
Ceramics	49	30			460	430
Fiber glass					939	915
Miscellaneous [6]	8	5	58	41	1,283	1,181
Total	874,986	459,506	152,416	108,645	35,189	33,326

[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite used to make pigments and metal.
[2] Includes ilmenite that was upgraded to a product containing more than 90 percent TiO_2 for use in making pigments and the losses of ilmenite incurred in upgrading the ilmenite.
[3] Figure withheld to avoid disclosing individual company confidential data.
[4] Included with "Pigments" to avoid disclosing individual company confidential data.
[5] Included with "Miscellaneous" to avoid disclosing individual company data.
[6] Includes consumption for chemicals and experimental purposes and losses in grinding.

According to a large producer, missile and space applications replaced military jet engines as the chief use for titanium. The estimated distribution of titanium mill product consumption was as follows:

Application:	*Percent*
Missile and space components	32
Military airframes	27
Jet engines	25
Civilian airplanes	9
Industrial (chemical)	4
Ordnance	2
Experimental (submarines)	1
Total	100

Wide use of titanium was scheduled for the Gemini two-man spacecraft.[3] The tricycle landing gear, the pressurized compartment for the crew, various pressure vessels, and the solid-fuel cases for the retrorockets were expected to be made largely of titanium and its alloys such as Ti-6Al-4V and Ti-7Al-4Mo. Tankage and other components of titanium were expected to be utilized in the Lunar Excursion

[3] Materials in Design Engineering. V. 58, No. 2, September 1963, p. 7.

Module scheduled to land on the moon. Solid rocket motors, tanks, and other components for a new upper-stage booster for the Titan III launch vehicle were scheduled to be built of titanium.[4]

Titanium was reported to be a basic material for America's supersonic transport (SST).[5] The SST was expected to fly at speeds between mach 2.2 and mach 3 (1,500 to 2,000 miles per hour) and use 15 to 50 tons of titanium per plane. Depending on the speed selected and the number of planes built, this could greatly increase the projected use of approximately 25,000 to 35,000 tons a year of titanium sponge metal in the 1970's.

Titanium was used in fabricating experimental sections for testing the feasibility of using the metal for deep-diving submarines.[6]

Industrial uses of titanium continued to grow at a faster rate than other uses. Titanium tubing and plates were planned for use in equipment for flash evaporation of sea water to produce fresh water to be installed at the Harvey Aluminum Co. alumina plant at St. Croix, V.I.[7] Several types of ball valves were constructed of titanium for use in wet chlorine, electroplating solutions, oxidizing agents, and brines.[8] An all-titanium anodizing rack was used in the production of anodized aluminum parts. The titanium frame does not draw current, such as encountered in metal to metal contacts, and the need for a protective coating of plastic is eliminated.[9]

A titanium heat exchanger, used to cool chlorinated brine, cost one company $140 more than a conventional graphite unit, but was expected to save the company $9,000 in replacement costs in 6 years.

A new calcium hypochlorite plant being built at Charleston, Tenn., was scheduled to use 1,750 feet of 3-inch titanium pipe and 500 feet of thin-wall 3-inch tubing.[10]

Technical developments resulted in marketing of new and improved titanium shapes, such as an all-titanium locknut, utilizing a special solid lubricant coating which can be used with steel bolts;[11] titanium rods of 99.9999 per cent purity for materials research with thin film capacitors and other electronic and aerospace devices;[12] seamless and welded tubing; and titanium plate, one-half inch thick, 10 feet wide, and 30 feet long, for use as a tank containing nitric acid.[13]

A titanium-aluminum alloy was used in the valve train of the motor of a British racing car.[14]

Pigments.—Consumption of titanium pigments based on gross weight and using shipments as a gage, increased 3 percent above 1962.

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[4] American Metal Market. Space Vehicle To Use Titanium. V. 70, No. 207, Oct. 25, 1963, pp. 1, 14.

[5] Cooke, Richard P., Titanium Likely To Be Basic Material in U.S. Supersonic Transport. Advocates Say Weight Saving Would Override High Cost: A Boost for Versatile Metal? Wall Street J., v. 161, No. 121, June 21, 1963, pp. 1, 16.

[6] American Metal Market. Nuclear Metals To Develop Titanium Alloy for Deep Diving Submarine. V. 70, No. 75, Apr. 19, 1963, p. 13.

[7] American Metal Market. Titanium Used in Water Desalting Unit at Harvey Alumina Plant. V. 70, No. 183, Sept. 23, 1963, p. 15.

[8] Iron Age. Titanium Ball Valves Handle Corrosives. New Materials and Components. V. 192, No. 24, Dec. 12, 1963, p. 110.

[9] E&MJ Metal and Mineral Markets. V. 34, No. 52, Dec. 30, 1963, p. 8.

[10] American Metal Market. Astro Completes Big Titanium Tube Order for Olin Chemical Plant. V. 70, No. 152, Aug. 8, 1963, pp. 1, 11.

[11] Iron Age. All-Titanium Fastener. V. 192, No. 7, Aug. 15, 1963, p. 15.

[12] Ruth, John P. NRC Develops 99.9999% Pure Titanium For Thin Film and Aerospace Devices. American Metal Market, v. 71, No. 43, Mar. 3, 1963, p. 9.

[13] American Metal Market. Largest Titanium Plate. V. 70, No. 233, Dec. 6, 1963, p. 14.

[14] Metallurgia (England). Titanium Alloy in B.R.M. V. 67, No. 404, June 1963, p. 294.

The Bureau of Mines canvass of titanium-pigment producers was expanded to obtain additional data on shipments to include four new categories, formerly reported as "Other." These are roofing granules, ceramics, plastics, and exports. Beginning in 1963, shipments to industries in the "Other" category included welding rods, leather, shoe dressing, and synthetic fabrics.

TABLE 6.—Distribution of titanium-pigment shipments, by industries [1]

(Percent)

Industry	1954–58 (average)	1959	1960	1961	1962	1963
Distribution by gross weight:						
Paints, varnishes, and lacquers	65.1	64.8	65.1	63.4	61.9	63.3
Paper	10.6	11.7	11.3	12.5	13.0	12.5
Floor coverings (linoleum and felt base)	4.5	4.9	4.8	4.5	4.7	4.3
Rubber	3.5	4.2	4.0	4.1	4.2	4.0
Coated fabrics and textiles (oilcloth, shade cloth, artificial leather, etc.)	2.8	3.1	2.8	3.3	3.3	2.0
Printing ink	1.3	1.7	1.3	1.6	1.7	1.6
Roofing granules	(2)	(2)	(2)	(2)	(2)	2.1
Ceramics	(2)	(2)	(2)	(2)	(2)	1.2
Plastics (except floor covering and vinyl-coated fabrics and textiles)	(2)	(2)	(2)	(2)	(2)	2.9
Other	12.2	9.6	10.7	10.6	11.2	1.8
Export	(2)	(2)	(2)	(2)	(2)	4.3
Total	100.0	100.0	100.0	100.0	100.0	100.0
Distribution by titanium dioxide content:						
Paints, varnishes, and lacquers	57.8	58.2	58.5	57.0	55.3	57.0
Paper	14.1	15.1	14.6	15.7	16.2	15.5
Floor coverings (linoleum and felt base)	5.3	6.3	6.2	5.6	5.8	5.2
Rubber	4.5	5.4	4.9	5.1	5.2	4.9
Coated fabrics and textiles (oilcloth, shade cloth, artificial leather, etc.)	3.6	3.9	3.5	4.1	4.0	2.0
Printing ink	1.8	2.2	1.7	2.0	2.1	2.0
Roofing granules	(2)	(2)	(2)	(2)	(2)	2.6
Ceramics	(2)	(2)	(2)	(2)	(2)	1.5
Plastics (except floor covering and vinyl-coated fabric and textiles)	(2)	(2)	(2)	(2)	(2)	3.7
Other	12.9	8.9	10.6	10.5	11.4	2.2
Export	(2)	(2)	(2)	(2)	(2)	3.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

[1] Data based on figures supplied to the Bureau of Mines by producers.
[2] Data not available. Included with "Other."

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
1962:						
Mine	29,121	14,387			9,148	8,605
Distributor	254	149			5,701	5,431
Consumer	572,071	313,504	140,152	100,095	60,538	57,522
Total	601,446	328,040	140,152	100,095	75,387	71,558
1963:						
Mine	27,450	13,675			9,752	9,337
Distributor	224	131			6,469	6,158
Consumer	625,581	346,118	105,541	75,315	76,572	73,073
Total	653,255	359,924	105,541	75,315	92,793	88,568

STOCKS

Industry stocks of rutile and ilmenite increased 23 and 9 percent, respectively. Titanium-slag inventories decreased 25 percent. Government stocks of rutile on December 31 totaled 46,238 tons, of which 18,599 tons was in the national (strategic) stockpile; 16,007 tons was in Defense Production Act (DPA) inventories; and 11,632 tons was in the supplemental stockpile.

Yearend stocks of titanium sponge metal held by producers, smelters, and semifabricators totaled 1,400 tons, compared with 1,300 tons on hand at the end of 1962. Titanium metal scrap held by melters and semifabricators at yearend was 3,400 tons, 100 tons more than in 1962. Government-held stocks of titanium sponge metal totaled 31,392 tons, 22,371 tons in DPA inventories, and 9,021 tons in the supplemental stockpile.

PRICES

Concentrates.—The price quoted for ilmenite in E&MJ Metal and Mineral Markets remained unchanged at $23 to $26 per long ton (59.5 percent TiO_2, f.o.b. Atlantic seaboard).

The quoted price of rutile (94 percent TiO_2, f.o.b. Atlantic seaboard) increased from $95 per short ton at the end of 1962 to $104 per short ton at the end of 1963.

Manufactured Titanium Dioxide.—The base prices of rutile and anatase grades of manufactured titanium dioxide pigment and calcium-rutile base titanium pigments were unchanged. The half-cent-per-pound price differential on shipments of one company's titanium pigment to users west of the Rocky Mountains was eliminated. Some reductions of the base price was given to purchasers of large lots. The following prices were quoted in the Oil, Paint and Drug Reporter at yearend:

	Price per pound
Anatase, 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.—Prices per pound for various grades of titanium sponge metal at the begining of 1963 ranged from $1.32 to $1.60, and at the end of the year from $1.27 to $1.60.

Quoted prices of most titanium mill shapes were unchanged during the year. Prices per pound of mill shapes (f.o.b. mill, commercially pure grades, in lots of 10,000 pounds) were quoted in December as follows:

Sheet	$4.90–$5.10
Strip	4.90– 5.10
Plate	3.80– 4.00
Wire	3.50– 3.80
Forging billets	2.40– 2.55
Hot-rolled bars	3.15– 3.35

Ferrotitanium.—Nominal prices at yearend for various grades of ferrotitanium were quoted in E&MJ Metal and Mineral Market as follows:

	Price
Low-carbon:[1]	
Titanium, 40 percent; carbon, 0.10 percent maximum	$1.35
Titanium, 25 percent; carbon, 0.10 percent maximum	1.50
Medium-carbon:[2]	
Titanium, 17 to 21 percent; carbon, 3 to 5 percent	375
High-carbon:[2]	
Titanium, 15 to 19 percent; carbon, 6 to 8 percent	310

[1] Price per pound contained titanium in 1 ton or more, lump (½-inch, plus), packed; f.o.b. destination northeastern United States.
[2] Price per short ton, carload lots, lump, packed; f.o.b. destination northeastern United States.

FOREIGN TRADE

Imports.—Increased imports of ilmenite (chiefly titanium slag) from Canada and resumption of imports of Indian ilmenite resulted in a 21-percent increase in the total. Rutile imports from Australia were double those of the previous year and reflected the increased demand for rutile used in making titanium dioxide.

Imports of titanium metal totaled 1,468 short tons, 59 percent higher than in 1962. As in past years Japan with 1,318 tons accounted for most of the total; however, imports of 133 tons from the United Kingdom were the highest recorded from that country. Canada, with almost 17 tons, and West Germany accounted for the remainder. Of the totals, about 7 tons from Canada and 3 tons from the United Kingdom were free under certain public laws. The remainder was dutiable.

Imports of titanium dioxide and titanium pigments totaled 25,277 tons, nearly double the quantity brought in during 1962. The chief sources of imported pigment were France, 4,927 tons; Japan, 5,106 tons; Finland, 8,944 tons; Italy, 2,879 tons; West Germany, 1,887 tons; and Spain, 1,500 tons. Most of the remainder came from the United Kingdom and Canada. About 270 tons of titanium compounds was imported.

Exports.—Titanium dioxide and pigment exports totaling 26,702 tons, declined for the seventh successive year. As in past years, Canada, receiving 10,884 tons, was the destination of most of the exports. Other countries that received more than 1,000 tons were as follows: The Philippines, 2,272 tons; Mexico, 1,889 tons; Italy, 1,107 tons; The Netherlands, 1,564 tons; the United Kingdom, 1,142 tons; and Belgium-Luxembourg, 1,030 tons.

Exports of 1,212 tons of titanium ores and concentrates included 790 tons to Canada, 200 tons to Hong Kong, and 75 tons to Iran. Smaller quantities were sent to Colombia, West Germany, Kuwait, Argentina, Mexico, and the United Kingdom.

Titanium sponge and scrap exports increased 5 percent over that of 1962. Of the 1,261 tons exported, the United Kingdom was shipped 1,056 tons, West Germany, 77 tons, and most of the remainder was sent to France, Austria, The Netherlands, Italy, and Sweden.

TABLE 8.—U.S. imports for consumption of titanium concentrates[1] by countries

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
Ilmenite:						
Australia	4,587	47,317	33,089	35,362	57,941	52,883
Canada[2]	160,225	157,296	104,243	127,123	108,493	133,885
India	188,161	167,074	128,313	44,666		14,112
Malaya, Federation of	6,229					(3)
Other countries	25					
Total: Short tons	359,227	371,687	265,645	207,151	166,434	200,880
Value	[4] $7,661,108	$7,991,208	$5,066,502	$5,017,911	$4,469,648	$5,087,539
Rutile:						
Australia	[5] 40,917	22,954	27,847	26,047	35,542	71,990
South Africa, Republic of		274	1,358	1,450	424	
Other countries	42		30			
Total: Short tons	[5] 40,959	23,228	29,235	27,497	35,966	71,990
Value	$5,362,335	$2,943,258	$3,610,616	$2,544,312	$2,646,174	$4,920,526

1 Clasified as "ore" by the Bureau of the Census.
2 Chiefly titanium slag averaging about 70 percent TiO_2.
3 Less than 1 ton.
4 Data known to be not comparable with other years.
5 Excludes 19 tons rutile content of zirconium ore as reported to the Bureau of Mines by importers.

Source: Bureau of the Census.

Exports of primary forms of titanium metal decreased to 494 tons. Of this total, 238 tons went to Canada, 135 tons to France, 103 tons to West Germany, and most of the remainder to Italy and Japan. Of the 211 tons of titanium ferroalloys exported, Canada received 162 tons; The Netherlands, 11 tons; and most of the remainder went to Belgium-Luxembourg, United Kingdom, Sweden, Mexico, and the Republic of South Africa.

TABLE 9.—U.S. exports of titanium products, by classes

Year	Ores and concentrates		Metal and alloys in crude form and scrap[1]		Primary forms, n.e.c.[2]		Ferroalloys		Dioxide and pigments	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1954–58 (average)	1,382	$208,177	48	$290,768	376	$5,547,142	294	$104,382	54,587	$19,561,211
1959	4,656	289,507	496	543,104	499	5,161,074	321	145,621	36,282	10,558,287
1960	1,260	166,685	879	868,846	426	3,237,949	245	157,419	33,655	10,000,884
1961	1,436	190,480	886	926,783	384	2,702,322	212	93,389	31,104	9,215,839
1962	1,224	166,987	818	925,495	561	4,102,113	130	95,265	29,095	8,636,350
1963	1,212	176,231	1,261	1,232,245	494	3,443,940	211	182,828	26,702	8,051,111

1 Beginning Jan. 1, 1955, classified as sponge and scrap.
2 Beginning Jan. 1, 1955, classified as intermediate mill shapes and mill products, n.e.c. (not elsewhere classified).

Source: Bureau of the Census.

WORLD REVIEW

The United States continued to be the principal source of ilmenite and the chief market for ilmenite and rutile in the non-Communist world. Australia was the leading rutile producer, accounting for approximately 93 percent of the total. In addition to the 20,000-ton-per-year titanium dioxide plant completed in the United States, new titanium pigment plants and expansion of existing plants were completed in Australia, Canada, and West Germany. Further expansions were reported underway in France, Spain, India, and Japan.

TABLE 10.—World production of titanium concentrates (ilmenite and rutile) by countries [1] [2]

(Short tons)

Country [1]	1954–58 (average)	1959	1960	1961	1962	1963
Ilmenite:						
Australia (shipments)	32,789	93,606	119,377	186,369	204,000	224,000
Canada [3]	188,127	270,477	389,586	463,362	301,449	379,321
Ceylon	----------	----------	7,000	3,071	4,652	21,041
Finland	99,366	94,966	92,219	21,272	96,110	120,398
Gambia	9,673	14,553	----------	----------	----------	----------
India	320,826	334,024	275,303	192,018	152,241	28,619
Japan (titanium slag)	6,059	3,445	1,444	1,774	578	963
Malagasy Republic (Madagascar)	[4] 1,151	659	3,008	3,640	3,510	[5] 3,300
Malaya (exports)	86,768	81,593	132,255	119,695	113,856	164,656
Mexico	[6] 45	----------	----------	----------	----------	155
Mozambique	----------	11,400	784	----------	----------	----------
Norway	202,740	250,206	258,542	342,723	276,790	[5] 275,600
Portugal	601	2,113	1,002	109	75	[5] 65
Senegal	27,624	32,941	24,159	19,286	24,727	[5] 14,300
South Africa, Republic of	7,301	87,233	90,432	99,010	87,096	31,039
Spain	8,541	8,113	12,267	33,184	45,935	69,297
Thailand	[7] 1,116	550	----------	----------	----------	----------
United Arab Republic (Egypt)	3,373	17,100	13,200	38,004	49,210	596
United States [8]	627,246	634,886	786,372	782,412	807,725	888,400
World total ilmenite (estimate) [1] [2]	1,623,300	1,937,900	2,207,000	2,305,900	2,168,000	2,222,000
Rtuile:						
Australia	92,584	91,734	99,274	113,603	133,497	203,800
Brazil	235	231	238	245	144	144
Cameroon, Republic of	64	----------	----------	----------	----------	----------
India	385	429	1,082	898	1,770	2,062
Norway	12	----------	----------	----------	----------	----------
Senegal	410	----------	----------	187	811	[5] 830
South Africa, Republic of	[9] 292	3,381	3,695	3,483	3,575	1,385
United Arab Republic (Egypt)	----------	1,157	[5] 1,100	[5] 1,100	198	4
United States	9,206	9,466	8,808	9,045	9,981	11,915
World total rutile (estimate) [1] [2]	103,200	106,400	114,200	128,600	150,000	220,100

[1] Titanium concentrates are produced in Brazil and the U.S.S.R. but no reliable figures are available; no estimates are included in the total.
[2] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[3] Represents titanium slag containing approximately 70 percent TiO_2 and small quantities of "titanium ore."
[4] 1 year only, as 1958 was the first year of commercial production.
[5] Estimate.
[6] Average annual production 1955–58.
[7] Average annual production 1956–58.
[8] Includes a mixed product containing ilmenite, leucoxene, and rutile.
[9] Average annual production 1957–58.

TABLE 11.—Production of titanium sponge metal, by countries

(Short tons)

Country	1959	1960	1961	1962	1963
France	25	25	25	30	30
Japan	2,730	2,543	2,516	1,696	1,939
United Kingdom	350	----------	----------	----------	----------
United States	3,898	5,311	6,727	6,730	7,879
Total	7,003	7,879	9,268	8,456	9,848

NORTH AMERICA

Canada.—Quebec Iron & Titanium Corp. (QIT) resumed operation of its titanium ore smelter at Sorel, Quebec, in April, after a 7-month strike, and operated at full capacity for the remainder of the year. Total output for the year was the third highest on record.[15] A new 2-year labor agreement, expiring March 18, 1965, was reached at Sorel and a 3-year contract was made at the Lac-tio mine, Harvre St. Pierre.

TABLE 12.—Consumption of titanium dioxide and extended titanium dioxide pigments in Canada

(Short tons)

	1959	1960
Refined titanium dioxide (TiO_2):		
Industrial chemicals	(1)	7
Other chemicals	(1)	302
Linoleum and coated products	2,301	1,860
Paint and varnish	15,316	16,334
Polishes and dressings	128	(1)
Pulp and paper mills	2,244	2,461
Rubber	871	766
Synthetic textile mills	(1)	46
Toilet preparations	(1)	14
Other nonmetallic minerals	516	618
Total	21,376	22,408
Extended titanium dioxide pigments: Paints	[2] 14,489	[2] 13,986

1 Not listed separately.
2 Estimated TiO_2 content 4,300 tons in 1959 and 4,151 tons in 1960

TABLE 13.—Quebec Iron & Titanium Corp. smelting operations

(Short tons)

	1954–58 (average)	1959	1960	1961	1962	1963
Ore smelted	437,111	626,310	967,373	1,155,977	745,753	915,360
Titanium slag produced	184,910	243,700	386,639	463,361	301,448	379,320
Estimated TiO_2 content	133,079	175,464	278,380	333,620	217,048	273,110
Value of slag produced	$6,407,629	$8,509,149	$14,257,292	(1)	(1)	(1)
Desulfurized iron produced	135,431	163,509	248,578	310,360	207,190	251,943

1 Data not available.

According to the Canadian Department of Mines and Technological Surveys, QIT owned one of the world's largest known reserves of ilmenite—150 million tons of measured and indicated ore averaging 35 percent titanium dioxide (TiO_2) and 40 percent iron, and additional millions of tons of inferred ore.[16] QIT smelted virtally all of the ilmenite-hematite ore mined in eight electric-arc furnaces, 50 feet long, 20 feet deep, and 20 feet wide, producing a slag containing 72 percent TiO_2.[17] Some ore was shipped for use as heavy aggregate for concrete shielding of nuclear reactions, a weighting material for oil and gas transmission lines, and diesel locomotive ballast.

15 Kennecott Copper Corp. Annual Report 1963, pp. 9–11.
16 Schneider, V. B. Titanium. Canadian Dept. of Mines and Tech. Surveys, 1962, 14 pp.
17 Skillings, David N., Jr. Q.I.T. 15 Years of Pioneering. Skillings' Min. Rev., v. 52, No. 28, July 13, 1963, pp. 4, 5, 19.

Production of titanium dioxide pigment from the new British Titan Products (Canada) Ltd., plant at Tracy, Quebec, was started. The plant, costing $15.4 million, has a rated capacity of 22,000 short tons of TiO_2 per year.[18]

EUROPE

Czechoslovakia.—Titanium sheet metal and other items were reportedly produced at the "Kovoshute" Metallurgical Enterprise in Rokycany; production of seamless titanium tubes was planned at the Pipe Rolling Mills and Iron Works in Chomutov; and the Research Institute of Metals increased its output of titanium ingot.[19]

France.—Fabriques de Produits Chimiques de Thann et de Mulhouse, with a 14,000-short-ton-per-year plant at Strasbourg and the 36,000-ton-per-year plant of its subsidiary, Le Produits du Titane, S.A., at Le Havre, was the sole producer of titanium dioxide pigments. The company planned to build a 22,000-ton-per-year TiO_2 plant at Thann (Strasbourg) which would utilize the chloride process.[20] The Thann subsidiary, Societé Postosse et Produits Chimiques, was expected to supply chlorine for the plant.

British Titan Products announced that it intended to construct a 25,000-ton-per-year titanium dioxide plant at Calais or some other location in the Common Market area.[21] Estimated cost of the plant was $20 million.

Germany, West.—Pigment-Chemie G.m.b.H. started production of titanium dioxide pigment from its new 20,000-ton-per-year plant at Hamburg.[22] Pigment-Chemie, which is 74 percent owned by Sachtleben A.G. fur Bergbau of Cologne and 26 percent by Du Pont, Wilmington, Del., planned to market the pigment in 30 countries.

Total annual capacity for the TiO_2 production was estimated at 165,000 short tons, composed of an 89,000-ton plant at Leverkusen (Titangesellshaft m.b.H.) and a 56,000-ton plant at Uerdingin (Farbenfabrikin Bayer A.G.) in addition to the Hamburg plant.

Italy.—Production of titanium pigment in 1955 was reportedly 3,900 short tons and rose to 38,000 tons in 1962. Output was expected to total 52,800 tons by 1965.[23]

Netherlands.—N.V. Titaandioxydefabriek continued operation of its 12,000-ton-per-year plant in the Botlek Harbour district of Rotterdam.[24] The plant's annual sulfuric acid requirement is about 40,000 tons. The company, which previously produced only the anatase grade, began production of rutile-type pigment.[25]

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[18] Chemical Age (London). B.T.P. in Production With New Canadian Titanium Oxide Unit. V. 89, No. 2270, Jan. 12, 1963, p. 100.

[19] Technicky Tydenik. Use of Titanium in Industry. June 26, 1963, p. 3.

[20] Chemical Trade Journal and Chemical Engineer (London). France. V. 152, No. 3961, May 10, 1963, p. 745.

[21] Chemical Age (London). Finance Difficulties Hold Up B.T.P. Calais Titanium Oxide Plans. V. 90, No. 2311, Oct. 26, 1963, p. 642.

[22] Oil, Paint and Drug Reporter. Germany TiO_2 Facility Starts Up Production. V. 183, No. 7, Feb. 18, 1963, pp. 5, 30.

[23] Chemical Age (London). More Titanium Oxide in Italy. V. 91, No. 2327, Feb. 15, 1964, p. 265.

[24] Chemical Trade Journal and Chemical Engineer (London). Holland. V. 152, No. 3952, March 8, 1963, p. 390.

[25] Chemical Trade Journal and Chemical Engineer (London). Rutile to be Produced. V. 153, No. 3986, Nov. 1, 1963, p. 680.

Spain.—Reports indicated that capacity of the Union Quimica del Norte de España, S.A., titanium dioxide plant at Axpe would be raised from 8,000 tons to 13,100 tons per year.

United Kingdom.—A semicommercial plant for producing titanium dioxide by the chloride process (described in the Technology section) was completed.[26] The plant, located at Stallingborough, near Grimbsy, was being developed jointly by Laporte Titanium, Ltd., and the American Potash & Chemical Corporation (U.S.A.), and the process was expected to be used at a new plant in Aberdeen, Miss., in the United States, which was being built by the American company.

Imperial Metal Industries, Ltd. (IMI), a wholly owned subsidiary of Imperial Chemical Industries, Ltd. (ICI), planned to resume titanium sponge metal production at its Bain Works in Wilton, North Yorkshire. The titanium sponge plant had an annual capacity of 1,800 tons when it was closed in 1959 and was expected to begin operations again in mid-1964.

IMI uses sodium metal to reduce titanium tetrachloride and produce finely divided granules of titanium. Melting is done at Wilton, North Yorkshire, in three consumable-arc furnaces capable of producing 2,000 tons of ingot a year. IMI melts other metals such as zirconium, special steels, and nickel alloys as well as titanium at Wilton, and planned to install a new furnace costing about $280,000 that will be twice the size of the largest installed at the plant in 1963.[27]

ASIA

Ceylon.—The Mineral Sands Corp. of Ceylon (Government of Ceylon) reportedly signed a 10-year agreement to supply ilmenite to a Japanese firm. Prices were to be negotiated from time to time.[28] Apparently, production-cost difficulties at the mine at Pulmoddai were overcome.[29]

India.—Ilmenite is concentrated in certain areas along the beaches of Kerala and Madras States between Nandikaria, north of Quilon, on the west coast, to Cape Comarin and up the east coast to Lipurum in Tirunelvelli District, a distance of nearly a hundred miles. Smaller patches of similar sands also occur on the beaches of the Malabar, Ramannathapuram, Tanjore, Visakhapatnam, Gamjam, and Ratnagiri Districts. India's reserve of ilmenite in beach sands is estimated at 350 million tons. Beach sands in Chavara, near Quilon, Kerala, where most of the ilmenite was mined in 1963, contain 65 to 75 percent ilmenite, 3 to 4 percent rutile, 5 to 10 percent zircon, 5 to 10 percent sillimanite, 5 to 10 percent quartz, and about 1 percent monazite.

Despite the abundance of ilmenite in India's beaches, changes in titanium dioxide production technology, development of new sources (especially in Australia and Canada), Government (Kerala) policy, technical difficulties in separating impurities in Indian ilmenite, and a high ferric iron content, have led to a steady decline in production

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[26] Chemical Trade Journal and Chemical Engineer (London). Laporte and Chlorine Titanium Oxide Process. V. 153, No. 3990, Nov. 29, 1963, p. 811.
[27] Metal Bulletin. What's New at Witton. Nov. 22, 1963, pp. 13–14.
[28] Mining Journal (London). Ceylon Ilmenite. V. 261, No. 6694, Dec. 6, 1963, p. 548.
[29] Mining Journal (London). Ilmenite Industry in Ceylon. V. 258, No. 6605, Mar. 23, 1962, p. 296.

of ilmenite since 1956. India, which was the world's leading supplier of ilmenite prior to World War II and was second only to the United States until 1960, was the ninth leading world producer in 1963.

Tentative plans for modernizing ilmenite processing plants were reportedly made and negotiations were underway for expanding ilmenite export to Japan and Czechoslovakia.[30]

Travancore Titanium Products, Ltd., the only titanium-pigment producer, planned to increase daily output at its Trivandrum, Kerala, plant from 11 tons to 20 tons. The company was operating a pilot plant to use its waste sulfuric acid for manufacturing ammonium sulfate by a German process.[31] The Kerala Government was considering a proposal to build a new 27-ton-a-day titanium dioxide plant as part of a growing chemical-industry complex at Alwaye. Byproduct sulfuric acid from a proposed zinc smelter at Alwaye would be utilized.

Laporte Titanium, Ltd., postponed for an indefinite period its plans for a 4,900-ton titanium dioxide plant at Bombay, known as M/S Botanium.[32]

The expansion at Trivandrum and construction of the new plant at Alwaye would bring India's annual titanium dioxide production capacity to about 20,000 short tons compared with the present capacity of 4,000 tons. Annual consumption was estimated at 35,000 tons in 1963.

Japan.—Toho Titanium Co., at its Chigasaki plant in Kanagawa Prefecture, and Osaka Titanium, Ltd., at its plant in Hyogo Prefecture, continued to produce titanium sponge metal. Combined annual capacity of the two plants was 4,900 short tons, Toho accounting for 2,600 tons and Osaka, 2,300 tons. Nippon Soda, Ltd., produced titanium metal at a 500-ton-per-year plant at Aizu, Fukushima Prefecture, until mid-1960, and shipped all of its stockpiled sponge metal in 1963. Based on data on total shipments by producers in the first quarter, domestic consumption in 1963 was estimated at about 800 short tons.

Kobe Steel Works Co. obtained permission from the Coordinating Committee for Exports to Communist countries (COCOM) to export 60 tons of titanium pipe to the Soviet Union, for use in a petrochemical plant.[33] Kobe also concluded a contract with Vereinigte Deutsche Metallwerke, a West German firm, to supply 15 tons of titanium metal slab (ingot).[34]

Based on various reports [35] estimated and planned annual titanium dioxide production capacity at the end of 1963 was estimated as follows:

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[30] Chemical Trade Journal and Chemical Engineer (London). India. V. 152, No. 3954, Mar. 22, 1963, p. 474.
Engineering and Mining Journal. V. 164, No. 5, May 1963, p. 157.

[31] Chemical Age (London). Plastics and Tariff Cuts. Indian TiO_2 Firm Plan Expansion. V. 90, No. 2312, Nov. 2, 1963, p. 682.
Chemical Trade Journal and Chemical Engineer (London). More Titanium Oxide. V. 153, No. 2987, Nov. 8, 1963, p. 712.

[32] European Chemical News (London). Laporte's Indian TiO_2 Venture Shelved. V. 4, No. 84, Aug. 23, 1963, p. 24.

[33] Mining Journal (London). COCOM Sanctions Japan's Russian Deal. V. 260, No. 6663, May 3, 1963, pp. 433–434.

[34] Metal Bulletin (London). Kobe Exporting Titanium to W. Germany. No. 4832, Sept. 24, 1963.

[35] Chemical Trade Journal and Chemical Engineer (London). Japan. V. 152, No. 3950, Feb. 22, 1963, p. 304.
Oil, Paint and Drug Reporter. Sakai, of Japan, Weighs a Boost in TiO_2 Capacity. V. 183, No. 9, Mar. 4, 1963, p. 7.

	Short tons TiO_2 (est.) December 1963	December 1965
Titanium Industry Co., Ltd	7, 900	10, 000
Teikoku Kako Co., Ltd	13, 200	15, 000
Furukawa Mining Co., Ltd	13, 200	15, 000
Sakai Chemical Industry Co., Ltd	9, 900	10, 000
Ishihara Sangyo Kaisha, Ltd	35, 000	45, 000
Fuji Titanium Industry Co., Ltd	9, 400	15, 000
Total	88, 600	110, 000

AFRICA

Sierra Leone.—Arrangements for commercial development of reportedly large deposits of rutile were nearing completion by Pittsburgh Plate Glass Co. and British Titan Products Co., Ltd.[36]

Senegal.—Societé Minière Graziello et Cie., a wholly owned subsidiary of Thann et de Mulhouse (France), was installing facilities to mine new deposits in the M'Bour-Joal area to triple output in 1964. The plant will be designed to produce 60,000 tons of ilmenite, 10,000 tons of zircon, and 1,000 tons of rutile per year.[37] Reserves in the area were said to contain 1.2 millions tons of ilmenite.[38]

South Africa, Republic of.—The Rutile-Zircon-Titanium Corp., was registered to operate a titanium mine in the Komga district near East London. Over 800 tons of ore reportedly was processed in a pilot plant. The company planned to concentrate on production of rutile and zircon and stockpile the ilmenite.[39]

Umgababa, Minerals, Ltd., continued to produce ilmenite and rutile concentrates at Natal, but was reportedly closed by the Government for polluting offshore sea water by effluent from the plant.[40]

OCEANIA

Australia.—The Bureau of Mineral Resources estimated world demand for rutile (or titanium dioxide from other sources) in 1970 at 500,000 short tons per year, about 310,000 tons for pigment and 190,000 tons for other uses.[41] It was postulated that Australian rutile production would reach about 330,000 tons in 1970 and African output from deposits in Sierra Leone and South Africa might reach 110,000 tons.

Reflecting the market increase in demand for rutile for making titanium pigments, the first bulk shipment, consisting of 18,000 tons, was made from Brisbane.[42]

Laporte Titanium (Australia), Ltd., opened its 10,000-ton-per-year titanium-pigment (anatase and rutile grades) plant at Bunbury, Western Australia, in November, 18 months after construction started. The plant, which cost $9.8 million, employs about 250 men and at full

[36] Chemical Week. V. 93, No. 25, Dec. 21, 1963, p. 20.
[37] Mining Journal (London). Senegalese Beach Sand Mining. V. 261, No. 6673, July 12, 1963, p. 41.
[38] Mining Journal (London). Senegalese Ilmenite Expansion. V. 260, No. 6661, Apr. 19, 1963, p. 373.
[39] Mining Journal (London). New S. African Titanium Mine. V. 260, No. 6654, Mar. 1, 1963, p. 208.
[40] Mining Magazine (London). V. 108, No. 6, June 1963, p. 356.
[41] The Australian Mineral Industry. V. 16, No. 2, pt. 1 and 2, December 1963.
[42] Daily Commercial News and Shipping List. Shipping and Commerce of Australia Annual. Special issue, Dec. 30, 1963.

capacity, would require 25,000 tons of ilmenite and 40,000 tons of sulfuric acid.[43] Australian Titan Products Co., Ltd., was nearing completion of construction to expand its capacity of 12,000 tons to 24,000 tons per year.[44]

TABLE 14.—Australia: Exports of ilmenite concentrates by countries

(Short tons)

Destination	1959	1960	1961	1962	1963 [1]
France	6,274	2,011	4,563	115	(2)
Japan	9,969	25,500	31,799	30,776	(2)
Netherlands	34	698	12,533	46	(2)
United Kingdom	354	35,159	76,813	84,426	(2)
United States	60,108	20,377	35,334	57,983	(2)
Other countries	148	612	248	338	(2)
Total	76,887	84,357	161,290	173,684	58,658

[1] January through June, inclusive.
[2] Countries of destination not available for 1963.

TABLE 15.—Australia: Exports of rutile concentrates by countries [1]

(Short tons)

Destination	1959	1960	1961	1962	1963 [2]
Belgium	1,390	1,314	2,846	3,725	(3)
France	7,482	9,675	8,084	8,211	(3)
Germany, West	10,037	10,546	9,855	9,521	(3)
Italy	3,519	4,536	6,030	7,587	(3)
Japan	7,967	9,042	13,765	9,298	(3)
Netherlands	12,243	11,091	13,590	17,387	6,096
Sweden	2,824	3,771	4,013	4,785	(3)
United Kingdom	9,690	14,243	15,989	19,017	8,750
United States	25,241	29,360	26,357	35,625	26,697
Other countries	10,258	11,372	11,081	16,210	25,820
Total	90,651	104,950	111,610	131,366	67,363

[1] This table incorporates some revisions.
[2] January through June, incluseive.
[3] Data not separately recorded.

Kootenay Base Metals (Consolidated), Ltd., planned to produce 10,000 tons a year each of rutile and zircon concentrate from sand deposits on Bribie Island, north of Brisbane, Queensland.[45] The deposit was said to have a proven reserve of 5 million tons containing 3.7 percent heavy minerals, a probable reserve of 2.5 million tons containing 3.76 percent heavy minerals, and a possible reserve of 13 million tons with 2 percent heavy minerals.[46]

TECHNOLOGY

The results of several titanium resource studies in Idaho, Montana, and Virginia were published.[47] A good potential for large low-grade

[43] Chemical Age (London). Australian P.M. Opens Laporte's TiO_2 Plant. V. 90, No. 2313, Nov. 9, 1963, p. 724.
[44] Queensland Government Mining Journal (Australia). No. 740, June 1963, pp. 387–388.
[45] Metal Bulletin (London). Ambitious Rutile Plans. No. 4824, Oct. 29, 1963, pp. 21–22.
[46] Western Miner & Oil Review (Canada). Australia. V. 36, No. 12, December 1963, p. 39.
[47] Fish, George E., Jr. Titanium Resources of Nelson and Amherst Counties, Va. (In Two Parts) 1 Saprolite Ores. BuMines Rept. of Inv. 6094, 1962, 14 pp.
Holt, Dean C. Titanium Placer Resources in Western Montana. BuMines Rept. of Inv. 6365, 1964, 39 pp.
Storch, R. H., and D. C. Holt. Titanium Placer Deposits of Idaho. BuMines Rept. of Inv. 6319, 1963, 69 pp.

deposits containing ilmenite, monazite, columbite, euxenite, and other minerals was indicated in Idaho. Areas examined in the Bitteroot, Upper Clark Fork, and Jefferson River drainage in Montana contained more than 10 pounds of ilmenite and other black sand minerals per cubic yard. It was concluded that saprolite ore bodies in Nelson and Amherst Counties, Va., warranted further consideration by industry for economic development.

Methods and costs of exploring The Glidden Co. ilmenite deposit in New Jersey were described.[48] A detailed breakdown of exploration operating expenses showed that hourly wages accounted for 48 percent of the total costs; clerical and supervising salaries, 17 percent; and engineering services and hydrology tests, 19 percent. Travel expenses, maintenance, social security, insurance, and other miscellaneous items accounted for the remainder. Reserves at the mine were adequate to supply the company's titanium-pigment plant in Baltimore for 20 years at the 1963 rate of consumption.

Titanium Tetrachloride.—The fluid-bed chlorination of titanium slags made from ilmenite from Idaho, South Carolina, Florida, and New York and from rutile from Australia and Arkansas was described. All of the materials were amenable to fluid-bed chlorination although some required special operating conditions. Titanium extraction and chlorine utilization was over 90 percent for most of the slags and for the Australian rutile.[49]

A patent was issued describing the use of a mixture of mineral oil and vegetable and animal oils containing iodine in purifying titanium tetrachloride.[50]

Two French patents (1,315,167 and 1,315,168) assigned to the American Cyanamid Co., covered the treatment of ferric chloride, a byproduct in chlorinating iron bearing titanium materials to produce titanium tetrachloride for making titanium metal and pigment. Liquid ferric chloride was heated and flashed into a combustion chamber where it was reacted with oxygen to form iron oxide and recover the chlorine.[51]

Pigment.—Technological developments in the chloride process for making titanium dioxide pigment by oxidizing titanium tetrachloride and in improving the acid treatment of iron-bearing titanium materials to produce titanium dioxide by the sulfate method continued.

A chloride process for making titanium dioxide pigment, reportedly used in a small commercial plant, was described.[52] Titanium-bearing ore and coke is chlorinated to produce titanium tetrachloride. Purified titanium tetrachloride is oxidized with air or oxygen to form titanium dioxide which is separated from the byproduct chlorine, and degassed before being ground. A small quantity of water is used for cooling and in the final wet grinding of the pigment. Chlorine is

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[48] Quirk, Richard, and N. A. Ellertsen. Methods and Costs of Exploration and Pilot Plant Testing of Ilmenite-Bearing Sands, Lakehurst Mine, The Glidden Co., Ocean County, N.J. BuMines Inf. Circ. 8197, 1963, 68 pp.

[49] Perkins, E. C., H. Dolezal, D. M. Taylor, and R. S. Lang. Fluidized-Bed Chlorination of Titaniferous Slags and Ores. BuMines Rept. of Inv. 6317, 1963, 13 pp.

[50] Stanley, Howard Arthur (assigned to Laporte Titanium Ltd., London). Process for the Purification of Titanium Tetrachloride. British Pat. 3,102,785, Sept. 3, 1963.

[51] Chemical Week. Titanuim Tipoff? V. 93, No. 3, July 20, 1963, pp. 102, 104.

[52] European Chemical News (London). Technical Week, Cost-Quality Lead of Chlorine Process TiO_2. V. 4, No. 90, Oct. 4, 1963, p. 27.

recycled. The reported yield for both chlorine and titanium is 95 percent.

Investigation of the reaction between titanium tetrachloride and oxygen conducted in the U.S.S.R. indicated that oxychlorides of titanium are not formed. Reaction begins at 500° to 600° C and its rate increases as the temperature and oxygen content are increased. Studies of the reaction products indicated that at 800° C, anatase is formed; at 950° C, brookite; and 1,100° C, rutile.[53]

Several patents were issued covering various aspects of the chloride process. Boron compounds were introduced into the gaseous reaction to control acidity of pigment produced.[54] Oxygen was reacted with sulfur to produce a source of heat sufficient to sustain the reaction between $TiCl_4$ and oxygen.[55] A method for reacting $TiCl_4$ with oxygen in a fluidized bed of inert particles was described.[56] Part of the TiO_2 formed is carried out of the bed. The portion adhering to the inert particles is removed by introducing a chlorinating agent and carbonaceous material, rechlorinating the adhering particles, and reoxidizing the resulting $TiCl_4$.

A process was patented for producing titanium dioxide from titaniferous iron materials by a two-stage, sulfuric acid process.[57] The material is leached in concentrated acid, the iron reduced to ferrous iron, and the titanium precipitated in the conventional way. The titanium precipitate is redissolved in dilute acid and reprecipitated producing a high purity pigment.

A method for producing TiO_2 from iron containing titanium minerals was patented whereby the ore was subjected to a reducing gas above 500° C to reduce 70 percent of the ore to metallic iron. The iron and titanium are separated from nonmagnetic materials and the iron dissolved with dilute acid producing a titanium dioxide residue. The colored oxide impurities in the residue are chlorinated in an oxidizing atmosphere leaving a white titanium dioxide.[58]

A process for separating titanium and iron compounds was patented whereby the mixture is dissolved with a 6- to 12-molar solution of hydrochloric acid at 40° to 80° C. The dissolved iron and titanium are separated by treating the solution with trialkyl phosphates, alkyl amines, monoalkyl phosphate, or dialkyl phosphates to remove iron in the organic phase. The titanium remains in the acid, aqueous phase, and is subsequently precipitated and calcined.[59]

Russian investigators reported the selective dissolution of iron in ilmenite.[60] Under optimum conditions 97 percent of the iron, virtu-

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[53] Shchegrov, L. N. (The Reaction Between Titanium Tetrachloride and Oxygen.) Associated Technical Service, Inc., East Orange, N.J., 1960, No. 96, 9 pp.

[54] Arkless, Kenneth, and Edward Whyman (assigned to British Titan Products Co., Ltd., England). Treatment of Titanium Dioxide. U.S. Pat. 3,088,840, May 7, 1963.

[55] Allen, Edward M., and Floyd E. Benner, Jr. (assigned to Pittsburgh Plate Glass Co.). Process for Producing Titanium Oxide. U.S. Pat. 3,105,742, Oct. 1, 1963.

[56] Arkless, Kenneth (assigned to British Titan Products Co., Ltd., Durham, England). Preparation of Titanium Dioxide. U.S. Pat. 3,097,923, July 16, 1963.

[57] Dantro, Horas F., Anthony T. Kalinowski, and Walter T. Siuta (assigned National Lead Co.). Method for Producing Titanium Dioxide Pigments. U.S. Pat. 3,091,515, May 28, 1963.

[58] Judd, Harold (assigned to Champion Papers, Inc., Hamilton, Ohio). Method of Preparing TiO_2. U.S. Pat. 3,112,178, Nov. 26, 1963.

[59] Ellis, David A. (assigned to The Dow Chemical Co., Midland, Mich.). Process for the Separation of Iron and Titanium Values by Extraction and the Subsequent Preparation of Anhydrous Titanium Dioxide. U.S. Pat. 3,104,950.

[60] Belyakova, Ye. P., and A. A. Dvernikova. (Decomposition of Ilmenite by Ihydrochloric Acid.) Ukr. Khim. Zh., v. 29, No. 2, 1963, pp. 220–225; abs. in OTS Current Rev. Soviet Tech. Press, May 17, 1963.

ally 100 percent of the manganese and vanadium oxides and lime, and about half of the aluminum and magnesium oxides are dissolved. Silica remained with the titanium. About 0.7 percent of the original titanium is dissolved and a residue containing 96 percent TiO_2 produced.

The effects of titanium dioxide in glass and paper were discussed. Titanium dioxide increases the chemical durability of glass in acidic solutions, lowering the melting temperature and coefficient of expansion and causing changes in light transmission characteristics of the glass.[61] In paper fillers and coatings, titanium dioxide has a greater ability to opacify the paper than other materials, even in waxed-paper sheet where the air to pigment interfaces that normally contribute to paper opacity are absent.[62]

Metal.—Fused-chloride electrolysis experiments using anodes of titanium carbide and a material consisting of titanium, carbon, nitrogen, and ogygen (sometimes called titanium cyanonitride) yielded only a low recovery of titanium. Better recoveries were obtained using a mixed chloride-fluoride electrolyte.[63]

The reaction rate between titanium metal and titanium subchlorides in molten sodium chloride was determined by the Bureau of Mines.[64] The reaction rate was believed to be surface controlled. The effect of temperature on the rate was found to follow Arrhennius' law.

A survey of significant titanium alloys and those under development was made.[65] Of the Alpha type alloys, only titanium 5 aluminum 2.5 tin has been produced in commercially significant quantities. It reportedly has the best weldability of all titanium alloys. New alpha alloys with higher strength that were under development incorporated more aluminum or tin, and some contained zirconium or small quantities of beta-stabilizing elements such as columbium, tantalum, molybdenum, or vanadium.

Titanium alloyed with 6 percent aluminum and 4 percent vanadium was the most widely used of the alpha-beta-type alloys. This alloy is readily forged, machined, and welded. It is heat treatable with good strength and stability up to 900° F. Alpha-beta titanium alloys contain a larger proportion of beta stabilizing elements than the alpha alloys. Some of those under development contain up to 22.5 percent columbium and 15 percent aluminum.

Only one all-beta titanium alloy was in production. It contained 13 percent vanadium, 11 percent chromium, and 3 percent aluminum, and was available in all mill forms.

Elements being tested in titanium alloys included boron [66] and

[61] Beals, M. D., J. H. Strimple. Effects of Titanium Dioxide in Glass. Glass Ind., v. 44, No. 12, December 1963, pp. 679–683, 694.

[62] Chemical and Engineering News. Coatings for Paper. Special Report. Sept. 9, 1963, pp. 86–93.

[63] Wong, M. M., R. E. Cambell, D. C. Fleck, and D. H. Baker, Jr. Electrolytic Methods of Preparing Cell Feed for Electrorefining Titanium. BuMines Rept. of Inv. 6161, 1963, 22 pp.

[64] Henrie, T. A., E. K. Kleespies, and D. H. Baker, Jr. Reaction Rate of Titanium and Titanium Subchlorides in Molten Sodium Chloride. BuMines Rept. of Inv. 6162, 1963, 20 pp.

[65] Frost, P. S., R. A. Wood, and R. I. Jaffee. Recent Progress in Titanium. J. Metals, v. 9, No. 12, February 1963, pp. 141–146.

[66] Brown, A. R. G., H. Brooks, K. S. Jepson, and G. I. Lewis. High-Modulus Titanium Alloys Containing Boron and Aluminum. J. Inst. Metals (London), v. 91, January 1963, pp. 161–166.

cobalt.[67] Development in titanium alloys in the United Kingdom also was reviewed. A high level of creep strength and uniformity of properties in many of the new alloys was directly related to the addition of silicon.[68]

A new type of rolling mill called the pendulum mill was devised that achieved the reduction in thickness by the backward and forward movement of two small-diameter work rolls, which oscillate at high speeds in relation to the strip being rolled.[69] A reduction as high as 12.5 to 1 has been achieved with titanium. The extent of reduction of the metal is not determined by the system as it is with conventional mills because a relatively large increase in reduction results in only a small increase in load.

Considerable progress in joining titanium was made. Soviet research indicated that the strongest soldered titanium joints are made when the heating cycle is kept short. High frequency electric current or dipping in a fused-salt bath was recommended for heating.[70] Heliarc titanium welds were made in an 8-foot-long vacuum chamber, 3.5 feet in diameter.[71] A titanium alloy containing 6 percent aluminum and 4 percent vanadium was electron-beam welded successfully to AISI type 321 stainless steel.[72]

A titanium alloy containing 6 percent beryllium was reported as a good material for brazing beryllium to itself.[73]

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[67] Materials in Design Engineering. A Stronger Titanium Alloy. Cobalt Strengthens Ti-6Al-4V With Relatively Little Effect on Ductility, Impact Strength. V. 57, No. 2, February 1963, pp. 74–75.

[68] Child, H. C. Titanium Alloys in Britain. Metal Progress, v. 83, No. 6, June 1963, pp. 90–94.

[69] Metallurgia (England). Progress in the New Metals at I.M.I. V. 68, No. 410, December 1963, pp. 249–255.

[70] Current Review of the Soviet Technical Press. Titanium Brazing (U.S.S.R.). July 19, 1963, p. 2 (2/5).

[71] Metalworking News. Heliarc Titanium Welds Done in Vacuum Chamber. V. 4, No. 169, Nov. 18, 1963, p. 14.

[72] Megginson, Joyce. Say Ti, Stainless Are Beam Welded. Metalworking News, v. 4, No. 169, Nov. 18, 1963, p. 1, 4.

[73] Iron Age. Makes Beryllium Joints. V. 192, No. 8, Aug. 22, 1963, p. 61.

Tungsten

By Richard F. Stevens, Jr. [1]

DOMESTIC shipments of tungsten concentrate decreased approximately 33 percent in 1963 and totaled 5.4 million pounds of contained tungsten. Imports, which accounted for about 28 percent of the tungsten consumed in the United States, decreased approximately 25 percent.

World production continued to decrease in 1963, reflecting the low prices which prevailed throughout most of 1963. Many mines were shut down and many others curtailed output.

A United Nations Ad Hoc Tungsten Committee was established and met during the year to study the tungsten situation and consider methods for stabilizing the tungsten market.

TABLE 1.—Salient tungsten statistics

(Thousand pounds of contained tungsten)

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Mine production	[1] 12,948	(2)	6,669	8,188	8,280	(2)
Mine shipments	10,307	3,473	6,972	7,847	8,021	5,384
Imports, general	17,350	6,248	5,178	2,744	3,709	3,882
Imports for consumption	17,262	5,435	3,525	2,123	[3] 4,030	3,060
Consumption	7,186	9,835	11,605	11,128	13,691	11,061
Stocks:						
Producer	[1] 1,672	(2)	2,402	2,667	3,004	3,313
Consumer and dealer	3,834	3,196	3,143	3,212	3,054	2,934
World: Production	69,571	58,245	68,714	73,663	69,760	61,576

[1] 1958 not included to avoid disclosing company confidential data.
[2] Figure withheld to avoid disclosing individual company confidential data.
[3] Revised figure.

LEGISLATION AND GOVERNMENT PROGRAMS

On June 13, 1963, the Office of Emergency Planning (OEP) authorized a tungsen disposal program developed by the General Services Administration (GSA). Under this program 1.1 million pounds of tungsten ores and concentrates was released from the Defense Production Act inventory as partial payment-in-kind for upgrading certain stockpile materials to columbium and tantalum metal and carbide powders.[2]

[1] Commodity specialist, Division of Minerals.
[2] Office of Emergency Planning. Stockpile Report to the Congress. January–June 1963, p. 8.

The following stockpile specifications for tungsten materials issued by GSA remained in effect during 1963:

Tungsten metal powder—carbon reduced—National Stockpile Specification (N.S.S.) P-102, Aug. 12, 1960.

Tungsten metal powder—hydrogen reduced—N.S.S. P-89-R1, May 13, 1960.

Tungsten carbide powder—N.S.S. P-93-R1, May 13, 1960.

Ferrotungsten—N.S.S. P-57a-R2, May 13, 1960.

Tungsten ores and concentrates—N.S.S. P-57-R4, Feb. 21, 1958.

Tungsten carbide—crystalline—N.S.S. P-92, Apr. 6, 1954.

As a result of a request from a member of the domestic tungsten industry, the OEP initiated an investigation to determine if the reduction or elimination of the tariff on imported tungsten mill products would be detrimental to the national security.

DOMESTIC PRODUCTION

U.S. tungsten mine shipments decreased 33 percent owing to the closing of a major mine and a continuing low price of tungsten concentrates. Of the five mines in four States which reported production during the year, only two operated continuously throughout 1963. These two were the Pine Creek mine of Union Carbide Nuclear Co. near Bishop, Calif., and the Climax mine of American Metal Climax, Inc., at Climax, Colo. A third operation at the Hamme mine of Tungsten Mining Corp. in Vance County, N.C., suspended production on February 14. Intermittent tungsten production was also reported from Nye County, Nev., and Lake County, Colo.

TABLE 2.—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
1954-58 (average)	10,830	649,792	10,307	$35,130	$54.06	$3.41
1959	3,649	218,927	3,473	4,502	20.56	1.30
1960	7,325	439,530	6,972	9,815	22.33	1.40
1961	8,245	494,741	7,847	10,565	21.36	1.35
1962	8,429	505,685	8,021	11,639	23.02	1.45
1963	5,657	339,402	5,384	7,202	21.22	1.34

[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.

CONSUMPTION AND USES

Consumption of tungsten concentrate decreased 19 percent. In the major use categories, consumption of tungsten in pure metal uses decreased 9 percent, consumption of tungsten in high-speed and other alloy steels increased 5 percent, and consumption in high-temperature and other nonferous alloys increased 2 percent.

Tungsten carbides accounted for 40 percent of the total consumption, cemented carbides for 33 percent, and other carbides (crystalline and cast) for 7 percent.

Data in table 4 include consumption of imported ferrotungsten and other imported products and scrap. The nonferrous alloys include cutting and wear-resistant alloys, high-temperature and other superalloys, alloy welding rods, and electrical contact and resistance alloys. The "other" category under tungsten metal includes wire, rod, and sheet produced from arc-melted material and various shaped parts produced by powder metallurgy techniques.

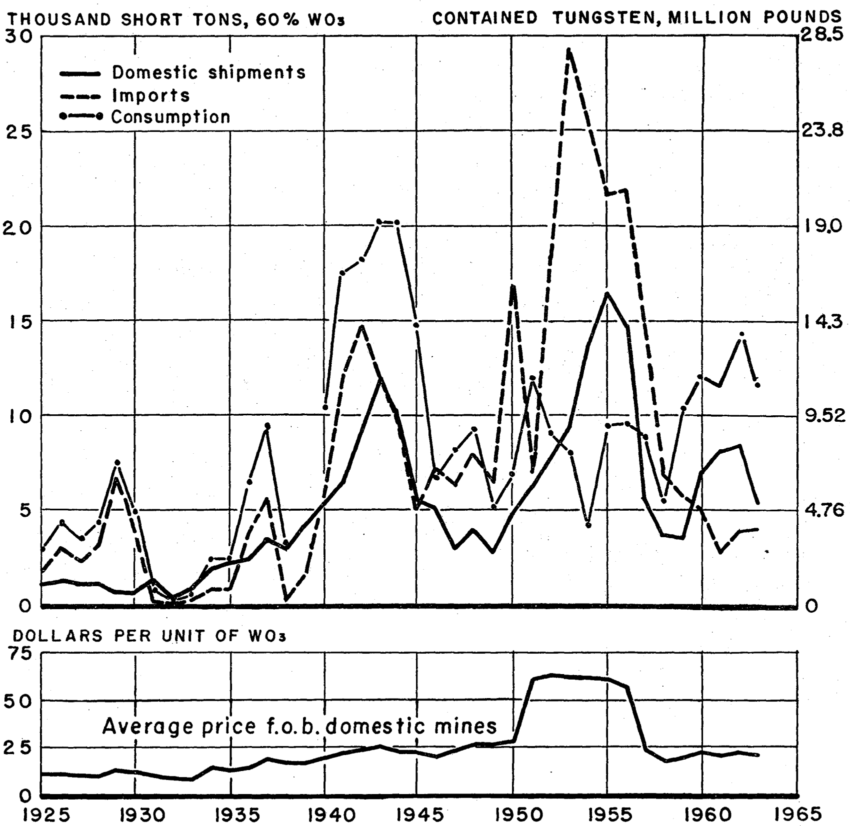

FIGURE 1.—Domestic shipments, imports consumption, and average price of tungsten ore and concentrate, 1925–63.

TABLE 3.—Production, shipments, and stocks of tungsten products in the United States in 1963

(Thousand pounds of contained tungsten)

	Hydrogen- and carbon-reduced metal powder	Tungsten carbide powder		Chemicals	Other [1]	Total
		Made from metal powder	Crushed cast			
Received from other producers	3,160	4	----------	2,630	1,438	7,232
Gross production during year	5,952	2,334	986	8,726	2,145	20,143
Used to make other products listed here	3,136	----------	----------	6,605	835	10,576
Net production	2,816	2,334	986	2,121	1,310	9,567
Shipments [2]	6,079	2,419	933	4,245	2,785	16,461
Producer stocks, December 31	1,907	95	172	2,667	736	5,577

[1] Includes ferrotungsten, tungsten carbide powder (crystalline), scheelite (produced from scrap), nickel-tungsten, self-reducing oxide, pellets, and scrap.
[2] Includes quantities consumed by producing firms for manufacture of products not listed here.

TABLE 4.—Consumption of tungsten products, by end uses, in 1963

(Thousand pounds of contained tungsten)

End use	Ferro-tungsten, melting base, self-reducing tungsten, tungsten sponge mix, etc.	Carbon-reduced tungsten powder [1]	Hydrogen-reduced tungsten powder [2]	Tungsten carbide powder		Chemicals	Scheelite (natural or synthetic)	Scrap	Total
				Made from metal powder	Crystalline and crushed cast				
Steel:									
High speed	611	45	--------	--------	--------	--------	1,084	129	1,869
Hot work and other tool	290	14	--------	--------	--------	--------	185	51	540
Alloy (other than tool) [3]	238	10	3	--------	--------	--------	130	74	455
High-temperature nonferrous alloys [4]	58	102	34	--------	--------	--------	173	195	562
Other nonferrous alloys [5]	13	7	132	5	233	224	3	124	741
Tungsten metal:									
Wire, rod, and sheet	--------	--------	1,276	--------	--------	--------	--------	--------	1,276
Other	--------	1	718	--------	--------	--------	--------	--------	719
Carbides:									
Cemented or sintered	--------	--------	40	2,284	1,069	--------	--------	65	3,458
Other (including cast or fused)	3	61	38	19	599	--------	--------	32	752
Chemicals [6]	--------	--------	--------	--------	--------	144	--------	--------	144
Total	1,213	240	2,241	2,308	1,901	368	1,575	670	10,516
Stocks at consumer plants Dec. 31	299	44	665	160	6	220	--------	204	1,598

[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 steel mill rolls, stainless and other alloy steels.
[4] Includes cutting and wear-resistant alloys.
[5] Includes diamond drill bit matrices, electrical contact points, and welding rods.
[6] Includes fluorescent powders and organic and inorganic pigments.

STOCKS

Stocks of concentrate held by consumers and dealers at yearend were 4 percent lower than at yearend 1962. Industry stocks at all locations are given in table 1. Data on tungsten materials in Government inventories on December 31 are presented in table 5.

TABLE 5.—Tungsten materials in Government inventories as of December 31, 1963

(Thousand pounds, tungsten content)

	National (strategic) stockpile	Defense Production Act Inventory	Supplemental stockpile	Total
Tungsten, all forms:				
Stockpile grade	103,842	52,503	4,479	160,824
Nonstockpile grade	16,230	25,284	1,295	42,809
Tungsten carbide powder [1]	(886)		(1,080)	(1,966)
Ferrotungsten [1]	(1,652)			(1,652)
Tungsten metal powder: Hydrogen reduced [1]	(1,092)			(1,092)
Tungsten metal powder: Carbon reduced [1]	(499)			(499)

[1] Figures in parentheses are upgraded forms and are included in the figures for tungsten, all forms.

Source: Office of Emergency Planning. Statistical Supplement, Stockpile Report to the Congress. OEP-4, July-December 1963, pp. 27, 32.

PRICES AND SPECIFICATIONS

Domestic concentrate, quoted in E&MJ Metal and Mineral Markets from January through March, ranged from $16 to $20 per short-ton unit of tungsten trioxide (WO_3), f.o.b. mine or mill. Thereafter prices dropped to $16 to $18 where they remained. Foreign tungsten concentrate was quoted at the 1962 rate of $7.75 to $9 most of the year. Starting in mid-October the price began to rise and reached a high of $11.50 in December.

Tungsten metal powder (99.8 percent in 1,000-pound lots) continued to be quoted at $2.75 per pound in E&MJ Metal and Mineral Markets. The price of hydrogen-reduced tungsten metal powder (99.99 percent) ranged from $2.70 to $3.55 per pound through February. In March the price declined to $2.45 to $3.20, where it remained.

In mid-February, ferrotungsten prices dropped from the 1962 quotation of $2.15 to $1.75 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).

TABLE 6.—Prices of Tungsten concentrates in 1963

	Foreign ore per short-ton unit of WO_3, 65-percent basis, c.i.f. U.S. ports, duty extra		London market, per long-ton unit of WO_3
	Wolfram	Scheelite	
Jan. 7	$ 8.00 to $ 8.75	$ 8.00 to $ 8.75	63s. to 69s.
Feb. 4	7.75 to 8.25	7.75 to 8.25	60s. to 70s.
Mar. 4	8.75 to 9.25	8.75 to 9.25	70s. to 75s.
Apr. 1	8.00 to 8.75	8.00 to 8.75	60s. to 70s.
May 6	8.25 to 9.00	8.25 to 9.00	65s. to 70s.
June 3	8.00 to 8.75	8.00 to 8.75	60s. to 70s.
July 1	7.75 to 8.50	7.75 to 8.50	57½s. to 67½s.
Aug. 5	7.75 to 8.50	7.75 to 8.50	60s. to 67½s.
Sept. 16	8.00 to 8.50	8.00 to 8.50	60s. to 70s.
Oct. 7	8.00 to 8.50	8.00 to 8.50	62½s. to 70s.
Nov. 4	9.50 to 9.75	9.50 to 9.75	75s. to 80s.
Dec. 16	11.00 to 11.50	11.00 to 11.50	92s. to 96s.
Average price	8.70	8.70	
Duty	7.93	7.93	
Average price, duty paid	16.63	16.63	

Source: E&MJ Metal and Mineral Markets.

FOREIGN TRADE

Imports.—General imports of tungsten concentrate increased 5 percent; 93 percent of the total, in descending order of importance, came from Bolivia, the Republic of Korea, Portugal, Argentina, and Australia. Seven percent came from four other countries. Imports for consumption of tungsten concentrate decreased 25 percent.

Imports of tungsten or tungsten carbide scrap were 355,910 pounds, gross weight, valued at $210,403. Imports of ore and concentrate duty-free for the U.S. Government were 80,000 pounds, tungsten content, valued at $80,528, from the Republic of Korea.

TABLE 7.—U.S. imports for consumption of tungsten ore and concentrate, by countries

(Thousand pounds and thousand dollars)

Country	1962			1963		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
North America [1]	2	1	$1	162	96	$59
South America:						
Argentina	110	59	39	716	398	134
Bolivia	1,304	721	438	1,697	942	437
Chile	272	150	98	---	---	---
Peru	350	202	173	59	35	17
Uruguay	106	4	2	---	---	---
Total	2,142	1,136	750	2,472	1,375	588
Europe:						
Germany, West	---	---	---	(2)	(2)	(3)
Portugal	[4] 1,634	[4] 915	[4] 728	739	435	261
Spain	132	80	78	---	---	---
Total	[4] 1,766	[4] 995	[4] 806	739	435	261
Asia:						
Burma	---	---	---	149	85	78
Japan	3	2	2	69	38	17
Korea, Republic of	2,688	1,491	1,060	1,542	846	478
Total	2,691	1,493	1,062	1,760	969	573
Oceania: Australia	701	405	303	326	185	98
Grand total	[4] 7,302	[4] 4,030	[4] 2,922	5,459	3,060	1,579

[1] Canada and Mexico, 1962; Canada, 1963.
[2] Less than 1,000 pounds.
[3] Less than $1,000.
[4] Revised figure.

Source: Bureau of the Census.

Exports.—Exports of tungsten concentrate were 99,217 pounds, valued at $66,198. Exports of ferrotungsten totaled 2,405 pounds valued at $2,927.

Exports of tungsten metal powder totaled 178,738 pounds valued at $887,817. Exports of tungsten metal and alloys in crude form and scrap were 106,969 pounds valued at $278,874. Exports of semifabricated forms were 52,180 pounds valued at $1,001,320.

TABLE 8.—U.S. imports for consumption of ferrotungsten, by countries

(Thousand pounds and thousand dollars)

Country	1962			1963		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Australia				33	26	$17
Austria	409	328	$333	421	338	228
Belgium-Luxembourg	15	12	11			
France	36	30	31	250	202	150
Germany, West	16	13	14	207	166	108
Japan	12	10	11			
Netherlands	1	(1)	1			
Portugal				55	46	33
Sweden	169	141	130	127	104	73
Total	658	534	531	1,093	882	609

[1] Less than 1,000 pounds.

Source: Bureau of the Census.

TABLE 9.—U.S. imports for consumption of tungsten or tungsten carbide forms

Year	Ingots, shot, bars, and scrap		Wire, sheets, or other forms, n.s.p.f.[1]		Total	
	Pounds	Value	Pounds	Value	Pounds	Value
1954-58 (average)	257,492	[2] $476,522	131,463	$346,114	388,955	[2] $822,636
1959	258,051	199,464	193,061	367,324	451,112	566,788
1960	170,383	207,217	174,877	528,035	345,260	735,252
1961	131,117	164,460	93,199	551,473	224,316	715,933
1962	194,111	188,668	73,448	383,670	267,559	572,338
1963	363,656	217,892	144,675	440,210	508,331	658,102

[1] Not specifically provided for.
[2] Data known to be not strictly comparable with other years.

Source: Bureau of the Census.

WORLD REVIEW

At the request of the Interim Co-ordinating Committee for International Commodity Arrangements of the Economic and Social Council of the United Nations, a U.N. Ad Hoc Tungsten Committee was established. The Ad Hoc Tungsten Committee met three times during 1963, twice in New York City and once in Geneva, Switzerland, to assess and evaluate the current tungsten situation and to consider methods for stabilizing tungsten market conditions. A fourth meeting was scheduled to be held in New York City early in 1964.

The world tungsten price was lower than for any year since 1958, and mine production declined for the second consecutive year. Numerous mine closings were reported.

747-149—64——74

TABLE 10.—World production of tungsten ore and concentrate, by countries [1]

(Short tons, 60 percent WO_3 basis)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	1,499	---	---	---	3	---
Mexico	431	138	198	193	88	36
United States (shipments)	10,830	3,649	7,325	8,245	8,429	5,657
Total	12,760	3,787	7,523	8,438	8,520	5,693
South America:						
Argentina	1,246	827	893	892	635	129
Bolivia (exports)	4,672	2,671	2,370	3,104	2,798	2,513
Brazil	[2] 1,968	2,302	1,867	1,361	1,368	[2] 1,050
Peru	1,038	542	538	428	435	510
Total	8,924	6,342	5,668	5,785	5,236	4,202
Europe:						
Austria	[3] 143	152	243	317	320	246
Finland	105	42	---	58	---	---
France	1,248	959	753	806	757	---
Italy	25	6	8	2	1	2
Portugal	4,514	2,478	3,189	3,274	2,754	1,635
Spain	1,722	854	1,030	1,192	777	160
Sweden	547	268	311	345	386	[4] 385
U.S.S.R.[4]	8,600	9,900	10,500	11,000	11,600	12,100
United Kingdom	62	---	---	---	---	---
Yugoslavia	83	86	86	9	9	[4] 10
Total [4]	17,050	14,750	16,100	17,000	16,600	14,500
Asia:						
Burma [5]	1,664	1,269	1,041	1,102	882	728
China [4]	18,500	22,500	24,900	24,900	24,900	24,900
Hong Kong	35	47	40	20	18	9
India	1	1	3	11	12	6
Japan	1,015	1,194	1,082	1,033	1,160	858
Korea:						
North [4]	2,370	4,400	5,500	5,500	4,400	4,400
Republic of	4,099	3,760	6,321	8,107	8,219	6,724
Malaya	100	24	46	41	11	8
Thailand	1,182	553	486	565	463	226
Total [4]	29,000	33,750	39,400	41,300	40,100	37,900
Africa:						
Congo, Republic of the (formerly Belgian) [5]	1,035	1,038	634	642	408	223
Morocco	3	---	---	---	---	---
Nigeria	2	---	---	---	---	---
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	219	36	11	55	24	2
Ruanda Urundi	755	171	504	734	165	[4] 110
South Africa, Republic of	412	42	37	30	28	9
South-West Africa [5]	261	2	154	190	184	239
Tanganyika (exports)	4	---	---	3	---	---
Uganda (exports)	168	14	84	243	105	---
United Arab Republic (Egypt)	6	---	---	91	---	---
Total	2,865	1,303	1,424	1,988	914	583
Oceania:						
Australia	2,500	1,218	2,075	2,866	1,946	1,771
New Zealand	29	11	10	6	10	6
Total	2,529	1,229	2,085	2,872	1,956	1,777
World total (estimate)	73,100	61,200	72,200	77,400	73,300	64,700

[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Exports.
[3] Average annual production 1957–58.
[4] Estimate.
[5] Including WO_3 in tin-tungsten concentrates.

NORTH AMERICA

Canada.—The Canada Tungsten Mining Corp., Ltd., which began producing tungsten concentrate in the latter part of 1962, suspended its operations in the Northwest Territory in August after processing the mined ore that was stockpiled on hand. The low demand was given as the reason for closing this mine and mill, which had a potential annual tungsten production capacity of 3.2 million pounds.[3]

Diamond drilling and surface exploration were conducted by Burnt Hill Tungsten & Metallurgical Ltd. on its property near Napadogan, about 44 miles north of Frederickton, New Brunswick. After exposing the vein structure, hydraulic operations will be used to facilitate sampling. Previous work had indicated a probable deposit of 260,000 tons averaging 1.5 percent WO_3.[4]

SOUTH AMERICA

Argentina.—All large tungsten-mining operations in Argentina were closed down, and only a few small scattered mines continued to operate. The Government agency, Comite para la Comercialización de Minerales, which had been subsidizing tungsten producers terminated its agreement 2 months ahead of schedule.

Bolivia.—Production of tungsten from the Kami, Caracoles, Bolsa Negra, and Unificanda mines was sporadic and approximately 50 percent lower than in 1962 owing to the numerous mine strikes and the low world price.

EUROPE

France.—With the closure of the Le Montmins mine, tungsten production in France ceased. No operations were conducted at the new Costabonne mine which had been scheduled to begin production during 1963.

Plasmamet, a group formed by Compagnie Générale de Télégraphie Sans Fil and Air Liquide, announced the development of a plasma blowpipe method for despositing high-density, high-purity tungsten powder.[5]

Italy.—Italy was authorized by the European Economic Council (EEC) to prohibit the import from other EEC countries of ferrotungsten, ferrovanadium, and ferromolybdenum which originated from Communist bloc countries.[6]

Portugal.—Empresa Technica e Administracoes has invested over $750,000 in a 2-year exploration and plant expansion program. Construction of a new plant to produce 4 tons per day of tin and tungsten concentrates is planned.[7]

Spain.—Abdon Merladet curtailed production at its large scheelite mine while the Santa Comba mine worked by Cia Minera Celta S.A.,

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[3] Mining Journal (London). Canadian Producer Closes. V. 261, No. 6680, Aug. 30, 1963, p. 198.

[4] Northern Miner (Toronto, Canada). New Drill Program, Burnt Hill Tungsten. No. 35, Nov. 21, 1963, p. 13.

[5] Metalworking News. Blowpipe Method for Depositing Used in France. V. 4, No. 173, Dec. 23, 1963, p. 8.

[6] Metal Bulletin (London). Protectionism—Latest Moves. No. 4795, May 10, 1963, p. 26.

[7] Engineering and Mining Journal. V. 14, No. 1, January 1963, p. 7.

the Santa Eulalia mine of Minas de Penouta, and the mine operated by Fernando Cort Boti near Silleda have ceased production.[8]

Sweden.—The Swedish mining company of AB Yxsjoe Gruvor suspended operations of its Yxsjoeberg mine in central Sweden at the end of October. The deposit was uneconomical to mine at current prices.[9]

The Sandvik Steelworks of Sweden began expanding its production of tungsten carbide to meet the growing world demand for drill steel tips. Sandvik has manufactured cemented carbide-tipped drill steels longer than any other company.[10]

ASIA

Burma.—The Petroleum & Minerals Development Corp. announced plans to lease the tin-tungsten mines in Southern Chan State and to increase mine production from 35 to 100 tons per month over a 5-year period.[11]

India.—Sandvik Asia, Ltd., the Indian subsidiary of the Sandvik Steelworks of Sweden, began production of tungsten carbides for rock drills at its plant in Poona, near Bombay. The Poona factory also will produce the tungsten powder required for carbide manufacture.[12]

AFRICA

Burundi.—A modification of the 1937 decree on mining rights authorized renewable 6-month licenses for exploration and renewable 3- to 15-year licenses for exploitation. Three major companies, all operating in Rwanda, were engaged in tin-tungsten mining operations during 1963.

Uganda.—The Ugandan Minister of Mineral and Water Resources appointed a three-man committee to study the state of the tungsten industry in Uganda. The commission will advise the government on measures which could be taken to assist the industry.[13]

TECHNOLOGY

The thermodynamic properties of various tungstate compounds, obtained by the solution calorimetry method, were studied and published by the Bureau of Mines.[14]

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[8] Metal Bulletin (London). Mass Closure of Spanish Tungsten Mines. No. 4799, May 24, 1963, p. 19.

[9] Mining Journal (London). Swedish Producer Compelled to Close. V. 260, No. 6660, Apr. 12, 1963, p. 355.

[10] South African Mining and Engineering Journal (Johannesburg, Republic of South Africa). Tungsten Carbide Firm Expands. V. 74, Pt. 1, No. 3659, Mar. 22, 1963, p. 661.

[11] Bureau of Mines. Mineral Trade Notes. V. 59, No. 4, April 1963, p. 38.

[12] Steel and Coal (London). Sandvik's India Factory Soon in Full Operation. V. 186, No. 4941, Mar. 29, 1963, p. 626.

[13] Metal Bulletin (London). Uganda Wolfram. No. 4791, Apr. 26, 1963, p. 22.

[14] Barany, R. Heats and Free Energies of Formation of Calcium Tungstate, Calcium Molybdate, and Magnesium Molybdate. BuMines Rept. of Inv. 6143, 1963, 11 pp.

Mah, A. D. Heats of Combustion and Formation of Carbides of Tungsten and Molybdenum. BuMines Rept. of Inv. 6337, 1963, 9 pp.

Weller, W. W., and K. K. Kelley. Low-Temperature Heat Capacities and Entropies at 298.15° K of Sodium Dimolybdate and Sodium Ditungstate. BuMines Rept. of Inv. 6191, 1963, 5 pp.

Wicks, C. E., and F. E. Block. Thermodynamic Properties of 65 Elements—Their Oxides, Halides, Carbides, and Nitrides. BuMines Bull. 605, 1963, 146 pp.

The Bureau also reported on the chemical analysis of tungsten, describing and evaluating solvent extraction-spectrophotometric and radiotracer methods for quantitatively determining the impurities in tungsten metal and tungsten concentrate.[15]

Another Bureau report described and appraised tungsten deposits in Montana. Of all the deposits investigated, those of scheelite in tactite were the most numerous and most promising economically.[16]

One Bureau report was issued on refining tungsten by fused-salt electrolysis.[17]

Another report described studies of the feasibility of employing low-temperature nonaqueous baths for the electrodeposition of high-purity tungsten metal.[18]

The analysis and evaluation of various protective coatings for tungsten and tungsten alloys was the subject of numerous reports. These detailed reviews on the oxidation of tungsten included an overall picture of the oxidation of tungsten at room and elevated temperatures and summarized the status of alloying, cladding, and coating methods to prevent oxidation.[19]

Results of studies conducted on the development of ductile tungsten-base alloys indicated that good workability persists to at least the 5-volume-percent level of thorium dioxide (ThO_2) and zirconium dioxide (ZrO_2) additives.[20]

The inherent brittleness of tungsten metal was reported to be inhibited and the room-temperature ductility improved by alloying with 5 to 30 weight-percent rhenium. Fine-grained structured tungsten-27 percent rhenium alloys exhibited ductility at $-100°$ F.[21]

Technetium, element 43, a radioisotope which is closely related to rhenium in its chemistry and properties, is being studied as an alloying

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[15] Broadhead, K. G., and H. H. Heady. Radiotracer Applications to Electrometallurgical Processing. BuMines Rept. of Inv. 6195, 1963, 14 pp.
Green, T. E. Determination of Copper in Tungsten Metal and Tungstic Oxides. BuMines Rept. of Inv. 6277, 1963, 7 pp.
Peterson, H. E., W. L. Anderson, and M. R. Howcroft. Methods for Analyzing Tungsten Ores and Concentrates. BuMines Rept. of Inv. 6148, 1963, 30 pp.
Spano, E. F., T. E. Green, and W. J. Campbell. Determination of Cobalt and Nickel in Tungsten by a Combined Ion Exchange X-Ray Spectrographic Method. BuMines Rept. of Inv. 6308, 1963, 20 pp.

[16] Walker, D. D. Tungsten Resources of Western Montana. BuMines Rept. of Inv. 6334, 1963, 60 pp.

[17] Cattoir, F. R. Experiments in Fused-Salt Electrolysis of Tungsten. BuMines Rept. of Inv. 6154, 1963, 10 pp.

[18] Meredith, R. E., and T. T. Campbell. Electrodeposition Studies of Molybdenum, Tungsten, and Vanadium in Organic Solvents. BuMines Rept. of Inv. 6303, 1963, 15 pp.

[19] Dickinson, C. D., and M. Nicholas. An Analysis of the Basic Factors Involved in the Protection of Tungsten Against Oxidation. General Telephone and Electronics Laboratories, Inc., Bayside, N.Y., ASD-TDR-62-205 (U.S. Air Force Contract No. AF 33(616)-8175), June 1963, 85 pp.
Dickinson, C. D., and L. L. Seigle. Experimental Study of Factors Controlling the Effectiveness of High-Temperature Protective Coatings for Tungsten. General Telephone and Electronics Laboratories, Inc., Bayside, N.Y., ASD-TDR-63-744 (U.S. Air Force Contract No. AF 33(657)-8787), July 15, 1963, 42 pp.
Gibeaut, W. A., and E. S. Bartlett. Production Problems Associated With Coating Refractory-Metal Hardware for Aerospace Vehicles. Defense Metals Inf. Center, Battelle Memorial Inst., Columbus, Ohio, DMIC Memorandum 172, July 26, 1963, 22 pp.
Nolting, H. J., and R. A. Jefferys. Oxidation Resistant High Temperature Protective Coatings for Tungsten. Thompson Ramo Wooldridge, Inc., Cleveland, Ohio, ASD-TDR-63-459 (U.S. Air Force Contract No. AF 33(616)-8188), May 1963, 127 pp.

[20] Ratliff, J. L., D. J. Maykuth, H. R. Ogden, and R. I. Jaffee. Further Development of Ductile Tungsten-Base Sheet Alloy. Defense Documentation Center AD-405857, May 8, 1963, 10 pp.

[21] Clark, J. W. Flow and Fracture of Tungsten and Its Alloys: Wrought, Recrystallized and Welded Conditions. Defense Documentation Center AD-408985, April 1963, 85 pp.
Jaffee, R. I., and G. T. Hahn. Structural Considerations in Developing Refractory Metal Alloys. Defense Documentation Center AD-407394, Jan. 31, 1963, 30 pp.

addition to tungsten to replace rhenium, the known reserves of which are limited.[22] Since technetium is a manmade element recovered from the waste fission products of uranium and plutonium reactors, its supply is unlimited.[23]

Studies on the consolidation of tungsten ingots by arc melting were conducted. Refinement of the ingot structure was produced by 0.06- and 0.12-percent additions of zirconium and by increased melting rates. Adding 0.12 percent zirconium also significantly improved the elevated temperature (3,000° F) tensile properties.[24]

Additional reports were published covering the properties of tungsten, the phase diagrams of refractory alloys, and the properties of refractory composites.[25]

Tungsten was found to be a more effective strengthener than molybdenum as an alloying addition to tantalum. Tungsten additions provided higher stress-rupture strengths with less degrading effects on the low-temperature ductility of tantalum alloys than did equivalent atomic percentages of molybdenum.[26]

Arc-cast molybdenum-30 percent tungsten alloy in wrought form gave superior dynamic and static corrosion resistance to molten zinc at 488° to 600° C for 672 hours.[27]

Considerable effort was made in the nuclear-space field to develop cladding materials of refractory metals for prolonged operation at 2,500° to 3,500° F. One of the main areas of interest centered around the development of thermionic emitters which would be heated to emission temperatures by nuclear fuels. Materials of prime importance in this area include tungsten, rhenium, and tantalum, and their alloys.[28] Tungsten is also being considered for use as a matrix material to contain nuclear fuels for fast reactors.

A tungsten carbide alloy has been developed that is self-fusing and self-bonding. This alloy, which contains 12 percent cobalt, is applied with a plasma flame spray process. Thickness of the coating can be varied from 0.002 to 0.015 inch. For short exposures the coating will tolerate temperatures above the softening temperature of 1,900° F.[29]

An economical method for reclaiming contamination-free tungsten carbide and tungsten base alloys and rejects has been developed. The

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[22] Nucleonics. Space Contracts Boost Hanford's Diversification Effort. V. 22, No. 5, May 1964, p. 26.

[23] Hogerton, John F. The Atomic Energy Deskbook. Reinhold Pub. Corp., New York, 1963, p. 542.

[24] Ratliff, J. L., and H. R. Ogden. Some Observations on the Arc Melting of Tungsten. Defense Metals Inf. Center, Battelle Memorial Inst., Columbus, Ohio, DMIC Memorandum 168, May 31, 1963, 15 pp.

Reimann, G. A. Vacuum Arc Melting of Tungsten + 0.6 Columbium. Defense Documentation Center AD-403394, April 1963, 84 pp.

[25] English, J. J. Binary and Ternary Diagrams of Columbium, Molybdenum, Tantalum, and Tungsten. Defense Metals Inf. Center, Battelle Memorial Inst., Columbus, Ohio, DMIC Rept. 183, Feb. 7, 1963, 131 pp.

Gibeaut, W. A., and H. R. Ogden. Summary of the Seventh Meeting of the Refractory Composites Working Group. Defense Metals Inf. Center, Battelle Memorial Inst., Columbus, Ohio, DMIC Rept. 184, May 30, 1963, 54 pp.

Schmidt, F. F., and H. R. Ogden. The Engineering Properties of Tungsten and Tungsten Alloys. Defense Metals Inf. Center, Battelle Memorial Inst., Columbus, Ohio, DMIC Rept. 191, Sept. 27, 1963, 133 pp.

[26] Schmidt, F. F., E. S. Bartlett, and H. R. Ogden. Investigation of Tantalum and Its Alloys. Defense Documentation Center AD-406757, May 1963, 128 pp.

[27] Burman, R. W., and G. Litchfield. Severe Molten Zinc Corrosion Is Reduced by Improved Molybdenum-Tungsten Alloy. Eng. and Min. J., v. 164, No. 4, April 1963, pp. 88–90.

[28] De Mastry, John. Refractory Metals in Nuclear Uses. Battelle Tech. Rev., v. 12. No. 2. February 1963, pp. 3–8.

[29] Missiles and Rockets. Tungsten Carbide Coatings. V. 13, No. 13, Sept. 23, 1963, p. 46.

process starts with material that has been rough crushed by conventional methods; the crushed material is fed into an airstream and fired against a target composed of the same type and grade of material. The key to the process was the development of a method that would fire the particles without introducing contaminating materials. To prevent contamination, a thorough cleanout of equipment is required between processing of different tungsten alloys.[30]

The use of tungsten carbide studs in automobile tires to prevent skidding on ice and snow has been widely accepted in Europe. The studs are encased in plastic and imbedded in the tire tread to provide traction and improve acceleration and stopping ability. The plastic enclosure absorbs and dissipates the excess heat developed.[31]

A method of plating materials with tungsten at low temperatures has been developed in which the base material is plunged into a solution of tungsten hexacarbonyl in benzene at 104° F.[32]

Methods of fabricating tungsten parts for space hardware which eliminate casting, rolling, and machining are slip forming and plasma spraying. After the parts are formed, their density is increased from about 87 percent to nearly 100 percent by high-energy-rate techniques.[33]

A commercial process for producing high-purity tungsten has been developed. Tungsten fluoride is reduced with hydrogen to produce tungsten granules which are consolidated into shapes by gas-pressure bonding to produce forms with densities in excess of 99 percent of theoretical. Forms made by this process exhibit greater retention of hardness and ductility and better resistance to recrystallization and cracking under thermal stress than forms made from tungsten previously available. The improved properties result from the uniform granular structure, which remains fine grained after consolidation.[34]

Successful development of gas turbine engines for use in automobiles would provide another outlet for tungsten metal. It is estimated that about 0.7 pound of tungsten would be required per engine for parts requiring high-temperature, high-strength properties.[35]

Tungsten–26 percent rhenium and tantalum–8 percent tungsten–2.5 percent rhenium alloys have been developed for use as heat shields of reentry vehicles in space and for nuclear power space probes. These alloys have both low temperature ductility and elevated temperature strength.[36]

Electron-beam welding techniques have been successfully used to join tungsten to itself and other refractory metals. Because of the precise control of welding variables possible, the method lends itself well to

[30] American Metal Market. New Process Reclaims Tungsten Carbide Scrap Parts and Rejects. V. 70, No. 173, Sept. 9, 1963, pp. 8, 25.

[31] Chemical & Engineering News. Studs Gain Grip on Snow Tire Market. V. 42, No. 6, Feb. 10, 1964, pp. 30–37.

[32] Steel. Tungsten Deposits. V. 153, No. 25, Dec. 16, 1963, p. 18.

[33] Materials in Design Engineering. The Materials Age. V. 58, No. 3, September 1963, p. 11.

[34] Materials in Design Engineering. The Materials Age. V. 58, No. 6, November 1963, p. 5.

[35] Chemical & Engineering News. Auto Turbines Could Alter Metals Picture. V. 41, No. 43, Oct. 28, 1963, pp. 98–99.

[36] Ruth, J. P. Tantalum, Rhenium, Tungsten Alloy Developed by G. E. Am. Metal Market, v. 70, No. 235, Dec. 10, 1963, p. 15.

the joining of thin sections. The high depth-to-width ratio obtainable also permits welding of thick sections.[37]

Synthetic polycrystalline tungsten displaying uniform thermionic emission properties was prepared by chemically depositing tungsten so that all the crystallites are oriented to give the emitter surface an unusually uniform work function. The thermionic conversion efficiency was enhanced by surface uniformity.[38]

A review of the present and projected uses of tungsten describing current alloys, present defense uses, current research and development programs, and future (1970) potential was published.[39]

Research is being conducted on neodymium-doped calcium tungstate as a highly active laser material which operates at room temperature.[40]

The stress-strain behavior of tungsten-fiber-reinforced copper composites was investigated by the National Aeronautics and Space Administration. Elongation at failure was found to decrease with increasing fiber content. Composites were made of tungsten wires infiltrated with binary alloys of copper containing aluminum, chromium, cobalt, columbium, nickel, titanium, and zirconium. In all cases the tungsten-fiber-reinforced copper alloy composites exhibited less tensile strength than did the tungsten-fiber-reinforced copper composites.[41]

Interest in methods of extracting, consolidating, and alloying tungsten were reflected by some of the patents issued in 1963.[42]

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[37] Monroe, R. E., and R. M. Evans. Electron-Beam Welding of Tungsten. Defense Metals Inf. Center, Battelle Memorial Inst., Columbus, Ohio, DMIC Memorandum 152, May 21, 1962, 15 pp.

[38] Electronic News. Synthetic Polycrystalline Tungsten Claimed at Varian. V. 8, Whole No. 404, Nov. 18, 1963, p. 6.

[39] Barth, V. D. The Current Status and 1970 Potential of Selected Defense Metals: Tungsten. Defense Metals Inf. Center, Battelle Memorial Inst., Columbus, Ohio, DMIC Memorandum 183, Oct. 31, 1963, pp. 35–37.

[40] Chemical Week. Lively Hunt for Lasers. V. 93, No. 22, Nov. 30, 1963, pp. 47, 49–50, 52.

[41] McDaniels, D. L., R. W. Jech, and J. W. Weeton. Stress-Strain Behavior of Tungsten-Fiber-Reinforced Copper Composites. Lewis Research Center, Cleveland, Ohio, Rept. No. NASA TN D–1881, October 1963.

Petrasek, D. W., and J. W. Weeton. Alloying Effects on Tungsten-Fiber-Reinforced Copper Alloy or High Temperature Alloy Matrix Composites. Lewis Research Center, Cleveland, Ohio, Rept. No. NASA TN D–1568, October 1963.

[42] Bither, Jr., and Tom Allen (assigned to E. I. duPont de Nemours and Co., Inc., Wilmington, Del.). Oxides of Tungsten and Group III–A Elements. U.S. Pat. 3,112,992, Dec. 3, 1963.

Gatti, Arno (assigned to General Electric Company, Schenectady, N.Y.). Method for Sintering Tungsten Powder. U.S. Pat 3,116,146, Dec. 31, 1963.

Gaudin, A. M., H. R. Spedden, and J. H. Sullivan (assigned to Union Carbide Corp., New York). Froth Flotation Beneficiation. Canadian Pat. 661,416, Apr. 16, 1963.

Grant, N. J., K. M. Zwilsky, and A. S. Bufferd (assigned to New England Materials Laboratory, Inc., Medford, Mass.). Dispersion Strengthened Molybdenum. U.S. Pat. 3,105,760, Oct. 1, 1963.

Semchyshen, Marion (assigned to American Metal Climax, Inc., New York). Tungsten-Hafnium Alloy Casting. U.S. Pat. 3,116,145, Dec. 31, 1963.

Uranium

By Charles T. Baroch [1]

THE YEAR 1963 was characterized by a worldwide retrenchment in uranium mine development and production. The demand for uranium for military purposes decreased substantially, while that for nuclear power plants continued at about the same level. In 1963, domestic production began to reflect the effects of a cutback and stretchout in procurement announced by the U.S. Atomic Energy Commission (AEC) on November 17, 1962. About 730 mines produced over 5.9 million tons of ore valued at $119 million, from which 24 mills produced concentrate containing 14,218 tons of uranium oxide (U_3O_8) valued at $225 million. Receipts from foreign countries totaled 8,802 tons of U_3O_8, 25 percent less than in 1962, compared with 16 percent less for domestic procurement.

TABLE 1.—Salient uranium statistics

(Short tons)

	1959	1960	1961	1962	1963
United States:					
Production:					
Mine (ore shipments)	6,934,927	7,970,211	8,041,329	7,052,870	5,947,571
Mill (U_3O_8 content) [1]	16,420	17,760	17,399	17,010	14,218
Imports: Concentrate (U_3O_8)	[2] 18,570	15,770	12,915	[2] 11,720	8,802
Free world: Production (U_3O_8 content)	[2] 43,350	[2] 41,130	[2] 36,490	[2] 34,600	30,200

[1] Concentrate marketed.
[2] Revised figure.

Research and development on nuclear reactors continued, with five nuclear power plants attaining criticality and five others under construction. Net installed nuclear electrical generating capacity attained over 1 million kilowatts, compared with overall domestic electric generating capacity of 200 million kilowatts. Six reactor projects were under consideration. Strong public opposition developed concerning a proposal to locate a nuclear power reactor in a heavily populated area in a New York borough and contributed to the cancellation of the project.

Legislation, submitted by AEC, was introduced in Congress to permit private ownership of special nuclear materials that would place nuclear fuel on a competitive footing with other energy sources.

[1] Commodity specialist, Division of Minerals.

LEGISLATION AND GOVERNMENT REGULATIONS

AEC announced that no mining claim on which notice of location or relocation is filed or recorded after July 20, 1963, shall be considered by AEC as having ore reserves developed prior to November 24, 1958. Furthermore, no such mining claim shall be considered as eligible for a market by reason of a history of production of uranium ores. This clarified the ruling of November 24, 1958, that purchases of uranium concentrates would be limited to appropriate quantities derived from ore reserves developed prior to that date.[2]

During the year 1963, under authority of section 274 of the Atomic Energy Act of 1954, as amended, the States of Texas and Arkansas made agreements with AEC for transfer of certain phases of regulatory authority for the control of byproduct, source, and special nuclear material in quantities not sufficient to form a critical mass. Four other States—Kentucky, California, Mississippi, and New York—previously made effective agreements, and 10 States enacted legislation authorizing each Governor to enter into agreements with AEC. Approximately 22 percent of AEC materials licenses were transferred to the six agreement States.

On March 15, 1963, AEC submitted to Congress a proposal to amend the Atomic Energy Act to eliminate mandatory Government ownership of special nuclear material within the United States. Later in the year, bills H.R.5035 and S.1160 were referred to the Subcommittee on Legislation of the Joint Committee on Atomic Energy. Under these bills, private ownership of atomic fuels would be permitted immediately and would be mandatory after July 1, 1973. Many problems as well as advantages of the legislation became apparent from the discussion aroused and it was held over for further consideration in the 1964 congressional session.[3]

President Kennedy announced on July 3, 1963, that the quantities of enriched uranium to be made available for peaceful uses have been increased to a total of 350,000 kilograms; 200,000 for domestic distribution to licensed users and 150,000 for foreign countries under civil agreements for cooperation. The new total is more than double the previous total announced on September 26, 1961. The action was authorized under sections 41b and 54 of the Atomic Energy Act of 1954, as amended.

AEC issued 16 amendments directly concerning licensed activities.[4]

DOMESTIC PRODUCTION

Mine and Mill Production.—Approximately 730 mines in 14 States produced about 5.9 million tons of ore, a drop of 1.1 million tons from 1962 and 2.1 million tons from 1961, the highest production year in history. New Mexico was the leading State in the value of produc-

[2] Federal Register. Mining Claims—Notice of Policy on Market Allocation. V. 28, No. 141, July 20, 1963, pp. 7438–7439.

[3] Chemical & Engineering News. AEC Backs Private Ownership of Atomic Fuel. V. 41, No. 32, Aug. 12, 1963, pp. 32–33.

Spivak, Jonathan. Power Paradox—Atomic Firms are Cool to Freedom from Government. Wall Street J., v. 162, No. 61, Sept. 25, 1963, p. 18.

U.S. Atomic Energy Commission. Major Activities in the Atomic Energy Programs. January–December 1963, pp. 17–21.

[4] U.S. Atomic Energy Commission. Major Activities in the Atomic Energy Programs. January–December 1963, pp. 353–388.

tion, followed by Wyoming, Utah, Colorado, Arizona, Washington, South Dakota, Texas, Alaska, California, North Dakota, Oregon, Nevada, and Montana. More than 80 percent of the ore came from about 80 mines.

TABLE 2.—Uranium mine and mill production in 1963, by States

State	Ore shipped		U_3O_8 content		Concentrate purchased by AEC		
	Short tons	Value (thousands)	Percent	Pounds	Number of mills	Pounds U_3O_8	Cost (thousands)
Arizona	150,584	$4,844	0.37	1,122,502			
Colorado	1,014,206	15,864	.20	4,184,976	6	4,267,481	$34,126
New Mexico	2,304,577	41,372	.22	10,257,534	5	11,023,334	85,892
North Dakota	5,567	141	.30	34,039			
Oregon	1,763	45	.30	10,626			
South Dakota	72,088	1,931	.31	462,015			
Utah	743,792	23,852	.37	5,525,699	3	6,160,988	49,348
Washington	117,286	2,545	.26	618,046			
Wyoming	1,475,070	27,243	.23	6,888,945	6	5,132,840	41,045
Other States [1]	62,638	1,378	.27	341,056	4	1,850,700	14,810
Total	5,947,571	119,215	.25	29,445,438	24	28,435,343	225,221

[1] Ore shipments: Alaska, California, Montana, Nevada, and Texas. Concentrates: Arizona, South Dakota, Texas, and Washington.

Uranium ore was milled in 24 processing mills which produced concentrates containing 14,218 tons of U_3O_8, compared with 17,008 tons in 1962. The mills were privately owned and operated, and were licensed to buy ore from producers under allocations prescribed by AEC. Concentrates were sold to AEC under contracts mostly extending to December 31, 1966, which established delivery and production rates. Under a program announced by AEC in November 1962, uranium producers were invited to submit proposals for deferral to 1967 and 1968 of a portion of the concentrates originally contracted for delivery by December 31, 1966. An additional quantity of concentrates, equal to that amount deferred to 1967 and 1968, will be purchased by AEC during 1969 and 1970. The Anaconda Co., the only one to execute a new contract by yearend, deferred delivery of 1,500 tons, but negotiations continued with 11 or 12 other companies.

Uranium concentrates received by AEC during the 1963 calendar year contained 23,020 tons of U_3O_8, of which 14,218 tons was from domestic producers, 4,651 tons from Canada, 4,134 tons from South Africa, and 17 tons from Australia. The total compared with 28,728 tons in 1962.

Three mills were shut down. Vanadium Corp. of America purchased the uranium mill at Shiprock, N. Mex., from Kerr-McGee Oil Industries, Inc., closed its mill at Durango, Colo., and diverted all ores to Shiprock. United Nuclear Corp, purchased all the uranium mining and milling properties of Phillips Petroleum Co. in the Grants, N. Mex., area, closed down the mill there, and contracted to have its ores treated on a toll basis at the Homestake-Sapin Partners mill, also at Grants. The third mill closed was that of Susquehanna-Western, Inc., at Riverton, Wyo., and its ore was treated on a toll basis at the Federal-Radorock-Gas Hills Partners mills in Gas Hills, Fremont County, Wyo. Federal-Radorock-Gas Hills Partners also purchased

TABLE 3.—Uranium processing plants, Dec. 31, 1963

State and company	Plant location	Date of first delivery to AEC	Contract expiration date	Tons U_3O_8 deliverable under contract from Jan. 1, 1963
Arizona: El Paso Natural Gas Co.	Tuba City	July 1956	Dec. 31, 1966	1,034
Colorado:				
American Metal Climax, Inc.	Grand Junction	June 1951	do	1,907
Cotter Corp.	Canon City	August 1958	Feb. 28, 1965	560
Union Carbide Corp., Nuclear Division.	Maybell	December 1957	Dec. 31, 1966	773
Do	Rifle	December 1947	Dec. 31, 1967[1]	5,015
Do	Uravan	March 1950	do	
New Mexico:				
Anaconda Co.	Grants	September 1953	Dec. 31, 1970	6,046
Homestake-Sapin Partners	do	September 1958	Dec. 31, 1966	12,524
Kermac Nuclear Fuels Corp.	do	December 1958	do	9,986
Vanadium Corp. of America	Shiprock	January 1955	do	1,768
South Dakota: Mines Development, Inc.	Edgemont	August 1956	do	1,523
Texas: Susquehanna-Western Co.	Falls City	June 1961	do	544
Utah:				
Atlas Corp.	Moab	November 1956	do	8,964
Do	Mexican Hat	November 1957	do	
Vitro Chemical Co.	Salt Lake City	October 1951	do	940
Washington: Dawn Mining Co.	Ford	September 1957	do	1,075
Wyoming:				
Federal-Radorock-Gas Hills Partners.	Fremont County	December 1959	do	3,156
Globe Mining Co.	Natrona County	February 1960	Dec. 31, 1967[1]	1,358
Petrotomics Co.	Carbon County	April 1962	Dec. 31, 1966	1,355
Utah Construction & Mining Co.	Fremont County	March 1958	do	3,718
Western Nuclear, Inc.	Jeffrey City	August 1957	Dec. 31, 1967[1]	3,811

[1] Previous expiration dates extended under provisional stretchout agreements.

Source: AEC Annnual Report for 1963, table 1, p. 38; AEC Annual Report for 1962, table 1, p. 213.

the Gas Hills mines of Vitro Minerals Corp., jointly owned by Vitro Corp. of America and Rochester & Pittsburgh Coal Co. Vitro Chemical Co., a division of Vitro Corp. of America, completed a new contract with AEC for its plant at Salt Lake City, Utah, extending the original contract to December 31, 1966, which would have expired on December 31, 1963. Deliveries were cut from "up to" 920,000 pounds U_3O_8 per year to 540,000 pounds for the 1963 fiscal year and 475,000 pounds each year thereafter. Atlas Corp. purchased the properties and mill of Texas-Zinc Minerals Co. at Mexican Hat, Utah, and AEC approved a new agreement consolidating the previous contracts with the two mills.

AEC renewed a contract to run through June 30, 1968, with Lucius Pitkin, Inc., for the conduct of supporting technical and service-type functions in connection with the domestic uranium raw-materials procurement program in the Western States. Sampling and analytical operations performed at Grand Junction, Colo., by Pitkin will be gradually transferred to Mallinckrodt Chemical Works at Weldon Spring, Mo., the AEC feed material plant. Pitkin will continue to operate the Grand Junction facility as a freight consolidation and transshipment point for uranium concentrates from mills in the surrounding area.

Refining and Enrichment.—The AEC uranium refinery at Weldon Spring, Mo., operated by Mallinckrodt Chemical Works continued producing uranium trioxide (UO_3, or orange oxide) from mill concentrates. Part of the UO_3 was used to produce UF_4 from which high-purity uranium metal was made. A new prototype cell for the electrolytic reduction of uranium was almost completed in 1963. UO_3 from the Weldon Spring refinery and depleted uranium from reactors was processed to uranium hexafluoride, UF_6, at the Paducah, Ky., plant, the only AEC plant remaining in operation for the production of UF_6. It is operated for AEC by the Nuclear Division of Union Carbide Corp. Under contract with AEC, UF_6 was also produced from mill concentrates at the privately owned plant of Allied Chemical Corp. at Metropolis, Ill. UF_6 sublimes at a low temperature and is primarily used as feed for uranium enrichment.

Uranium enriching is the only major area in the fuel cycle that was still performed solely by the Government. Three gaseous diffusion plants for enriching uranium continued operation at the following locations: Oak Ridge, Tenn., and Paducah, Ky., both operated by Union Carbide Corp., and Portsmouth, Ohio, operated by Goodyear Atomic Corp.

TABLE 4.—Enriched uranium furnished to industry (excluding the weapons production chain)

(Pounds) [1]

	Fiscal year				
	1959	1960	1961	1962	1963
Furnished as UF_6	243,170	190,040	261,025	276,900	221,070
Furnished in forms other than UF_6	13,890	7,500	15,210	6,610	8,630
Total	257,060	197,540	276,235	283,510	229,700

[1] Converted from data in AEC Annual Report for 1963, p. 291.

CONSUMPTION AND USES

Uranium continued to be used principally for weapons production and as fuel for power, propulsion, and irradiation reactors.

Weapon Applications.—Under Presidential authorization, the production of nuclear weapons by AEC continued to fulfill Department of Defense military requirements. Plutonium for the weapons stockpile was produced in eight graphite-moderated reactors at Hanford, Wash., and five heavy-water reactors at Savannah River, S.C. The New Production Reactor (NPR) at Hanford, which will produce electricity as well as plutonium, achieved initial criticality on December 31, 1963, in preparation for preliminary tests. Under the test ban treaty, signed on August 5, 1963, by representatives of the United States, United Kingdom, and Union of Soviet Socialist Republics, nuclear detonations in the atmosphere, outer space, and underwater were prohibited, but underground nuclear explosions were permitted. Development of weapons designed to meet Department of Defense requirements continued at AEC laboratories at Albuquerque, N. Mex., Los Alamos, N. Mex., and Livermore, Calif. The program of modernizing existing nuclear warheads and bombs continued. No atmospheric weapons tests were made, but 24 low or intermediate yield underground events were conducted at the Nevada Test Site, making a total of 109 carried out there since the initiation of the underground series in September 1961.

Civilian Reactors.—Five nuclear power plants attained initial criticality—Humboldt Bay, Carolinas-Virginia, Piqua, Enrico Fermi, and Experimental Breeder Reactor No. 2—and reactors at Big Rock Point, Mich., Indian Point, N.Y., Hallam, Nebr., Humboldt Bay, Calif., and Saxton, Pa., reached their design power levels for the first time. The 12 principal central-station, nuclear-energy, electric-power plants, together with about 37,300 kilowatts from experimental plants, reached a total generating capacity of over 1 million kilowatts. Five plants were under construction, four others were in the planning stage, and two utilities had announced plans for building nuclear units. The Consolidated Edison Co. had planned a 1-million-kilowatt Ravenswood station for New York City, but withdrew its application on January 6, 1964.

TABLE 5.—Principal civilian nuclear power reactors [1]

Reactor	Location	Electrical capacity, kilowatts	Initial criticality
Operable:			
Shippingport Atomic Power Station	Shippingport, Pa	[2] 60,000	1957
Dresden Nuclear Power Station	Morris, Ill	208,000	1959
Yankee Nuclear Power Station	Rowe, Mass	175,000	1960
Big Rock Nuclear Power Plant	Big Rock Point, Mich	47,800	1962
Elk River Reactor	Elk River, Minn	[3] 20,000	1962
Indian Point Unit No. 1	Indian Point, N.Y	[3] 255,000	1962
Hallam Nuclear Power Facility	Hallam, Nebr	75,000	1962
Humboldt Bay Power Plant	Humboldt Bay, Calif	48,500	1963
Piqua Nuclear Power Facility	Piqua, Ohio	11,400	1963
Carolinas-Virginia Tube Reactor	Parr, S.C	[3] 17,000	1963
Enrico Fermi Atomic Power Plant	Lagoona Beach, Mich	60,900	1963
Experimental Breeder Reactor No. 2	Idaho Falls, Idaho	16,500	1963
Total operable capacity		995,100	
Under construction:			
Boiling Nuclear Superheat Reactor	Puente Higuera, P.R	16,300	1964
Pathfinder Atomic Power Plant	Sioux Falls, S. Dak	58,500	1964
Peach Bottom Atomic Power Station	Peach Bottom, Pa	40,000	1964
La Crosse Boiling Water Reactor	Genoa, Wis	50,000	1965
Experimental Gas-Cooled Reactor	Oak Ridge, Tenn	21,900	1965
Under consideration:			
Bodega Bay Atomic Park	Bodega Bay, Calif	313,000	1966
San Onofre Nuclear Generating Station	San Clemente, Calif	375,000	1966
Malibu Nuclear Plant	Corral Canyon, Calif	463,000	1967
Connecticut Yankee Atomic Power Station	Haddam Neck, Conn	463,000	1967
Niagara Mowhawk Power Co. (Nine Mile Point).	Oswego, N.Y	500,000	1968
Jersey Central Power & Light Co	Oyster Creek, N.J	515,000	1969

[1] Including experimental reactors of over 10,000-kilowatt generating capacity.
[2] An increase to 150,000 kilowatts is scheduled for mid-1964.
[3] Including organic-fueled superheat.

Source: Adapted from AEC Annual Report for 1963, pp. 75–90.

Nine other experimental civilian nuclear power reactors were operable and seven were planned. The Experimental Boiling Water Reactor at Argonne, Ill., was shut down all year for conversion to plutonium fuel, and the Vallecitos (Calif.) Boiling Water Reactor was shut down by the owner, General Electric Co., in December 1963, because data derived from its operation was completed.

Adequate industrial capability and facilities were available for producing uranium materials and fabricating nuclear fuels. No firms ceased operations during the year, but the nuclear operations of Spencer Chemical Co. were taken over by Kerr-McGee Oil Industries, Inc., in Cushing, Okla. Nuclear Materials & Equipment Corp., Apollo, Pa., established a facility for producing highly enriched uranium metal, in addition to enriched uranium oxides and compounds, and General Electric Co. established a capability to produce enriched uranium oxide.

TABLE 6.—Principal producers of uranium materials and fabricators of uranium fuels

Company and principal location	Metal, oxides, and compounds	Coated particles	Fabricators of uranium fuels
Aeroject General Nucleonics, San Ramon, Calif			X
Allis-Chalmers Manufacturing Co., Greendale, Wis			X
American Radiator & Standard Sanitary Corp., Mountainview, Calif			X
Atomics International, Canoga Park, Calif			X
The Babcock & Wilcox Co., Lynchburg, Va			X
Battelle Memorial Institute, Columbus, Ohio [1]			X
The Carborundum Co., Niagara Falls, N.Y.[1]			X
Combustion Engineering, Windsor, Conn			X
Coors Porcelain Co., Golden, Colo			X
Davison Chemical Division., W. R. Grace & Co., Erwin, Tenn	X	X	X
Diamond Alkali Co., Painesville, Ohio		X	
General Electric Co., San Jose, Calif.[1]	X		X
General Dynamics Corp., San Diego, Calif		X	X
Kerr-McGee Oil Industries, Inc., Cushing, Okla	X		
Martin Marietta Corp., Baltimore, Md			X
Metals & Controls Inc., Attleboro, Mass			X
Minnesota Mining & Manufacturing Co., St. Paul, Minn		X	
National Carbon Co., Lawrenceburg, Tenn		X	
National Lead Co., Albany, N.Y	X		X
Nuclear Materials & Equipment Corp., Apollo, Pa.[1]	X	X	X
Nuclear Metals Inc., Concord, Mass			X
Sylvania Electric Products, Inc., Hicksville, N.Y			X
United Nuclear Corp., Hematite, Mo.[1]	X	X	X
United Nuclear Corp., New Haven, Conn			X
Westinghouse Electric Corp., Pittsburgh, Pa			X

[1] Also possess some capabilities for processing plutonium.

Source: Adapted from AEC Annual Report for 1963, pp. 290–292.

AEC spent $114.2 million on civilian nuclear reactor projects. Of 35 projects, 21 were classed as electric power reactor and experiments and 14 were research and test reactors. This expenditure compared with $150.7 million in 1962, $217.4 million in 1961, and $218.3 million in 1960. Excluded from these surveys are the costs for critical experiments, military and space reactor projects, small assembled civilian training reactors, general research and development, and reactors built for export.

The nuclear ship *Savannah*, after 2 years of operating experience and 30,000 miles of travel, established acceptable design and engineering data for a commercial nuclear-powered ship. In May, after undergoing her annual inspection, the *Savannah* was tied up at Galveston, Tex., because of a labor dispute. The original operating agreement was terminated, and the ship was assigned to American Export & Isbrandtsen Lines, and on November 28 the reactor was brought to criticality at dockside to train new seagoing crews in preparation for resumption of tours to domestic and foreing ports in 1964.

Military Reactors.—AEC continued its military reactor programs in coordination with Department of Defense aimed to provide reliable plants and designs for proven military nuclear power plants, which would reduce the dependence of military forces on the transportation of bulky fuels. Prototypes of stationary and portable plants were operated at Fort Belvoir, Va., Fort Greeley, Alaska, Camp Century, Greenland, Sundance, Wyo., and McMurdo Sound in the Antarctic. Work was continued on two mobile reactor plants.

At the end of the year the U.S. Navy had 3 surface ships and 34 submarines in operation, of which 16 were capable of launching Polaris missiles. This was an increase of six submarines over those of 1962. An additional 52 submarines and 1 surface ship, authorized by Congress, were in planning or construction stages. One nuclear-powered submarine, the U.S.S. Thresher, was lost in the Atlantic on April 10, 1963.

TABLE 7.—Status of military and civilian test, research, and teaching reactors as of Dec. 31, 1963

	Operable	Being built	Planned
Military reactors:			
Defense power-reactor applications:			
Electric-power reactors, remote installations	5	1	1
Propulsion reactors (naval)	47	53	----------
Developmental power reactors:			
Reactor experiments and prototypes	1	----------	1
Naval propulsion reactor prototypes	6	1	----------
Missile-propulsion reactor experiments	----------	1	----------
Test and research	10	2	1
Total	69	58	3
Civilian test, research, and teaching reactors:			
General irradiation test	4	1	----------
Special test	11	3	5
Research	37	9	3
Teaching	41	1	10
Total	93	14	18

Source: AEC report TID-8200 (9th Rev.), Nuclear Reactors Built, Being Built, or Planned in the United States as of Dec 31, 1963. Available from the Office of Technical Services, Department of Commerce.

Research and Test Reactors.—Dominant in this group were the 175-megawatt thermal (t) Engineering Test Reactor, the 40-megawatt (t) Materials Testing Reactor near Idaho Falls, Idaho, operated by AEC, and the 60-megawatt (t) Plum Brook Reactor Facility at Sandusky, Ohio, operated by the National Aeronautics and Space Administration. The only private general irradiation-testing installation was the General Electric Testing Reactor, 33-megawatt (t) at Pleasanton, Calif.

Foreign Reactors.—A total of 80 foreign reactors and critical assemblies subject to U.S. safeguards were operating in 24 foreign countries at the end of the year. Most of these used either enriched fuel or heavy water from the United States, and 40 of them were United States built. Two were central-station, electric-power reactors—Kahl Nuclear Power Station in Germany (15,000 kilowatts), and the Garigliano Nuclear Power Station in Italy, (150,000 kilowatts). Other central-power stations were being built in France (210,000 kilowatts), Italy (165,000 kilowatts), and Japan (12,500 kilowatts), a 237,000-kilowatt unit was planned for West Germany, and a 380,000-kilowatt station at Tarapur, India. Of the balance, 43 were test, research, and teaching reactors, and 10 more of these were being built or planned.

Radioisotopes.—The AEC was still the principal producer and distributor of radioisotopes, although over 40 firms engaged in their packaging, encapsulation, and retailing. Radioisotopes were recovered from radioactive waste solutions resulting from fuel reprocessing and from special reactor irradiation. In the first 11 months of the year, 11,615 shipments totaling 243,018 curies of processed radioisotopes were made from the Oak Ridge National Laboratory, Oak Ridge, Tenn., the principal center of production and distribution. Cesium 137, cobalt 60, and hydrogen 3, used as large-scale radiation sources, accounted for most of the total activity shipped, whereas, radioisotopes used as tracers and small-scale radiation sources, notably iodine 131, phosphorus 32, and a large group of miscellaneous isotopes accounted for the greatest number of shipments.

The Hanford Works, Richland, Wash., produced 3,400 kilocuries of purified strontium 90, of which 1,800 kilocuries was shipped to Oak Ridge, and 155 kilocuries went to Martin Marietta Co., Quehanna, Pa., for use principally in isotopic heat sources. Other fission products shipped from Hanford to Oak Ridge included 790 kilocuries of cesium 137, 30 kilocuries of cerium 144, and about 60 kilocuries of promethium 147.

Other AEC installations engaged in isotope production were Argonne National Laboratory, Argonne, Ill.; Brookhaven National Laboratory, Upton, N.Y.; and Mound Laboratory, Miamisburg, Ohio. The principal industrial producers of radioisotopes were Abbott Laboratories, Oak Ridge, Tenn.; General Electric Co., San Jose, Calif.; Iso/Serve, Inc., Cambridge, Mass.; Nuclear Science & Engineering Corp., Pittsburgh, Pa.; Union Carbide Corp., Tuxedo, N.Y.; and Western New York Research Center, Buffalo, N.Y.

The world's largest food-irradiation source, consisting of 1.29 million curies of cobalt 60 was put in operation on January 14, 1963, at the Natick, Mass., laboratories of the Army Material Command. The Dow Chemical Co. operated a catalytic reactor for synthesizing ethyl bromide which uses 2,000 curies of cobalt 60. The Bureau of Mines at Albany, Oreg., continued testing the effects of radiation on metallurgical processes, using a 100,000 cobalt 60 source. The Martin Marietta Corp., Quehanna, Pa., produced a 225,000-curie source of strontium 90 titanate producing 1,500-watts (t) for a Coast Guard navigational light. Other uses of radioisotopes continued to expand, particularly their use as a substitute for X-rays, gages for the measurement and control of industrial operations, tracer applications, isotopic power applications, and in medicine. Radioisotopes were used by 6,000 leading medical, industrial, and research groups of all types. More than a half-million patients received medical applications. Radioiodine is used to diagnose the condition of the thyroid gland, blood capacity is measured with a chromium tracer, brain tumors are located by tracer techniques, and deep-seated tumors are treated by intense radiation from radiocobalt teletherapy machines.

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PRICES AND SPECIFICATIONS

Uranium Ore and Concentrate.—The average value of uranium ore, based on data supplied to the Bureau of Mines by producers, was \$20.05 per short ton, equivalent to \$4.05 per pound of contained U_3O_8, compared with \$19.61 per ton and \$4.05 per pound of U_3O_8 in 1962. The average cost of U_3O_8 in the concentrates purchased by AEC was \$7.92 per pound, compared with \$7.88 per pound in 1962. The variation from the \$8-per-pound price established on April 1, 1962, was due to one contract executed in 1960, whereby quantities deferred for delivery after April 1, 1962, were purchased at a price of less than \$8 per pound.

A price of \$8 per pound of U_3O_8 in specification-grade concentrate was stipulated in the contracts after April 1, 1962, and was continued in the stretchout programs through the calendar year 1968. Contracts for quantities delivered to AEC in 1969 and 1970, stipulated that the price per pound of U_3O_8 in acceptable concentrate will be 85 percent of the allowable production cost per pound plus \$1.60, subject to a maximum price of \$6.70. The production costs used will be based on those of the 1963–68 period.

Uranium Metal.—Normal uranium metal was quoted at \$24 per pound, unchanged from that of 1962.

Special Nuclear Materials.—Base charges for enriched uranium in the form of uranium hexafluoride remained the same as those on July 1, 1962, and varied with the degree of enrichment. The variation was from \$4.77 per gram of U^{235} content for 0.010 weight-fraction (1.0 percent), to \$9.59 per gram of 0.050 weight-fraction, and \$12.01 for 0.90 weight-fraction material.

Effective July 1, 1963, AEC established new base charges for plutonium and for uranium enriched in the isotope, U^{233} as follows: For plutonium, \$43 per gram of contained Pu^{239} and Pu^{241}, the isotopes readily fissionable by thermal neutrons; for uranium enriched in U^{233}, \$82 per gram of contained U^{233}, subject to adjustment for the presence of other uranium isotopes. Plutonium and U^{233} are produced in reactors by irradiation of uranium and thorium, respectively, and have potential uses as nuclear fuels for generating heat and electricity and as neutron sources. The base charges are applied to determine payments due AEC for use, consumption, and loss of leased material, and sales prices for material sold. Reduced base charges have been established for these materials used in certain research and development activities under domestic lease agreements.

Depleted Uranium.—Base prices for depleted uranium were unchanged from 1962 and varied from \$2.50 per kilogram for uranium containing less than 0.38 percent U^{235} to \$22.60 per kilogram for uranium containing 0.7 percent U^{235}.

Uranium Concentrate Specifications.—AEC specifications for uranium concentrate have changed only slightly since the last publication in the 1958 Minerals Yearbook, but are now brought up to date as follows:

Minimum U_3O_8 content remains unchanged at 75.00 percent. The maximum allowable content (expressed as percent of the U_3O_8 content) for specific impurities was as follows:

Constituent:	Percent
Vanadium oxide, V_2O_5	2.00
Phosphate, PO_4	4.00
Molybdenum, Mo	0.60
Boron, B	0.20
Halogens, Cl, Br, and I, expressed as Cl	0.30
Fluorine, F	0.10
Arsenic, As	2.00
Carbonate, CO_3	4.00
Sulfur as SO_4	10.00
Calcium, Ca	1.50
Thorium, Th	2.00
Zirconium, Zr	2.00
Samarium, Sm	0.015
Europium, Eu	0.015
Gadolinium, Gd	0.015
Dysprosium, Dy	0.015
U_3O_8 insoluble in nitric acid [1]	0.10
Organic content [1 2]	0.10
Moisture, H_2O [3]	10.00

[1] As determined by the standard method used by AEC for making such determinations.
[2] Concentrate shall be free of surface-active organic materials, which are found by AEC to interfere with subsequent refining of the concentrate by solvent extraction.
[3] Determined on an "as received" basis and drying at 110° C.

Concentrate shall pass a 0.25-inch screen. All determinations, except moisture and screen test, shall be determined on a dry basis.

FOREIGN TRADE

Imports of uranium concenrtate as reported by AEC totaled 8,802 tons of contained U_3O_8, 38 percent of total domestic procurement, compared with 41 percent in 1962; 4,651 tons came from Canada, 4,134 tons from Republic of South Africa, and 17 tons from Australia.

Uraniferous materials as reported to the Bureau of the Census were classified as uranium ore and uranium oxide and salts, for the first 8 months of the year and then as uranium oxide or compounds, beginning September 1, 1963. The total of these imports was 19,066,028 pounds valued at $180,735,155. Canada ranked first in the quantity of imports, with the Republic of South Africa a close second, and with token amounts coming from Australia and the United Kingdom.

Exports of ores, concentrates, and compounds aggregated 11,218 pounds valued at $659,314, most of which, based on value, went to West Germany with much smaller quantities credited to Canada, Belgium, Sweden, Norway, Japan, Italy, Federation of Malaya, Israel, and Mexico, listed in decreasing order.

Exports of uranium metal and uranium-bearing alloys, including semifabricated forms, except special nuclear material, totaled 7,553 pounds valued at $89,684, most of which went to Canada; the United Kingdom taking a large part of the remainder, and small shipments went to France and Japan.

WORLD REVIEW [5]

Production of uranium throughout the free world was curtailed in 1963 because of an excess supply. The excess supply was expected to continue through the 1960's; however, Euratom's Advisory Committee estimated that demand will be so great by 1980 that only half will be forthcoming from known reserves. Therefore European countries should actively participate in exploration for uranium.[6]

A subcommittee of the West European Coal Producers studied the outlook for nuclear energy and emphasized its importance as the only fresh primary energy source developed in this century to offset an impending energy shortage. They concluded that aside from nuclear-power developments, the inevitable increase in overall power generation will lead to a substantial rise in the demand for conventional fuels. The subcommittee also poined out pitfalls in calculating costs of nuclear power; primarily, that present nuclear power stations will become obsolete more rapidly than conventional power stations because of a rapidly developing nuclear technology.[7]

Late in the year nearly $1.3 million had been pledged by 26 countries to the International Atomic Energy Agency (IAEA) for operational programs, technical aid, and training in atomic energy. More than one-half was pledged by the United States, with other large amounts promised by West Germany, Japan, Sweden, and Australia.[8] The United States, Japan, and IAEA concluded a trilateral safeguards agreement in Vienna, Austria, the first of its kind, under which IAEA assumed responsibility for administering safeguards against the diversion to military uses of nuclear materials supplied to Japan by the United States. A similar agreement was signed with India to cover the Tarapur nuclear power station.[9]

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[5] Values in this section are U.S. dollars based on the average rate of exchange by the Federal Reserve Board unless otherwise specified.

[6] Mining Journal (London). Future Uranium Requirements. V. 260, No. 6663, May 3, 1963, p. 415.

[7] Mining Journal (London). Nuclear Energy—Its Effect on Coal in Western Europe. V. 261, No. 6676, Aug. 2, 1963, p. 100.

[8] American Metal Market. V. 70, No. 209, Oct. 29, 1963, p. 10.

[9] Chemical and Process Engineering (London). IAEA Safeguards. V. 44, No. 8, August 1963, p. 451.

U.S. Atomic Energy Commission. Major Activities in the Atomic Energy Programs. January–December 1963, pp. 9, 234.

TABLE 8.—Free world production of uranium oxide (U_3O_8) by countries [1,2,3]

(Short tons)

Country [1]	1959	1960	1961	1962	1963
North America:					
Canada	15,892	12,748	9,641	8,430	8,141
United States	[4] 16,420	[4] 17,760	[4] 17,399	17,010	14,218
South America: Argentina	[5] 13	[5] 7	[5] 5	4	[5] 4
Europe:					
Finland [5]	-----	40	20	-----	-----
France	950	[6] 1,379	[7] 2,078	[7] 2,601	[5,7] 2,021
Spain [5]	-----	60	55	55	55
Sweden [5]	10	10	10	10	10
Africa:					
Congo, Republic of the	2,300	1,200	-----	-----	-----
Malagasy Republic [8]	115	(6)	(7)	(7)	(7)
Rhodesia and Nyasaland, Federation of	38	-----	-----	-----	-----
South Africa, Republic of	6,445	6,409	5,468	5,024	4,532
Oceania: Australia [5]	1,100	1,300	1,600	1,400	1,200
Free world total (estimate) [1,2]	43,350	41,130	36,490	34,600	30,200

[1] Uranium is also known to have been produced in Colombia, India, Italy, Japan, Portugal, and West Germany, but production data are not available; however, an estimate for these countries has been included in the world total.

[2] Uranium is also believed to be produced in Czechoslovakia, East Germany, Hungary, U.S.S.R., and other Soviet-bloc countries, but production data are not available, and no estimate for these countries has been included in the world total. Estimates of production for the Soviet-bloc countries range from 10,000 to 20,000 tons per year.

[3] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

[4] Data represent deliveries to AEC. Includes uranium production from phosphate rock in eastern United States.

[5] Estimate.

[6] Malagasy Republic included with France.

[7] Malagasy Republic and Gabon included with France.

[8] Derived from uranothorianite.

NORTH AMERICA

Canada.—Seven companies operated eight underground uranium mines and associated mills in 1963. These were Eldorado Mining & Refining, Ltd., and Gunnar Mining, Ltd., in the Beaverlodge area, northern Saskatchewan; the Milliken and Nordic mines of Rio Algom Mines, Ltd., Denison Mines, Ltd.; and Stanrock Uranium Mines, Ltd., in the Elliot Lake District, northern Ontario; and Faraday Uranium Mines, Ltd., and the Bicroft Division of Macassa Gold Mines, Ltd., in the Bancroft area of southeastern Ontario. The milling capacity of the entire group was 22,300 tons per day. Macassa Gold Mines and Gunnar Mining closed operations during the year.[10] Uranium ore deposits of the Elliot Lake District and Bancroft area were also the principal Canadian sources of thorium. The Canadian Government announcéd a $20 million uranium stockpiling plan which would keep the Rio Algom and Faraday mines operating until July 1, 1964.[11] The chief objections to the plan were that it was only a year's stopgap and is a subsidy by which the companies will deplete their ore reserves with no profit.

The world's largest nuclear power station, up to the end of 1963, was planned to begin construction in 1964 by Ontario Hydro Electric Commission. It would consist of four 450-megawatt heavy-water

[10] Bureau of Mines. Mineral Trade Notes. V. 56, No. 5, May 1963, pp. 38–40. Northern Miner (Toronto, Canada). How the Canadian "U" Producers Have Weathered Curtailment. June 13, 1963, No. 12, sec. 1, pp. 1(517), 5(521), 11(527).

[11] Northern Miner (Toronto, Canada). Government "U" Stockpile Plan Meets Unenthusiastic Reception. July 4, 1963, No. 15, sec. 1, pp. 1(579), 12(590).

moderated units fueled with natural uranium and patterned after Canada's CANDU (Canadian Deuterium Uranium) 200-megawatt prototype station at Douglas Point, Ontario.[12] Canada also planned to build India's second nuclear power plant, a 200-megawatt CANDU-type station at Rana Pratap Sagar in Rajsthan.[13] Construction continued on the Whiteshell Nuclear Research Establishment in Manitoba by Atomic Energy of Canada, Limited (AECL), a Government-owned corporation responsible for the nuclear research and development program. This installation will concentrate on the development of nuclear power reactors, and the first will be an organic-cooled reactor moderated with heavy water.[14] AECL and the United Kingdom Atomic Energy Authority signed a 5-year agreement to exchange information on heavy-water moderated, water-cooled reactors.[15]

SOUTH AMERICA

Brazil.—Brazil's Nuclear Energy Commission listed seven areas as potential uranium producers, the most promising being in the States of Bahia and Minas Gerais. Prospecting was conducted by 33 geologists under the direction of 2 geologists from the French Atomic Energy Commission.[16]

Three research reactors were in operation at São Paulo, São Jose dos Campos, and Belo Horizonte. The fourth, at the University of Brazil in Rio de Janeiro, was expected to become critical early in 1964.

EUROPE

Austria.—A symposium, sponsored by IAEA, International Labor Organization (ILO), and World Health Organization (WHO) and held in Vienna, discussed occupational diseases among uranium miners and their prevention. Efforts to protect miners in Czechoslovakia began in 1930 and early reports indicated a high incidence of lung cancer among uranium miners. It seems possible to attribute this high rate to the toxicity of the decay products inhaled by workers, but the results are not fully conclusive.[17]

Czechoslovakia.—A newly discovered uranium deposit, together with extensive financial and scientific aid granted by the U.S.S.R., could make the country the world's largest uranium producer, according to a Central Committee newspaper published in Prague.[18] However, technical problems and rising costs have resulted in abandoning the program initiated in 1958 to build 10 nuclear power projects. One publication predicted that mastery of the required new and intricate technology could not be expected before 1970.[19]

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[12] Nucleonics. Canadians Propose 1,800-Mwe Station, Predict 3.6 Mill Power. V. 21, No. 6, June 1963, pp. 24–25.
[13] Nucleonics. 200-Mwe Candu for India. V. 21, No. 9, September 1963, p. 26.
[14] Western Mines & Oil Review (Vancouver, Canada). Whiteshell in Operation. V. 36, No. 12, December 1963, p. 28.
[15] Chemical Week. Atomic Exchange. V. 93, No. 21, Nov. 23, 1963, p. 160.
[16] Engineering and Mining Journal. V. 64, No. 11, November 1963, p. 160.
[17] Chemistry and Industry (London). Symposium on the Health of Uranium Miners. No. 36, Sept. 7, 1963, p. 1487.
[18] Engineering and Mining Journal. Czechs Credit Russian Aid for Uranium Mining Growth. V. 164, No. 9, September 1963, p. 113.
[19] Nucleonics. Czech Program Stymied. V. 21, No. 9, September 1963, p. 27.

Denmark.—Recommendations for improved cooperation between the Danish Atomic Research Center at Riso and Danish industry were contained in a report submitted in December 1963 to the Government by a special working group appointed to study the trend and policies of nuclear research in Denmark. The group also recommended that research activities continue at Riso and that the Danish Atomic Energy Commission prepare a justified working program and a personnel-expenditure budget through fiscal year 1970.

Germany, West.—The Gundremmingen, Bavaria, reactor planned in 1962 was accepted in 1963 under the U.S.-Euratom Joint Reactor Program, and site preparation was started about 60 miles west of Munich. Initiated by the German firm, Kernkraftwerk-RWE-Bayernwerk GmbH and designed by General Electric Co., the 237-megawatt boiling water reactor will feature several improvements over existing reactors of the same type.[20] The second major nuclear power plant was planned for a site near Lingen, north of Münster, Westfalen, by Kernkraftwerk Lingen GmbH. It will have a 160-megawatt nuclear reactor supplemented by a 90-megawatt oil- or coal-fired superheater. It will use only German components and is scheduled for completion in 1968. The keel for Europe's first nuclear-powered merchant ship was laid on September 7 at Kiel.[21]

Italy.—The first shipment abroad by AEC of enriched uranium for a large power reactor left New York by air on February 5. It consisted of 4.468.2 kilograms in 24 fuel elements valued at $740,800 and was for the General Electric-designed 150-megawatt boiling water reactor near Punta Fiume constructed under the U.S.-Euratom Reactor Program for Società Ellettronucleare Nazionale (SENN). Shipment of the full core of 229 fuel elements, costing about $7.8 million, was completed in March. The reactor achieved initial criticality on June 5, and was expected to be in full power operation early in 1964. It will be operated by Italian technicians trained at the Vallecitos and Dresden reactors in the United States.[22] The AEC will also provide 8,000 kilograms of enriched uranium for the 250-megawatt, Westinghouse pressurized-water reactor being built in northern Italy for Società Ellettronucleare Italiana. The fuel valued at $73 million will be a 20-year supply, and payment was arranged through Euratom.[23]

Netherlands.—The Netherlands received a reactor grant payment of $350,000 from the U.S. Atomic Energy Commission, the maximum contribution permitted.[24]

Spain.—Spain's first nuclear power plant, designed to produce 60 megawatts, was authorized to be built at Zorita de los Canes, 45 miles east of Madrid, by Unión Eléctrica Madrileña.[25] Other plans for

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[20] U.S. Atomic Energy Commission. Major Activities in the Atomic Energy Programs. January–December 1963, p. 231.
Nucleonics. Bonn To Pump $600 Million Into Lagging Reactor Program. V. 21, No. 3, March 1963, pp. 23–24.

[21] Nucleonics. German Nuclear Merchant Ship. V. 21, No. 11, November 1963, p. 26.

[22] Nucleonics. Italy's 3 Power Reactors on Schedule; New 5-Year Plan Set. V. 21, No. 2, February 1963, pp. 22–23.

[23] Nucleonics. U.S. To Supply SELNI Fuel. V. 21, No. 11, November 1963, p. 27.

[24] U.S. Atomic Energy Commission. Major Activities in the Atomic Energy Programs. January–December 1963, p. 240.

[25] Chemical & Engineering News. Spain-Mañana Becomes Today. V. 42, No. 3, p. 84.
Foreign Trade (Ottawa, Canada). Nuclear Power. V. 120, No. 5, Sept. 7. 1963. p. 12

a 300-megawatt station in Santa Maria de Garona, Burgos Province, were approved in principle by the Spanish Ministry of Industry.[26]

Sweden.—The Atomic Research Council was reported by several leading Swedish papers to have asked for an increase from $1.4 to $2.6 million for the next fiscal year. Ten new scientific positions and a professorship in nuclear chemistry were recommended, as well as a Van de Graaff accelerator for the University of Uppsala.

The first industrial pressurized heavy-water reactor for combined heating and power purposes neared completion at Agesta, south of Stockholm. A larger power reactor, 100 megawatts, was under construction at Marviken.[27]

The first shipment of irradiated or expended reactor fuel was returned from Gothenburg by ship and thence by rail to the AEC Idaho Chemical Processing Plant, Idaho Falls, Idaho. The fuel, enriched to 90 percent U^{235}, was leased in 1961 for the Studsvik Research Station, 60 miles south of Stockholm. All shipping and reprocessing costs are to be borne by the Swedish Government.[28]

U.S.S.R.—Two nuclear power stations were started up, one of 210-megawatt size near Voronezh and the other of 100 megawatts at Beloyarsk.[29] AEC Chairman Glenn Seaborg and a delegation from the United States visited both stations and other U.S.S.R. nuclear facilities in May.[30]

United Kingdom.—Britain's fast reactor, known as Zero Energy Breeder Reactor Assembly (ZEBRA), started operating early in the year with the purpose of providing data on large reactor cores based on plutonium fuel.[31] New nuclear plants at Berkeley and Bradwell, 2 of 10 programed, officially opened with 275 and 300 megawatts, respectively, are gas-cooled and fueled with natural uranium.[32] The Experimental Fast Reactor at Dounreay, Scotland, reached a record power level of 55 megawatts in June and is being used in developing fast reactor fuels of breeder types.[33] Britain also continued developing the advanced gas-cooled reactor (AGR), using heavy water as a moderator and light water to remove the heat.[34]

The international *Dragon* project sponsored by the Organization for Economic Cooperation and Development (OECD) continued at Winfrith in Dorset. Cooperating with the United Kingdom are Denmark, Norway, Sweden, Austria, and Switzerland, the Euratom Commission representing the six countries. The objective is to carry

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[26] Chemical Trade Journal and Chemical Engineer (London). Nuclear Power Plant To Be Built. V. 153, No. 3981, Sept. 27, 1963, p. 471.

[27] National Science Foundation. Technical Résumé of Nuclear Power Development in Sweden. September 1963, No. 9, pp. 2–9.

[28] American Metal Market. Sweden Returns Atom Fuel Elements to U.S. for Reprocessing. V. 70, No. 131, July 10, 1963, p. 13.

Nucleonics. First Foreign Shipment of Spent U.S.-Supplied Fuel Arrives in Savannah. V. 21, No. 9, September 1963, pp. 18–20.

[29] International Science and Technology. Atomic Energy in the U.S.S.R. No. 19, July 1963, pp. 58–64.

[30] Nucleonics. Seaborg Reports Soviet Nuclear Program "Well Balanced." V. 21, No. 8, August 1963, pp. 39–42.

[31] Nucleonics. Britain's ZEBRA Experiment Goes Critical. V. 21, No. 2, February 1963, p. 26.

[32] American Metal Market. Privately Financed A-Power Plants in U.K. Rated at 575,000 K.W. V. 70, No. 68, Apr. 9, 1963, p. 12.

[33] Chemistry and Industry (London). Dounreay Experimental Fast Reactor. No. 26, June 29, 1963, p. 1089.

[34] New Scientist (London). A New Type of Nuclear Power Reactor for Britain. V. 17, No. 328, Feb. 28, 1963, p. 462.

out a program of research and development on high-temperature, gas-cooled reactors.[35]

Yugoslavia.—A uranium mine and processing plant were opened officially on November 10, 1963, at Kalna in eastern Serbia near the Bulgarian border, where uranium dioxide will be produced. Reactor fuel elements will be processed at Vinca, the principal nuclear-energy center near Belgrade.

ASIA

India.—A uranium mine at Jaduguda in Bihar State was geared for the production of about 1,000 tons per day sometime in 1964.[36]

The Tarapur nuclear power plant to be built 62 miles north of Bombay will generate 380 megawatts when in operation as planned for 1968. The United States will lend up to $80 million for design and construction of the estimated $115 million plant. It will be fueled with enriched uranium from the United States, which also has the first option on the plutonium to be produced inthe reactor.[37] Canada agreed to build India's second nuclear power plant, a 200-megawatt CANDU-type station to be built at Rana Pratap Sagar in northwestern Rajsthan.[38]

Israel.—The chairman of the Israel Atomic Energy Commission announced that the country's first nuclear power station would be in operation before 1970.[39]

Japan.—Recently discovered uranium deposits near Toko City in eastern Gifu Prefecture would be examined intensively, it was announced by the Atomic Power Fuel Corp., a central Government agency.[40]

A 12,500-kilowatt nuclear power plant about 75 miles northwest of Tokyo was reopened by the General Electric Co. several weeks after labor difficulties had necessitated a suspension of operations.[41] A short time later, the company turned over the plant to the Japan Atomic Energy Research Institute after testing the reactor for 100 hours at full power.[42]

The United Kingdom Atomic Energy Authority agreed to supply about 400 tons of uranium fuel worth nearly $22.5 million to the Japan Atomic Power Co. for the 158-megawatt Tokai Mura nuclear power station.[43] An English firm, Nuclear Chemical Plant, Ltd., will also design a nuclear fuel processing plant for the Japan Atomic Fuel Corp. The plant, costing $14 to $16.8 million, will reprocess fuel elements used in the Tokai Mura station.[44]

Chubu Electric Power Co. announced its decision to build a 250-megawatt nuclear power plant in Mie Prefecture. The General Elec-

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[35] European Chemical News (London). Nuclear Energy for Industry. V. 3, No. 53, Jan. 18, 1963, p. 30.
[36] Mining Journal (London). Indian Uranium Plant's Progress. V. 261, No. 6682, Sept. 13, 1963, p. 241.
[37] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, p. 34.
U.S. Atomic Energy Commission. Major Activities in the Atomic Energy Programs. January–December 1963, pp. 228–229.
[38] Nucleonics. 200-Mwe Candu for India. V. 21, No. 9, September 1963, p. 26.
[39] European Chemical News (London). V. 3, No. 76, June 28, 1963, p. 32.
[40] Bureau of Mines. Mineral Trade Notes. V. 57, No. 5, November 1963, p. 35.
[41] Wall Street Journal. V. 162, No. 101, Nov. 20, 1963, p. 32.
[42] Wall Street Journal. V. 162, No. 116, December 12, 1963, p. 5.
[43] Mining Journal (London). V. 261, No. 6674, July 19, 1963, p. 68.
[44] Chemical Age (London). V. 90, No. 2298, July 27, 1963, p. 142.

tric boiling-water type and the Westinghouse pressurized-water type are favored. This plant should be started by 1966 and completed by 1970 when Japan expects to have five nuclear power plants producing about 1.3 megawatts, one in Mie-ken (Chubu), two on the Tsurugo Peninsula in Fukui-ken, one (275 megawatts) operated by Japan Nuclear Power Generating Corp., and the other (270 megawatts) by the Kansai Electric Power Co.

Turkey.—Uranium deposits discovered near the Aegean cities of Aydin, Mugla, and Denizli will be mined in the near future, according to the Mineral Research Institute.[45]

AFRICA

Gabon Republic.—Although uranium production has been underway only since 1961, over 1,400 short tons of uranium concentrate were shipped to France in 1963.

South Africa, Republic of.—Prescribed materials under the Atomic Energy Act were the only commodities to show a significant decrease in the foreign trade balance, decreasing from $104 million in 1962 to $94 million.

During the year gold and primary uranium producers treated over 12.5 million tons of ore from which over 4,500 tons of uranium oxide (U_3O_8) was recovered. The 9 primary producers treated 15 percent of the ore, extracted over 37 percent of the total uranium produced, and sales of U_3O_8 were 99 percent of their production yielding over $48.6 million.[46]

Upon request of the United Kingdom Atomic Energy Authority (UKAEA), five companies agreed to defer deliveries through the early years of the next decade. The companies acquire premiums from UKAEA on the deferred tonnage and extended interest-free loans made by UKAEA through the South African Government to assist in the repayment of plant construction loans. Also, operations will be continued into a period when a more favorable uranium market may prevail. West Rand Consolidated, the only primary uranium producer, and Buffelsfontein will defer part of their 1963–70 deliveries through 1972. Those deferring through 1973 are Harmony, Hartebeestfontein, and Vaal Reefs—Western Reefs.[47]

A uranium processing pilot plant, located at the Buffelsfontein gold and uranium mine near Klerksdorp, was commissioned in October 1963. Refining experiments produced an oxide product of 99.9 percent purity, instead of the 90-percent product exported since 1952.[48]

OCEANIA

Australia.—A significant event in the history of Australian uranium mining was the successful conclusion in January of the 10-year contract for uranium supplied from the Rum Jungle Project, Northern Territory, to the Combined Development Agency (CDA), the joint

[45] Engineering and Mining Journal. V. 15, No. 1, January 1964, p. 8.
[46] Mining Survey (Johannesburg, Republic of South Africa). Statistical Supplement. No. 54, March 1964, pp. 32–33.
[47] Mining Journal (London). V. 260, No. 6651, Feb. 8, 1963, pp. 138–139.
[48] Mining Survey (Johannesburg, Republic of South Africa). Pilot Plant Produces Nuclear-Grade Uranium. No. 54, March 1964, pp. 26–27.

Anglo-American uranium procurement agency. Deliveries totaled 3,249,483 pounds of uranium oxide, with a profit to the Commonwealth of about $7.6 million. The project has been the most important factor in the development of the Northern Territory. Realizing this, the Commonwealth Government plans to keep the plant in operation, even if stockpiling of output is necessary. Sufficient ore is stockpiled at Batchelor to keep the mill operating for another 8 years.[49]

The Mary Kathleen Uranium Co., Ltd., operation in northern Queensland, a part of the Rio Tinto-Zinc Corp. group, closed its crushing mill in October. The original $89.6 million contract for 9 million pounds of uranium oxide (U_3O_8) with UKAEA was nearly completed. The remaining 530,000 pounds of oxide would be shipped from a stockpile early in 1964. The plant was put on a care and maintenance basis pending increasing demand for uranium.[50]

TECHNOLOGY

Research and development in nuclear science and engineering continued to grow at an accelerated rate as measured by the volume of literature published. Nuclear Science Abstracts[51] contained 42,247 items in 1963, compared with 34,149 in 1962; 33,064 in 1961; 26,514 in 1960; 23,147 in 1959; and 17,960 in 1958. The technology of all phases of the uranium industry was reviewed concisely.[52] The scope of fundamental nuclear energy research by AEC was reported,[53] and a dictionary-encyclopedia was prepared under the auspices of AEC, which contains over 1,000 subject entries.[54]

The geological and geochemical processes that led to the formation of the uranium deposits of the western United States continued to be studied. One theory suggests that the uranium found in the Gas Hills deposits was derived from previously existing hydrothermal veins deposited in the Precambrian igneous rocks of the Granite Mountains. Other theories presuppose that the original source of uranium was from tuff that once overlay the Wind River rocks in the Gas Hills area, or that the uranium was leached originally from the Granite Mountains, which furnished most of the sediments making up the Wind River formation. The new theory is based on the finding of a rock fragment of core material inferred to be part of a previously existing primary uranium vein deposit.[55] Another study reinforces the theory that the formation of sandstone-type uranium ore deposits can be attributed to the precipitating action of hydrogen sulfide of

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[49] Australian Atomic Energy Commission (Coogee, N.S.W., Australia). Rum Jungle Project. 1963, 16 pp.
Engineering and Mining Journal. V. 164, No. 3, March 1963, p. 158.

[50] Bureau of Mines. Mineral Trade Notes. V. 58, No. 1, January 1964, p. 43.
Mining Journal (London). V. 261, No. 6688, Oct. 25, 1963, p. 402.

[51] U.S. Atomic Energy Commission, Division of Technical Information. Nuclear Science Abstracts. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. V. 17, Nos. 1–24 issued semimonthly, 1963, 5,707 pp.

[52] Steel. The Exploding Realm of the Peaceful Atom. V. 153, No. 8, Aug. 19, 1963, pp. 44–51; Tapping the Potential of the Peaceful Atom. V. 153, No. 9, Aug. 26, 1963, pp. 49–55.

[53] U.S. Atomic Energy Commission. Fundamental Nuclear Energy Research. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., December 1963, 407 pp.

[54] Hogerton, John F. The Atomic Energy Deskbook. Reinhold Publishing Corp., New York, 1963, 673 pp.

[55] Guilinger, R. R. Source of Uranium in the Gas Hills Area, Wyoming. Econ. Geol., v. 58, No. 2, March–April 1963, pp. 285–286.

bacteriological origin. These bacteria reduce sulfates and form hydrogen sulfide as part of their growth process accompanying the consumption of organic matter, which is their source of energy supplied by an abundance of organic debris in the sediments. The theory states that it is possible to make a distinction between bacteriogenic and magmatic hydrothermal or igneous sulfides on the basis of the ratio of the two principal isotopes of sulfur S^{32}/S^{34}.[56] Geologic maps of the Uravan Mineral Belt were consolidated from a number of sources and the geology of the area was discussed.[57]

Because of the recession in procurement, exploration and geological surveys of uranium areas came almost to a standstill. However, many publications appeared as terminal products of fieldwork started as early as 1952. Particularly comprehensive geologic studies were made of the Colorado Front Range Mineral Belt;[58] the Central City, Colo., District;[59] the Monument Valley of Ariz.;[60] the Deer Flat area, Utah;[61] the Strawberry Hill quadrangle, Wyo.;[62] the Capitol Reef area, Utah;[63] and the northern half of the Lehighton, Pa., quadrangle.[64] The geology, exploration, open-pit development, and mining in the Gas Hills district of Wyoming was described.[65] Described also was the design and sinking of the Gnome shaft, used for the first underground nuclear detonation in AEC Plowshare Program, which was sunk through 709 feet of rock and 506 feet of salt about 25 miles south of Carlsbad, N. Mex.[66]

The geology and technology around Grants, N. Mex., the richest uranium-producing region in the United States, were described in a group of articles by various experts. The report included geological studies of the renowned Ambrosia Lake and Smith Lake areas and such famous mines as the Black Jack and Jackpile.[67]

An electronic ore-sorting system was installed at the Beaverlodge mill of Eldorado Mining & Refining, Ltd., in northern Saskatchewan, Canada.[68] Pieces of washed plus-3-inch ore fall one at a time past a photoelectric cell and a radiation meter. The photoelectric cell automatically measures the size of the piece by recording the time the light

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[56] Adler, Hans H. Concepts of Genesis of Sandstone-Type Uranium Ore Deposits. Econ. Geol., v. 58, No. 6, September–October 1963, pp. 839–852.

[57] Reinhardt, Elmer V. The Uravan Mineral Belt—A Review, and a Few New Theories on Its Origins. Eng. and Min. J., v. 164, No. 6, June 1963, pp. 107–110.

[58] Sims, P. K., and Others. Geology of Uranium and Associated Ore Deposits, Central Part of the Front Range Mineral Belt, Colorado. Geol. Survey Prof. Paper 371, 1963, 119 pp.

[59] Sims, Paul K., A. A. Drake, Jr., and E. W. Tooker. Economic Geology of the Central City District, Gilpin County, Colo. Geol. Survey Prof. Paper 359, 1963, 231 pp.

[60] Witkind, I. J., and R. E. Thaden. Geology and Uranium-Vanadium Deposits of the Monument Valley Area, Apache and Navajo Counties, Ariz. Geol. Survey Bull. 1103, 1963, 171 pp.

[61] Fennell, T. L., P. C. Franks, and H. A. Hubbard. Geology, Ore Deposits, and Exploratory Drilling in the Deer Flat Area, White Canyon District, San Juan County, Utah. Geol. Survey Bull. 1132, 1963, 114 pp.

[62] Davis, R. E., and G. A. Izett. Geology and Uranium Deposits of the Strawberry Hill Quadrangle, Crook County, Wyo. Geol. Survey Bull. 1127, 1963, 87 pp.

[63] Smith, J. F., L. C. Huff, E. N. Hinricks, and R. G. Luedke. Geology of the Capitol Reef Area, Wayne and Garfield Counties, Utah. Geol. Prof. Paper 363, 1963, 102 pp.

[64] Klemic, Harry, James C. Warman, and Alfred R. Taylor. Geology and Uranium Occurrences of the Northern Half of the Lehighton, Pa., Quadrangle and Adjoining Areas. Geol. Survey Bull. 1138, 1963, 97 pp.

[65] Everett, F. D. Mining Practices at Four Uranium Properties in the Gas Hills, Wyoming. BuMines Inf. Circ. 8151, 1963, 83 pp.

[66] Howes, Merwin H. Methods and Costs of Shaft Sinking, U.S. Atomic Energy Commission Project Gnome, Near Carlsbad, N. Mex. BuMines Inf. Circ. 8195, 1963, 49 pp.

[67] Kelley, Vincent C. Geology and Technology of the Grants Uranium Region. Memoir 15, New Mexico Bureau of Mines and Mineral Resources, Socorro, N. Mex., 1963, 277 pp.

[68] Colborne, G. F. Electronic Ore Sorting at Beaverlodge. Canadian Min. & Met. Bull. (Montreal, Canada), v. 56, No. 616, August 1963, pp. 664–668.

beam is interrupted. The mass effect, or difference in radiation intensity between large and small pieces of rock, and the radiation intensity are integrated. A piece above a certain preset cutoff grade falls unhindered onto an ore conveyor, but if a piece is classed as waste, a blast of air is actuated which deflects it to a waste conveyor. Each machine sorted 22 tons per hour, removing 17 percent of waste containing 0.025 percent U_3O_8 and producing a mill feed containing 0.248 percent U_3O_8.

Flotation methods were tested on a number of uranium ores. Ore from Bihar State, India, was upgraded by first floating chlorite mica using Primene, then floating uranium minerals with oleic acid and petroleum sulfonate. A recovery of 95.2 percent was attained with a ratio of enrichment just under 2, producing a concentrate containing 0.156 percent U_3O_8.[69] Tests on Canadian ore indicated that 92 percent of the uranium could be obtained in a concentrate containing 0.24 percent U_3O_8 in about half the original ore weight. The saving of acid in leaching ranged from 30 to 46 percent.[70] Tests were conducted on two other Canadian ores, using isooctyl phosphate as a collector. Elliot Lake ore containing 0.11 percent U_3O_8 and pyrite produced a composite concentrate (sulfide float, cleaner float, and slimes) containing 0.41 percent U_3O_8 with 86.2 percent recovery, and similar results were obtained on Bancroft ore.[71]

The Bureau of Mines published the fourth of a series of reports describing research on disposal of radioactive liquid wastes.[72]

The 500-ton uranium mill of Mines Development, Inc., a subsidiary of Susquehanna-Western, Inc., at Edgemont, S. Dak., was described in detail.[73] Mill feed consisted of sandstone ores from Wyoming and South Dakota and ash residues from the burning of uranium-bearing lignite ore from North and South Dakota. The ash contains about 0.50 percent U_3O_8 and from 0.20 to 0.40 percent molybdenum, while the crude sandstone ores contain about 0.20 percent U_3O_8. Leaching is with dilute sulfuric acid, and the slime pulp is treated in a resin-in-pulp (RIP) circuit to recover the uranium and molybdenum, which are extracted by a strong sulfuric acid eluant. Uranium and molybdenum are then transferred to a soda ash solution by means of a solvent extraction unit and each is recovered separately. Vanadium was also recovered by releaching the slime tailings after treatment in the RIP circuit, using excavated ponds as washing and decantation vessels in place of the conventional thickeners.

A reaction vessel was developed for the continuous reduction of UF_6 in a one-step process to replace a two-step batch process. Sodium and UF_6 in vapor form were reacted in a helium atmosphere at 1,200° C., and the molten sodium fluoride slag and uranium metal were

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[69] Madhavan, T. R., J. Y. Somnay, and K. K. Majumdar. Studies in the Flotation of Uranium Ore From Jodugoda. J. Mines, Metals, and Fuels (Calcutta, India), v. 11, No. 2, February 1963, pp. 4–7.

[70] Honeywell, W. R., and V. F. Harrison. Two-Stage Flotation Treatment of Uranium Ore from Faraday Uranium Mines Limited. Canadian Min. & Met. Bull., v. 56, No. 616, August 1963, pp. 610–614.

[71] Somnay, J. Y., and D. E. Light. Collectors for Flotation of Brannerite and Uranothorite. Trans. Soc. Min. Eng., v. 226, No. 1, March 1963, pp. 60–63.

[72] Tame, K. E., and J. B. Rosenbaum. Disposal of Liquid Waste in the Resin-in-Pulp-Type Uranium Milling Flowsheet. BuMines Rept. of Inv. 6114, 1963, 11 pp.

[73] Seeton, Frank A. Mines Development, Inc., Edgemont, S. Dak. Deco Trefoil, v. 27, No. 5, November–December 1963, pp. 7–18.

spearated by difference in specific gravity.[74] The Bureau of Mines experimentally produced uranium (99.8 percent pure) by the electrolytic reduction of uranium dioxide in a fluoride bath at 1,200° C.[75]

Technologic advancement continued to broaden the use of radioisotopes,[76] and the use of radioactive tracers in analytical chemistry was reviewed and annotated exhaustively.[77]

The Food and Drug Administration (FDA) approved the use of radiation-sterilized bacon for public consumption, the first approval of irradiated food. The Army planned troop acceptance tests next. Bacon is canned, then treated with a 4.5-megarad dose of gamma radiation from a cobalt 60 source. The U.S. Army Quartermaster Corps continued research on the elimination of offensive flavor and odor in meat products sterilized by irradiation.[78] The FDA also approved a process developed at the University of Michigan which sterilizes insect eggs in wheat by irradiation with cobalt 60. Insect-caused losses of wheat imported by India amount to 30 percent in some cases. A prototype plant to process 200 tons of wheat per hour was considered and the cost of irradiation was estimated at about 15 cents per ton.[79]

AEC started constructing a plant at the Gloucester, Mass., Technological Laboratory of the Bureau of Commercial Fisheries, U.S. Department of the Interior, to demonstrate the technical and economic feasibility of radiation pasteurization of fishery products. It was named the Marine Products Development Irradiator and was based on a number of research findings.[80] A cobalt 60 shipboard irradiator for radiopasteurizing of fish soon after catching was designed for the commercial fishing industry.[81]

Thermoelectric generators fueled with radioisotopes reached new stages of development, supplying power in small terrestrial and space systems, largely as the result of AEC program identified as SNAP (systems for nuclear auxiliary power). Generators ranging from 2.5 to 60 watts have been constructed, fueled mainly by polonium

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[74] Scott, Charles D. Direct Reduction of Uranium Hexafluoride to Uranium Metal with Sodium. Ind. and Eng. Chem. Process Design and Development, v. 2, No. 2, April 1963, pp. 117–121.

[75] Kesterke, D. G., L. W. Schramm, R. G. Knickerbocker, and T. A. Henrie. Electrowinning Uranium from Uranium Oxide. BuMines Rept. of Inv. 6226, 1963. 10 pp.

[76] Atomics. Radioisotopes in Science and Industry. V. 16, No. 2, March–April 1963, pp. 20–42.

Chemical & Engineering News. Radiation Processing of Chemicals. V. 41, No. 6, Apr. 22, 1963, pp. 80–91.

Chemical Engineering. Irradiation Aims at Chemical-Process Outlets. V. 70, No. 17, Aug. 16, 1963, pp. 86–87.

Houseman, D. H.,Radioisotopes in Metallurgy. Steel and Coal, v. 186, No. 4947, May 10, 1963, pp. 896–902.

Johnson, P., R. M. Bullock, and J. Whiston. Some Applications of Radioisotopes in the Chemical Industry. Chem. and Ind. (London), No. 19, May 11, 1963, pp. 750–756.

[77] Reynolds, S. A., and G. W. Leddicotte. Radioactive Tracers in Analytical Chemistry. Nucleonics, v. 21, No. 8, August 1963, pp. 128–142.

[78] Battelle Memorial Institute. A Study of Flavor of Irradiated Meat. U.S. Dept. of Commerce, OTS, AD 409, 165, 1963, 34 pp.

[79] Chemical Week. FDA Okays Radiation. V. 93, No. 10, Sept. 7, 1963, p. 106.

[80] Fish and Wildlife Service. Annual Report on Radiation of Fish, October 1961 through September 1962. U.S. Dept. of Commerce, OTS, TID–17557, October 1962. 39 pp.

Louisiana State University. Radiation Pasteurization of Shrimp. U.S. Dept. of Commerce, OTS, ORO-601, 1962, 70 pp.

[81] Brookhaven National Laboratory and Vitro Engineering Co. Shipboard Cobalt 60 Radiopasteurizer for Marine Products. U.S. Dept. of Commerce, OTS, BNL 808 (T–311), 1963, 61 pp.

210, plutonium 238, and strontium 90.[82] Typical of these was SNAP-9A in a Transit 5–B satellite launched in September. The generator weighed 27 pounds and was about 20 inches in diameter and 10 inches high. It was fueled by plutonium 238 and was expected to generate 25 watts for a design life of 5 years.[83] Heat from the radioisotopes is converted to electricity by a thermionic or thermoelectric generator utilizing the Seebeck effect in which electric current flows in a closed circuit of two dissimilar metals when the junctions are maintained at different temperatures.[84] Similar types of radioisotope power generators were under development and tests as Coast Guard automated lighthouses and buoys, unmanned weather stations on land and sea, and underwater sonar beacons. The sound beacons produce a distinctive high-pitched sound that can be picked up by ships and submarines within a radius of about 20 miles to advise them of their locations.

Of the many nuclides produced by the fission of uranium and plutonium, only four are of prime interest as isotopic heat sources and, at the same time, are produced in sufficient quantities to have extensive application. These are strontium 90, cesium 137, cerium 144, and promethium 147, which have fission yields in percent, respectively, of 5.8, 6.0, 6.0, and 2.6.[85] Sr^{90} and Cs^{137} was produced in limited quantities, and a conceptual design of a plant for the high-volume production of the four isotopes was prepared at the request of AEC, together with estimates of capital, operating, and unit costs.[86]

The first commercial plant to use ionizing radiation as a catalyst in a chemical reaction was started by the Dow Chemical Co. at Midland, Mich., for the production of ethyl bromide.[87] Gaseous hydrogen bromide and ethylene are bubbled upward in an intense field of gamma radiation through ethyl bromide. About 1,800 curies of cobalt 60 are mounted in a cylindrical source in an underground reactor 2 feet in diameter and about 4 feet deep. The plant has a capability of about 1 million pounds of ethyl bromide per year.

The status of nuclear power was summarized in an article,[88] and much information on the political, economic, and technical aspects of nuclear energy were recorded at the hearings of the Joint Committee on Atomic Energy.[89] Developments on four of the five types of uranium-fueled reactors chosen for major development as the principal contenders for full-scale power generation were described, as follows:

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[82] Davis, Harold L. Radionuclide Power for Space—Part 1, Isotope Costs and Availability. Nucleonics, v. 21, No. 3, March 1963, pp. 61–65.
Harvey, D. G., P. J. Dick, and C. R. Fink. Radionuclide Power for Space—Part 2, Isotope-Generator Reliability and Safety. Nucleonics, v. 21, No. 4, April 1963, pp. 56–59.
Schulman, Fred. Radionuclide Power for Space—Part 3, Generator Performance and Mission Prospects. Nucleonics, v. 21, No. 9, September 1963, pp. 54–58.

[83] Davis, Harold L. Nuclear Space Projects Face up to Safety Problems. Nucleonics, v. 21, No. 12, December 1963, pp. 41–45.

[84] Morse, J. G. Energy for Remote Areas. Science, v. 139, No. 3560, Mar. 22, 1963, pp. 1175–1180.

[85] Rohrmann, C. A. Radioisotopic Heat Sources. Hanford Atomic Products Operation, Richland, Wash. U.S. Dept. of Commerce, OTS, HW–76,323 Rev. 1, Oct. 15, 1963, 54 pp.

[86] La Riviere, J. R., and Others. The Hanford Isotopes Production Plant Engineering Study. Hanford Atomic Products Operation, Richland, Wash. U.S. Atomic Energy Commission, Division of Isotopes Development, HW–77,770, July 1963, 124 pp.

[87] Harmer, David E., and John S. Beale, Jr. Radiation Catalysis of Ethyl Bromide—Six Months "On Stream." Nucleonics, v. 21, No. 9, September 1963, pp. 76–77.

[88] Starr, Chauncey. Nuclear Power Today. Internat. Sci. and Technol., No. 22, October 1963, pp. 32–42, 117.

[89] Eighty-eighth Congress. Development, Growth, and State of the Atomic Energy Industry. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 1963, 475 pp.

(1) The *boiling-water reactor* being developed by the General Electric Co. and Allis-Chalmers Manufacturing Co. and represented by the Dresden plant of Commonwealth Edison Co. of Chicago, was refueled after producing over 2.6-billion kilowatt hours;[90] (2) the *pressurized-water reactor*, under development by Westinghouse Electric Corp. and the Babcock & Wilcox Co., as represented by the Shippingport plant of Duquesne Light Co., was refueled for the third time;[91] (3) the *heavy-water natural-uranium reactor*, under development by Atomic Energy of Canada, Ltd. (AECL), Atomics International, and Savannah River Laboratory, is represented by Canada's first nuclear power station, Nuclear Power Demonstration (NPD), which began producing power on June 28, 1962;[92] and (4) the *high-temperature gas-cooled reactor* favored by the British, also represented in this country by the Peach Bottom reactor sponsored by 53 electric utility companies and Philadelphia Electric Co., and built by General Atomic Division of General Dynamics, was being readied for startup in 1964.[93] The fifth type, the *sodium-graphite reactor*, moderated with graphite and cooled by liquid sodium is represented by the Hallam, Nebr., plant with first production May 29, 1963. It was built for AEC by Atomics International, a division of North American Aviation, Inc., for operation by the Consumers Public Power District. A new type of reactor called ORGEL, a name derived from the French words *ORGanique* and *Eau Lourde*, is now being evaluated by Euratom, a part of the European Economic Community. It is fueled with natural uranium, moderated by heavy water, and uses an organic liquid as coolant or heat-exchange medium.[94]

A book, primarily useful to the student and for the engineer seeking a broad general outline of the nuclear field, was published. It was a successor to the "Elements of Nuclear Reactor Theory" published in 1952 and "Principles of Nuclear Reactor Engineering" published in 1955 by the same senior author.[95] The second part of volume IV in the series of Interscience Monographs and Texts in Physics and Astronomy appeared. Part I was concerned with experimental techniques, and Part II gives results and describes the theoretical basis for interpreting them.[96]

Depleted uranium, the residue of gaseous diffusion plants which remove most of the uranium 235, continued to be the subject of extensive research. About 10,000 tons of depleted uranium was estimated to have been produced annually in recent years. The Bureau of Mines, cooperating with AEC, continued research on various potential uses for depleted uranium, and found that uranium anodes offer a space saving in cathodic protection, as 1 cubic inch of uranium

[90] Eddy, P. P. Dresden Refuled and Improved. Nucleonics, v. 21, No. 10, October 1963, pp 101–105.

[91] Barclay, Richard E., and William J. O'Brien. Third Shippingport Refueling Still Faster. Nucleonics, v. 21, No. 9, September 1963, pp. 70–72.

[92] Atomics. Nuclear Power Development in Canada. V. 16, No. 1, January–February 1963, pp. 6–18.

[93] Atomics. High Performance Expected from Peach Bottom, Pa. V. 16, No. 4, July–August 1963, pp. 45–50.

[94] Leny, Jean-Claude. Euratom's High Hopes for the ORGEL Reactor. New Scientist (London), v. 20, No. 361, Oct. 17, 1963, pp. 142–145.

[95] Glasstone, Samuel, and Alexander Sesonske. Nuclear Reactor Engineering. D. Van Nostrand Co., Inc., Princeton, N.J., 1963, 830 pp.

[96] Marion, J. B., and J. L. Fowler. Fast Neutron Physics, Part II; Experiments and Theory. Interscience Pubs., New York, 1963, 1,308 pp.

gives approximately the same protection as 2 cubic inches of magnesium or 1½ cubic inches of zinc, but offers limited protection to iron, low-carbon steel, stainless steel, aluminum, zinc, and copper in simulated underground tests. Another Bureau project showed that a depleted uranium catalyst was effective in removing deleterious components of automobile exhaust gases.[97]

The use of depleted uranium as fertile material in breeder reactors where it is converted to fissionable plutonium 239 represents probably the most important large-scale potential use. Uses as a shielding material for nuclear reactors and gamma and X-ray facilities could possibly reach to several hundred tons per year, and use as counterweights in aircraft movable control surfaces might approach 100 tons per year. A large number of minor uses represented annual consumption of less than 1 ton.[98] Canadian research has emphasized the use of uranium in nonferrous metals and as a thermoelectric material. Promising applications are in the treatment of molten metals to combine with impurities, such as deoxidation and the possible formation of intermetallic compounds with many impurity elements. Thermoelectric properties of uranium nitrides were studied.[99]

Approximately 60 million gallons of high-level radioactive wastes were estimated to have been produced in nuclear-fuel reprocessing. This quantity is expected to grow as more reactors come into operation, probably reaching from 0.6 to 2.4 billion gallons annually by the year 2000. These liquid wastes have been stored mainly in underground storage tanks, the waste installation at National Reactor Testing Station near Idaho Falls, Idaho, consists of nine 300,000-gallon tanks. Application of a radiant-heat spray calciner was studied for producing a reasonably dense sintered or melted product. Results were sufficiently encouraging to warrant a large pilot-plant operation.[1] Another modification of the same general idea, tested a rotary kiln containing 1¼-inch steel balls maintained at about 1,500° F, into which the liquid waste was sprayed. Other methods tried were a fluidized-bed calciner, a spray tower, and pot calcination in a batch operation.[2] The United Kingdom Atomic Energy Authority at Harwell, England, announced a process in which radioactive liquid wastes were mixed into a slurry with borax and silica, which enters the top of a steel cylinder heated along its length by a furnace. The solution is quickly evaporated and the residual radioactive oxides combine with the borax and silica to form glass, which immobilizes the radioactive wastes and makes them far less subject to leaching.[3]

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[97] Bienstock, D., and Others. Removal of Hydrocarbons and Carbon Monoxide from Automotive Exhaust Using a Promoted Uranium Catalyst. BuMines Rept. of Inv. 6323, 1963, 18 pp.

Hoertel, F. W. Use of Depleted Uranium for Cathodic Protection. BuMines Rept. of Inv. 6285, 1963, 13 pp.

[98] Farkas, M. S. Review of Uses for Depleted Uranium and Nonenergy Uses for Natural Uranium. DMIC Memorandum 165, Defense Metals Information Center, Battelle Memorial Institute, Columbus 1, Ohio, Feb. 1, 1963, 21 pp.

[99] Thomson, R., and J. O. Edwards. Uranium in Nonferrous Metals. Canadian Min., and Met. Bull. (Montreal, Canada), v. 56, No. 612, April 1963, pp. 299–309.

Warren, I. H. Uranium Compounds as Thermoelectric Materials. Canadian Min. and Met. Bull. (Montreal, Canada), v. 56, No. 612, April 1963, pp. 288–298.

[1] Allemann, Rudolph T., and Benjamin M. Johnson. Radiant-Heat, Spray-Calcination Process for Solidification of Radioactive Waste. Ind. and Eng. Chem., Process Design and Development, v. 2, No. 3, July 1963, pp. 232–238.

[2] Chemical Engineering. Calcining Techniques To Ease Nuclear-Waste Woes. V. 70, No. 7, Apr. 1, 1963, pp. 26–28.

[3] Chemical Engineering. A Glass Trap for Nuclear Wastes. V. 70, No. 15, July 22, 1963, p. 84.

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Vanadium

By Gilbert L. DeHuff[1]

THE SUPPLY of vanadium in 1963 remained well in excess of consumption with most of the domestic production continuing to come from uranium mining and milling operations of the Western States. Consumption of vanadium in the United States continued to increase. Imports of ferrovanadium were 481 short tons compared with 88 tons in 1962, an appreciable portion of the imports being made, apparently, from pentoxide exported from the United States. Exports classified as ore, concentrates, oxides, and vanadates were approximately one-half those of 1962, reflecting keen competition among the ore-producing countries for the European market. Exports of ferrovanadium decreased also compared with those of 1962.

LEGISLATION AND GOVERNMENT PROGRAMS

In 1963 the uranium procurement program of the Atomic Energy Commission (AEC) no longer provided for purchases of vanadium concentrates or for payments for vanadium content of uranium ores or concentrates.

TABLE 1.—Salient vanadium statistics

(Short tons of contained vanadium)

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Production:						
Ore and concentrate:						
Recoverable vanadium [1]	3,380	3,719	4,971	5,343	[2] 5,211	3,853
Value thousands	([3])	$13,278	$17,748	$19,076	[2] $18,605	$13,756
Vanadium pentoxide recovered	3,432	4,092	5,495	5,817	3,586	3,897
Ore and concentrate processed	6,060	8,026	8,800	6,772	7,602	6,185
Imports:						
Ferrovanadium (gross weight)		16	15		88	481
Ore and concentrate	58	3	3			
Exports:						
Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium (gross weight)	128	152	162	120	201	183
Vanadium ore, concentrates, oxides, and vanadates	589	1,240	3,690	2,081	[2] 1,021	536
World: Production	4,325	5,321	[2] 7,236	[2] 8,727	[2] 8,286	7,004

[1] Measured by receipts at mills.
[2] Revised figure.
[3] Figure withheld to avoid disclosing individual company confidential data.

[1] Commodity specialist, Division of Minerals.

DOMESTIC PRODUCTION

Most of the vanadium produced in the United States in 1963 was obtained from uranium-vanadium ores mined primarily for their uranium content. There was, however, minor production from treatment of ferrophosphorus obtained as a byproduct in the course of producing elemental phosphorus from Idaho phosphate rock.

Vanadium Corporation of America purchased the Shiprock, N. Mex., mill of Kerr-McGee Oil Industries, closed its Durango and Naturita, Colo., mills, and transferred all of its western vanadium milling operations to the newer and more efficient Shiprock plant. Other plants recovering vanadium from uranium-vanadium ores were those of American Metal Climax, Inc., at Grand Junction, Colo.; Mines Development, Inc., at Edgemont, S. Dak.; and Union Carbide Nuclear Co., at Rifle, Colo. The ores came principally from mines in Arizona, Colorado, New Mexico, South Dakota, Utah, and Wyoming.

Two plants operated intermittently to produce vanadium in the form of oxides and metavanadate from byproduct ferrophosphorus: The Salt Lake City, Utah, plant of Vitro Chemical Co. (subsidiary of Vitro Corporation of America) and the newly constructed plant at Soda Springs, Idaho, of Kermac Nuclear Fuels Corp. (subsidiary of Kerr-McGee Oil Industries, Inc.).

Data in table 4 include all the vanadium pentoxide produced from the aforementioned sources plus relatively small quantities obtained from imported chromium ores in the course of producing chromium chemicals, oil residues, and other miscellaneous sources.

Ferrovanadium.—Ferrovanadium was produced in the United States principally by Reading Alloys, Shieldalloy Corp. (subsidiary of Metallurg, Inc.), Union Carbide Metals Co., and Vanadium Corporation of America. Production increased approximately 28 percent over that of 1962.

Vanadium Metal.—High-purity vanadium metal (99 percent plus) was produced by Oregon Metallurgical Corp. and by Vanadium Corporation of America.

TABLE 2.—Recoverable vanadium in ore and concentrate produced in the United States, by States

(Short tons of contained vanadium)

State	1954–58 (average)	1959	1960	1961	1962	1963
Colorado	2,576	2,949	4,026	4,149	3,742	3,047
Utah	444	536	462	514	525	382
Arizona and other States [1]	360	234	483	680	[2] 944	424
Total	3,380	3,719	4,971	5,343	[2] 5,211	3,853

[1] Includes Idaho, 1954, 1961–63; Montana, 1957; New Mexico, 1954, 1956–63; South Dakota, 1954, 1960–63; Wyoming, 1954, 1956–58, 1960–63.
[2] Revised figure.

TABLE 3.—Mine production and recoverable vanadium in ore and concentrate produced in the United States

(Short tons)

Year	Mine production [1]	Recoverable vanadium	Year	Mine production [1]	Recoverable vanadium
1954-58 (average)	6,022	3,380	1961	6,359	5,343
1959	7,392	3,719	1962	7,647	[2] 5,211
1960	8,047	4,971	1963	6,047	3,853

[1] Measured by receipts at mills, vanadium content.
[2] Revised figure.

TABLE 4.—Production of vanadium pentoxide in the United States

(Short tons)

Year	Gross weight	V_2O_5 content	Year	Gross weight	V_2O_5 content
1954-58 (average)	6,890	6,128	1961	10,796	10,387
1959	7,906	7,305	1962	6,876	6,403
1960	10,767	9,812	1963	7,347	6,959

CONSUMPTION AND USES

Ores and Concentrates.—Vanadium-bearing ores and concentrates processed at domestic plants in 1963 contained 6,185 tons of vanadium, compared to 7,602 tons in 1962.

Alloys and Compounds.—United States ferrovanadium consumption was 35 percent higher than that of 1962. The steel industry consumed 2,406 short tons of vanadium in 1963 compared with 1,850 tons in the previous year, an increase of 30 percent. Of this quantity, that reported used in making carbon steel increased 67 percent. As in 1962, the greatest consumption outside the steel industry was for nonferrous alloys. This use registered an increase of 27 percent.

STOCKS

At the end of 1963, consumers stocks, shown in table 5, were 18 percent higher than those held at the end of 1962.

The national (strategic) stockpile as of December 31, 1963, contained 7,865 short tons of vanadium. Of this quantity, 1,001 tons were held as vanadium contained in ferrovanadium.

TABLE 5.—Vanadium consumed and in stock in the United States in 1963, by forms

(Short tons of vanadium)

Form	Stocks at consumer plants, Dec. 31, 1962	Consumption	Stocks at consumer plants, Dec. 31, 1963
Ferrovanadium	267	2,302	313
Oxide	20	135	25
Ammonium metavanadate	31	122	34
Other [1]	63	347	79
Total	381	2,906	451

[1] Consists principally of vanadium-aluminum alloy, with relatively small quantities of other vanadium alloys and vanadium metal.

TABLE 6.—Vanadium consumed in the United States in 1963, by uses

Use	Short tons	Use	Short tons
Steel:		Gray and malleable castings	19
High-speed	336	Nonferrous alloys [2]	299
Hot-work tool	122	Chemicals	139
Other tool	94	Other [3]	43
Stainless	34		
Other alloy [1]	1,573		
Carbon	247	Total	2,906

[1] Includes some vanadium used in high-speed or other tool steels not specified by reporting firms.
[2] Principally titanium-base alloys.
[3] Includes high-temperature alloys, welding rods, cutting and wear-resistant materials.

PRICES

Domestic vanadium ore was quoted throughout the year at 31 cents per pound of contained vanadium pentoxide, nominal. Quotations for technical grade vanadium pentoxide were $1.25 per pound of contained vanadium pentoxide, but actual prices were said to be lower. Ferrovanadium, containing 50 to 55 percent vanadium, was quoted at yearend at $2.85 to $3.05 per pound of contained vanadium, depending on the grade; vanadium metal of 90 percent purity continued to be quoted at $3.45 per pound in 100-pound lots.

FOREIGN TRADE

General imports of ferrovanadium totaled 481 short tons, a considerable increase over the 88 tons reported in 1962. There were no imports of vanadium ores and concentrates or of vanadium-bearing flue dust in 1963. Imports of vanadic acid and vanadium compounds totaled 2,300 pounds, virtually all from Switzerland; imports of vanadium carbide amounted to 10 pounds, all from West Germany.

Exports of vanadium oxides and vanadates were again approximately half those of the previous year, while ferrovanadium exports decreased 9 percent to 183 tons. There were no exports of flue dust or other vanadium waste materials in 1963.

TABLE 7.—U.S. imports of ferrovanadium, by countries, in 1963

Country	General imports [1]		Imports for consumption [2]	
	Gross weight (pounds)	Value	Gross weight (pounds)	Value
Austria	187,391	$230,843	187,391	$230,843
Belgium-Luxembourg	471,577	678,958	464,659	670,027
Germany, West	170,892	216,632	170,892	216,632
Japan	132,069	150,927	96,292	109,223
Total	961,929	1,277,360	919,234	1,226,725

[1] Comprises ferrovanadium received in the United States; part for immediate consumption and remainder entering bonded warehouses.
[2] Comprises ferrovanadium received for immediate consumption plus material withdrawn from bonded warehouses.

Source: Bureau of the Census.

TABLE 8.—U.S. exports of vanadium, by countries

(Pounds)

Destination	Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium (gross weight)		Vanadium ore, concentrates, pentoxide, vanadic oxide, vanadium oxide, and vanadates (except chemically pure grade) (vanadium content)		Vanadium flue dust and other vanadium waste materials (vanadium content)	
	1962	1963	1962	1963	1962	1963
North America:						
Canada	398,523	317,041	22,625	21,106		
Mexico		2,682	1,736	11,487		
Total	398,523	319,723	24,361	32,593		
South America:						
Argentina			633			
Brazil			5,650	12,712		
Chile			246			
Colombia			493			
Peru				896		
Venezuela	2,000	18,000				
Total	2,000	18,000	7,022	13,608		
Europe:						
Austria			153,889	98,219		
Belgium-Luxembourg		10,089	681,724	252,300	13,776	
Czechoslovakia				3,080		
France		1,600	253,977	110,515		
Germany, West		16,251	187,534	6,451		
Italy			71,090			
Netherlands			265,448	62,283	119,746	
Portugal			2,469			
Switzerland				3,696		
United Kingdom	252	628		455	29,904	
Total	252	28,568	1,616,131	536,999	163,426	
Asia:						
Hong Kong			432			
India			956			
Indonesia	93					
Japan			[1] 393,756	487,552		
Pakistan			288			
Taiwan				742		
Thailand	1,100					
Total	1,193		395,432	488,294		
Oceania:						
Australia				81		
New Zealand				242		
Total				323		
Grand total:						
Quantity	401,968	366,291	[1] 2,042,946	1,071,817	163,426	
Value	$745,912	$587,690	[1] $2,997,995	$1,641,122	$23,527	

[1] Revised figure.

Source: Bureau of the Census.

WORLD REVIEW

South Africa, Republic of.—In 1962 there were exported from the Republic of South Africa 1,587 short tons of fused oxide and 52 tons of ammonium metavanadate (minimum 75 percent vanadium pentoxide); in 1961, exports were only of fused oxide but amounted to 2,529 tons. The drop resulted from a weaker European market for which

U.S. and Finnish exports continued to compete with those from South Africa and South-West Africa. Indications were that the situation carried over into 1963.[2]

TABLE 9.—World production of vanadium in ores and concentrates, by countries [1]

(Short tons)

Country	1954-58 (average)	1959	1960	1961	1962	1963
North America: United States (recoverable vanadium)	3,380	3,719	4,971	5,343	5,233	3,862
South America:						
Argentina	1	4	(2)	[3] 4	9	(2)
Peru (content of concentrate)	57	----	----	----	----	----
Europe: Finland	[4] 255	556	625	701	629	[3] 617
Africa:						
Angola	[5] 11	3	----	----	----	----
Rhodesia and Nyasaland, Federation of: Northern Rhodesia (recovered vanadium)	----	----	146	112	3	----
South Africa, Republic of	[6] 162	320	656	1,422	1,393	1,391
South-West Africa (recoverable vanadium)	459	719	838	1,145	1,019	1,134
World total (estimate) [1] [7]	4,325	5,321	7,236	8,727	8,286	7,004

[1] This table incorporates some revisions.
[2] Data not available.
[3] Estimate.
[4] Average annual production 1956-58.
[5] Average annual production 1955-58.
[6] Average annual production 1957-58.
[7] Total represents data only for countries shown in table and excludes vanadium in ores produced in countries for which figures are not available. Such production is believed to be relatively small. The table also excludes quantities of vanadium recovered as by-products from other ores and raw materials.

Transvaal Vanadium Co. (Pty.) Ltd., a subsidiary of Anglo American Corporation, was the only vanadium producer in the Republic at the beginning of 1963. Through another subsidiary, Highveld Development Co., Ltd., Anglo American Corp. was considering a second project for producing vanadium from vanadiferous magnetite ores of the Bushveld Complex in connection with the establishment of a steel plant. The feasibility of the steel-making project was under study in 1963 by a team of British engineers. African Metals Corp., Ltd. (AMCOR) also was interested in the Bushveld vanadiferous magnetites and obtained mineral rights in the Lydenburg district with vanadium recovery reported to be the primary objective.[3] African Metals Corporation reported that prospecting continued in 1963, and vanadium product research was conducted in a pilot plant at the Kookfontein works with particular overseas market requirements in mind.[4]

South-West Africa.—The Berg Aukas lead-zinc-vanadium mine of the South West Africa Co., Ltd., was the only producer of vanadium in South-West Africa in 1962, the same as in 1961. Production of lead-vanadium concentrate in 1962 decreased to 10,100 short tons from 11,400 tons in 1961, whereas production of zinc-lead concentrate, zinc-lead hand-cobbed ores, and zinc silicate concentrate showed large increases. In the company's fiscal year ending June 30, 1963, annual tonnage milled at Berg Aukas increased 14,200 tons to 82,700 tons, and "assured" reserves of vanadate ore were reported to have increased

[2] Mining Journal (London). V. 260, No. 6655, Mar. 8, 1963, p. 235.
[3] Bureau of Mines. Mineral Trade Notes. V. 58, No. 1, January 1964, p. 44.
[4] Mining Journal (London). V. 261, No. 6687, Oct. 18, 1963, p. 371.

55,000 tons.[5] The vanadium mineral present is the lead-zinc vanadate, descloizite; lead occurs as galena, cerussite, and anglesite; and zinc as willemite, sphalerite, and calamine. The mill produces a variety of concentrates using separate oxide and sulfide flotation circuits.[6]

United Kingdom.—Demand for ferrovanadium and other vanadium-bearing materials was weak early in 1963 with prices reported to be the lowest for some time.[7]

TECHNOLOGY

To improve the economics of ductile vanadium metal production, the Bureau of Mines at Salt Lake City, Utah, tried several modifications of the conventional method of reducing vanadium pentoxide with calcium in a bomb. A two-stage procedure involving alumino-thermic reduction of vanadium pentoxide in an open vessel, followed by bomb refining with calcium either with or without added pentoxide, doubled the capacity of the bomb and significantly lowered the requirements for expensive calcium. The ductile vanadium produced was somewhat less pure than metal prepared by direct calcium reduction, and overall recovery of vanadium was about 10 percent lower. Experiments using low-grade red cake and black cake as lower grade feed materials resulted in lower recoveries and poorer quality metal. Replacing part of the calcium with magnesium or silicon attained similar results. Use of aluminum to replace part of the calcium gave good recoveries, but relatively large quantities of aluminum or oxygen reported in the metal product.[8]

The feasibility of electrodepositing vanadium in nonaqueous baths in a temperature range of 20° to 200° C was investigated by the Bureau at Albany, Oreg. Amides, ammonia derivatives, ketones, polyhydroxy alcohols, and ethers were included among the organic solvents used, but no successful metallic deposits were obtained.[9]

Using a spark-excited unidirectional arc, 18 elements were determined spectrographically in vanadium metal and compounds in the general range of 1 to 1,000 parts per million. The samples were converted to vanadium pentoxide, and except for molybdenum determinations, were combined with a mixture of graphite, lithium carbonate, and gallium oxide. The average precision attained was 15.6 percent relative standard deviation, and relative error was 4.4 percent.[10]

Thermodynamic data were determined for crystalline vanadium silicide of the composition V_3Si for the temperature range from 298.15° to 1,500° K.[11] Supplementing previous Bureau observations for the vanadates of calcium, magnesium, and sodium, determinations of heat and free energy data were made for those of lead and manganese by hydrochloric acid solution calorimetry. It was indicated that thermal stability of comparable vanadates increases in order from

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[5] Metal Bulletin (London). No. 4858, Dec. 24, 1963, p. 17.
[6] Engineering and Mining Journal. V. 165, No. 1, January 1964, p. 33.
[7] Mining Journal (London). V. 260, No. 6655, Mar. 8, 1963, p. 235.
[8] Chindgren, C. J., L. C. Bauerle, and J. B. Rosenbaum. Modifications in Bomb Reduction of Vanadium Oxide. BuMines Rept. of Inv. 6284, 1963, 14 pp.
[9] Meredith, Robert E., and Thomas T. Campbell. Electrodeposition Studies of Molybdenum, Tungsten, and Vanadium in Organic Solvents. BuMines Rept. of Inv. 6303, 1963, 15 pp.
[10] Carpenter, Lloyd, and Kathleen Hazen. Analysis of High-Purity Vanadium by Optical Emission Spectrography. BuMines Rept. of Inv. 6182, 1963, 16 pp.
[11] Pankratz, L. B., and K. K. Kelley. High-Temperature Heat-Content and Entropy Data for Vanadium Silicide (V_3Si). BuMines Rept. of Inv. 6241, 1963, 5 pp.

magnesium through manganese, lead, and calcium to sodium, each being stable with respect to decomposition into the oxides.[12] New data on the heats of formation of vanadium nitride and vanadium carbide greatly reduced the uncertainties of the previously existing approximations.[13]

It was suggested that the formation of molten vanadium pentoxide upon exposure of vanadium to air at the relatively low temperature of 1,250° F may prove to be one of the important assets of its alloys in aerospace applications, although this property has heretofore been considered one of vanadium's undesirable features. Fabricability, weldability, and oxidation-protection capability of vanadium alloys are particularly good, and vanadium is favored by a high strength-weight ratio. The oxidation resistance of siliconized vanadium-columbium alloys may be due to localized formation of molten oxide. It was proposed that the silicon-protected vanadium-columbium alloys might have their greatest potential at temperatures above 2,000° F, applications of vanadium alloys below 1,900° F being limited to non-oxidizing atmospheres.[14]

Recovery of vanadium from petroleum ash was deemed economically feasible if the crude oil contains more than 1 percent vanadium pentoxide and there are at least 100 to 150 tons of ash available per day. A generalized procedure, subject to variation according to the particular ash being treated, was proposed as follows. Dried, ground ash is combined with sodium chloride and sodium carbonate. Upon roasting, carbon is driven off, vanadium oxides are partially converted to the pentoxide, and the pentoxide in turn converted to sodium vanadate. These reactions are completed by autoclave oxidation followed by leaching. Vanadium trioxide is precipitated by 300 pounds per square inch hydrogen which also precipitates nickel associated with the vanadium in the ash. After filtration, the nickel is removed by magnetic separation, leaving the vanadium trioxide which can be smelted with iron to obtain ferrovanadium.[15]

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12 Kelley, K. K., L. H. Adami, and E. G. King. Heats and Free Energies of Formation of Vanadates of Lead and Manganese. BuMines Rept. of Inv. 6197, 1963, 9 pp.

13 Mah, Alla D. Heats and Free Energies of Formation of Vanadium Nitride and Vanadium Carbide. BuMines Rept. of Inv. 6177, 1963, 8 pp.

14 Van Thyne, R. J. Vanadium Alloys in Aerospace. J. Metals, v. 15, No. 9, September 1963, pp. 642–644.

15 Chemical Engineering. V. 70, No. 1, Jan. 7, 1963, p. 42.

Vermiculite

By Timothy C. May [1]

CRUDE vermiculite produced in the United States in 1963 increased 10 percent, and consumption increased 13 percent over that of 1962. Imports from the Republic of South Africa rose 18 percent in 1963.

TABLE 1.—Salient vermiculite production statistics

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Production:						
Crude .... thousand short tons..	194	207	199	206	205	226
Average value .... per ton..	$13.52	$14.89	$15.62	$16.26	$16.06	$15.81
Exfoliated .... thousand short tons..	156	153	151	151	152	172
Average value .... per ton..	$64.33	$62.69	$68.25	$71.44	$73.37	$80.68
World: Production crude ..... thousand short tons..	251	261	269	279	295	329

DOMESTIC PRODUCTION

Crude Vermiculite.—Five domestic producers of crude vermiculite reported production of over 226,000 short tons in 1963. The principal producers were Zonolite Co., Lincoln County, Mont., and Laurens County, S.C.; Patterson Vermiculite Co., and American Vermiculite Co., Laurens County, S.C. Small quantities of vermiculite also were produced in Colorado and Wyoming.

Exfoliated Vermiculite.—Production in 1963 was over 172,000 tons with a value of $13.9 million; compared with over 152,000 tons and $11.2 million in 1962, this was an increase of 13 percent in quantity and 24 percent in value. Twenty-seven companies with 55 plants in 33 States exfoliated vermiculite in 1963.

TABLE 2.—Screened and cleaned domestic crude vermiculite sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1954–58 (average)	194	$2,623	1961	206	$3,350
1959	207	3,082	1962	205	3,293
1960	199	3,108	1963	226	3,572

[1] Commodity specialist, Division of Minerals.

TABLE 3.—Exfoliated vermiculite sold or used by producers in the United States

Year	Operators	Plants	States	Thousand short tons	Value (thousands)
1954–58 (average)	26	53	34	156	$10,035
1959	25	52	34	153	9,591
1960	27	53	34	151	10,305
1961	28	56	35	151	10,787
1962	26	52	34	152	11,152
1963	27	55	33	172	13,877

CONSUMPTION AND USES

The principal markets remained in the construction industry. Available data indicated that quantities used in lightweight aggregate for concrete, loose-fill-insulation, and building plaster were slightly larger than in 1962. Vermiculite for acoustical and fireproofing purposes, pipe covering, agriculture, and miscellaneous uses also increased.

PRICES

E&MJ Metal and Mineral Markets quoted nominal yearend prices for crude vermiculite as follows: Per short ton, f.o.b. mines, Montana, $9.50 to $18; and South Africa, c.i.f. Atlantic ports, $27.80 to $39.80.

The average mine value of all domestic crude vermiculite sold or used was $15.81 per ton, compared with $16.06 in 1962.

The average value of all exfoliated vermiculite, f.o.b. processing plants, was $80.68 per ton, compared with $73.37 in 1962.

FOREIGN TRADE

Crude vermiculite is imported duty-free into the United States. The Republic of South Africa continued to be the only important source of vermiculite imports.

WORLD REVIEW

Canada.—Six companies exfoliated vermiculite at 12 locations in 1963. The companies were in Vancouver (2) and Richmond, British Columbia; Calgary, Alberta; Regina, Saskatchewan; Winnipeg and St. Boniface, Manitoba; Toronto, Rexdale, and St. Thomas, Ontario; and Lachine and Montreal, Quebec. All crude vermiculite exfoliated in Canada was imported from the United States and the Transvaal, Republic of South Africa. The total exfoliated in 1962 was 350,000 cubic yards, 12 percent more than in 1961. Loose-fill insulation consumed 79 percent of production in 1962, plaster 13 percent, insulating concrete 5 percent, and underground insulation and agricultural purposes 3 percent.[2]

[2] Wilson, S. H., Lightweight Aggregates, 1962 (Preliminary), Dept. Mines and Tech. Surveys, Ottawa, Canada, June 1963, 6 pp.

TABLE 4.—Free world production of vermiculite by countries [1] [2]

(Short tons)

Country [1]	1954–58 (Average)	1959	1960	1961	1962	1963
Argentina	629	[3] 880	349	541	2,962	[3] 2,980
India	236	2	17	697	410	746
Kenya	363	112	283		22	101
Morocco	[4] 147					
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	209	50				
South Africa, Republic of	55,753	52,398	69,022	71,118	85,534	98,758
Sudan	[5] 132	[3] 130		55	55	
Tanganyika	19	125	20	157	72	30
United Arab Republic (Egypt)	67	331	132		313	[6] 66
United States (sold or used by producers)	193,351	206,579	199,072	206,637	205,747	226,278
Free world total [1] [2]	250,906	260,607	268,895	279,205	295,115	328,959

[1] Vermiculite is produced in Brazil, but data are not available, and no estimate of production is included in the total.
[2] This table incorporates some revisions.
[3] Estimate.
[4] 1 year only, as 1957 was the only year of commercial production.
[5] 1 year only, as 1958 was the first year of commercial production.
[6] Includes mica.

South Africa, Republic of.—Principal countries to which crude vermiculite was exported were the United Kingdom, 32 percent; Italy, 17 percent; the United States, 16 percent; West Germany and France, 8 percent each; and Canada, 5 percent.

TABLE 5.—Republic of South Africa: Exports of crude vermiculite, by countries [1]

(Short tons)

Destination	1962	1963
North America:		
Canada	2,917	4,839
Mexico	120	174
Puerto Rico	166	261
United States	12,098	14,337
Europe:		
Austria	186	104
Belgium	457	794
Denmark	761	1,313
Finland	145	252
France	7,513	7,413
Germany, West	7,815	7,599
Italy	12,029	15,721
Netherlands	501	1,647
Spain	829	1,368
Sweden	436	585
Switzerland	239	335
United Kingdom	26,250	28,308
Asia:		
Iraq	190	347
Israel	42	163
Japan	875	924
Kuwait	317	1,409
Malaya	60	167
Africa:		
Algeria	124	
Morocco	110	49
Rhodesia and Nyasaland, Federation of	100	120
Oceania:		
Australia	2,046	2,031
New Zealand	84	84
Other countries	487	443
Total	76,897	90,787
Total value [2]	$1,458,708	$1,723,365
Average value	$18.97	$18.98

[1] This table incorporates some revisions.
[2] Converted to U.S. currency at the rate of 1 rand equals US$1.3987 (1962) and US$1.3948 (1963).

Source: Compiled from Quarterly Information Circular on Minerals for the Republic of South Africa and the Territory of South-West Africa.

TECHNOLOGY

Papers presented at the annual Vermiculite Institute meeting at Chandler, Ariz., in March 1963, covered new developments of interest to the building and agricultural industries. A new cotton-planting method, using fertilizer-saturated vermiculite in combination with 20-inch-wide plastic strips, was described. The plastic is laid down by a precision planter which cuts a hole in the material and places the seed in the hole at a given depth. It is then covered with vermiculite that has been treated with fertilizer and insecticides.[3]

Different commercial vermiculites were examined, and it was found that the exfoliable minerals can be divided into three main groups—those which give a 26-Angstrom-unit spacing on an X-ray diffraction, those which give a 14-Angstrom-unit spacing, and those which give various spacings and are partially dehydrated.[4]

Australian research workers have developed a process for producing vermiculite films with a tensile strength similar to that of paper and electrical-insulating properties comparable to those of mica. The process treats the vermiculite with dispersing agents and then soaks it in water. When the resulting dispersion is dried out on a smooth flat surface, the vermiculite crystals form a continuous, flexible film of any desired thickness.[5]

Investigations into the use of a centrifuged bed of vermiculite indicated a method of obtaining high flow rates without seriously affecting its ion-exchange properties. Good decontamination factors of radioactive effluent have been obtained on both laboratory and pilot plant scale.[6]

To evaluate the suitability of Indian vermiculite as an insulating material, quality and exfoliation characteristics were studied for nine samples of vermiculite collected from different parts of India and an imported sample. Experiments were carried out in an electrically heated furnace and the effects of temperature, time of exposure, particle size, and presence of impurities on exfoliation were studied in all the samples under identical conditions.[7]

The use of exfoliated vermiculite impregnated with suitable reagent was suggested for absorbing gases in low concentrations. The application in absorption processes depends on a completely different procedure which utilizes, to the maximum extent, the available surface area of the vermiculite and also the liquid storage capacity of the material.[8]

The composition, properties, uses, and specifications of vermiculite found in Ontario, Canada, were discussed. Occurrences, grade and

[3] Pit and Quarry. Vermiculite Producers See Increase in Demand. V. 56, No. 1, July 1963, p. 77, 85.

[4] Midgley, H. G., and C. M. Midgley. Mineralogy of Some Commercial Vermiculites. Clay Mineral Bull., v. 4, No. 23, 1960, pp. 142–150; J. Am. Ceram. Soc. (Ceram. Abs.), v. 46, No 11, Nov. 21, 1963, p. 314.

[5] Chemical Trade Journal and Chemical Engineering (London). V. 153, No. 3991, Dec. 6, 1963, p. 872.

[6] Chemistry and Industry (London). Investigations Into the Use of Vermiculite for the Decontamination of Radioactive Effluent. No. 33, Aug. 17, 1963, p. 1395.

[7] Roy, S. B., and S. K. Chakravorty. Studies on Indian Vermiculite. Central Glass and Ceram. Res. Inst. Bull., v. 10, No. 1, 1963, pp. 1–13.

[8] Rabson, S. R. Vermiculite in the absorption of Gases, Vapors and Fumes. Ind. Chemist, v. 37, No. 5, 1961 pp. 219–220; J. Am. Ceram Soc. (Ceram. Abs.), v. 46, No. 2, Feb. 21, 1963, p. 54.

evaluation of deposits, mining, milling, and beneficiation are described.[9]

A review gave special attention to seven deposits mined in the U.S.S.R. Chemical composition and physical properties of the vermiculite from each deposit were described.[10]

A process to eliminate biotite mica, asbestos, and other intimately associated gangue materials from vermiculite ore was patented. The ore is wet with a strong sodium chloride or other salt brine and then soaked in water to cause swelling of the vermiculite particles. The vermiculite and gangue fractions can then be separated by a gravity method.[11]

The production method for a granular, lightweight, slow-release complete fertilizer composition was patented. Exfoliated vermiculite is impregnated with an acidified solution of methylol ureas under conditions that cause condensation in the particles.[12]

In the preparation of a high-analysis, granulated, lightweight mixed fertilizer product, muriate of potash and triple superphosphate are admixed with exfoliated vermiculite, and the mix is wetted down with acid and then ammoniated. The material is then cooled and bagged.[13]

A patent was issued on the use of exfoliated vermiculite as the preferred carrier for certain pesticides admixed with low-volatile solvent vehicles.[14]

A method for making fire-resistant composite board was patented. The board has a layer of exfoliated vermiculite glued to one or both of its sides.[15]

A British patent was granted covering a method for making foundry molding shapes from a mixture of exfoliated vermiculite and sodium silicate with calcium silicide or another exothermic material.[16]

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[9] Guillet, G. R. Vermiculite in Ontario With Appendix on Perlite. Ontario Dept. Mines, Ind. Miner. Rept. 7, 1962, 39 pp.

[10] N. N. Kal'yanov. Vermiculite, Its Properties, Technology, and Application in Industry. Perlit i Vermikulit (Geol. Metodika Rasvedki i Teknol.) Min. Geol. i Okhrany Nedr. SSSR, 1962, pp. 110–123. Chem. Abs., v. 58, No. 11, May 27, 1963, col. 11115.

[11] Ziegler, G. E., J. C. Hayes, and A. M. Gaudin (assigned to Zonolite Co., Chicago, Ill. Vermiculite Concentration. U.S. Pat. 3,076,546, Feb. 5, 1963.

[12] Renner, V. A. (assigned to O. M. Scott & Sons, Marysville, Ohio). Fertilizer Compositions and Process. U.S. Pat. 3,076,700, Feb. 5, 1963.

[13] Ridgeway, J. L. (assigned to Zonolite Co., Chicago, Ill). Method of Producing Granulated Fertilizer, U.S. Pat. 3,077,395, Feb. 12, 1963.

[14] Renner, V. A. (assigned to O. M. Scott & Sons Co., Marysville, Ohio). Granular Herbicidal Composition and Method. U.S. Pat. 3,083,089, Mar. 26, 1963.

[15] Polovtseff, B., D. Allen, and F. E. Childs. Composite Board and Method of Making Same. U.S. Pat. 3,109,767, Nov. 11, 1963.

[16] Newton, H S. (assigned to the Distillers Co., Ltd.). Brit. Pat. 922,505, Apr. 3, 1963.

Water

By William H. Kerns [1]

THE NATION'S water supply potential, as measured by streamflow and ground-water levels, was below median. Runoff on all major continental rivers in the United States was much below average. Ground-water levels at the end of the year were generally lower than average, and in many areas of heavy pumping were the lowest on record.

With the probable doubling of the world population by A.D. 2000 and the growing need for water by each household, by industry, and by agriculture, the problems of supplying an adequate and pure future water supply received increased attention from Government organizations, industry, and the public. Attention was given to saline water conversion, pollution control, and treatment and reuse of water.

LEGISLATION AND GOVERNMENT PROGRAMS

The Federal Council for Science and Technology, with the assistance of a Special Task Group on Coordinated Water Resources Research having representation from the several Federal agencies involved, issued a report [2] to the President on water resources research activities of the executive branch of the Government. It is a comprehensive statement of the objectives and activities of all Federal agencies engaged in water resources research.

Similar bills to establish water resources research centers at land-grant colleges and State universities were entered in the Senate (S. 2) and the House of Representatives (H.R. 2683 and H.R. 4048) of the Eighty-eighth Congress, first session. Hearings were held in both Houses and the amended version of S. 2 passed in the Senate in 1963. The bills were designed to provide highly trained personnel now in related disciplines in the colleges and universities to agencies responsible for meeting the Nation's water requirements, and to train much needed new personnel in hydrosciences.

Research and development programs of the U.S. Department of the Interior, Office of Saline Water (OSW), continued to expand under the Anderson-Aspinall Act of 1961.[3] Appropriations for this work increased to $10 million for fiscal year 1964, compared with $7 million for fiscal year 1963. The programs took major steps toward lowering the cost of producing fresh water from salt water. The Office of Saline Water assumed a major role under the aegis of the International Atomic Energy Agency in worldwide efforts to use nuclear power as a source of heat for desalting. At its San Diego, Calif.,

[1] Commodity specialist, Division of Minerals.
[2] Federal Council for Science and Technology—Federal Water Resources Research Activities. U.S. Senate, Committee on Interior and Insular Affairs, 88th Cong., 1st sess., Mar. 25, 1963, 213 pp.
[3] U.S. Department of the Interior. Saline Water Conversion Report for 1963. January 1964, 187 pp.

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demonstration plant, OSW achieved a 40-percent increase in output, to a daily capacity of 1.4 million gallons, with only a negligible increase in expense. Important applied research facilities began operating at the new Research and Development Test Station at Wrightsville Beach, N.C. Increased emphasis was placed on basic research on water. Favorable results were reported on two OSW studies, a nuclear-fired combination electric power and sea water desalting plant and an oil-fired combination electric power plant and desalting plant to serve Tijuana, Mexico.

A report[4] was published on the source, adequacy, requirements, treatment, costs, reuse, and disposal of water in Arizona mineral industries. Detailed schematic flow diagrams were shown for uses of water at many of the operations visited. Work was conducted throughout the year on a similar study in Nevada and New Mexico.

The Bureau of Mines continued to cooperate with other Government agencies in the preparation of comprehensive water development plans for all major river basins of the United States along the lines suggested by the Senate Select Committee on National Water Resources.

Several flood-control proposals, two deep-well pumping projects, and three surface-improvement projects were investigated by the Bureau of Mines in 1963 under an amendment passed in 1962 to the Act of July 15, 1955, relating to the conservation of anthracite coal resources through flood control and anthracite mine drainage. The program has implemented Federal and State anti-stream-pollution activities, assisted in conserving natural resources, and enhanced the economy of the anthracite-producing region.

A comprehensive State-by-State report[5] on the Nation's water resources was published by the U.S. Department of the Interior, Geological Survey. The report both reassures and cautions all who have an interest in the water situation. The report shows that, despite the availability of water reserves underground, the intensity of water development in this country has led to local shortages and acute water problems, such as permanent lowering of the water table in certain areas or the encroachment of salt water in coastal streams and wells.

DOMESTIC SUPPLY

Annual flow of water or runoff, a partial and convenient measure of potential water supply, was deficient in five large areas: An irregular area along the Great Lakes extending to the Atlantic; southern and central Florida; the southern midcontinent and Mississippi and part of Alabama; an area in the western Dakotas and eastern Montana; and an area in the Southwest including parts of Arizona, New Mexico, Utah, Colorado, and Wyoming. Only in four areas was runoff excessive: northern California, central Idaho, and small areas each in northern Wyoming and northern Alabama. Runoff was well above the median range in Maine, Minnesota, central California, eastern Oregon, and a small area in southwestern New Mexico and southeastern Arizona; it was far below median—approaching deficient—in

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[4] Gilkey, M. M., and Robert T. Beckman. Water Requirements and Uses in Arizona Mineral Industries. BuMines Inf. Circ. 8162, 1963, 97 pp.

[5] McGuinness, C. L. The Role of Ground Water in the National Water Situation. Geol. Survey Water-Supply Paper 1800, September 1963, 1121 pp.

an area including eastern Colorado, northern Kansas, central and southern Missouri, southern Illinois and Indiana, and western Kentucky and Tennessee.[6]

The mean discharge of the Mississippi River at Vicksburg, Miss., was 400,700 cubic feet per second. This was 70 percent of median, the sixth lowest in 35 years of record. At Vicksburg, the river drains about 40 percent of the contiguous United States. The Columbia River drains 237,000 square miles of the Northwest. Its average flow near The Dalles, Oreg. was 176,700 cubic feet per second or 94 percent of median. Mean discharge of the Colorado River at Grand Canyon, Ariz., draining 137,800 square miles of the Rocky Mountain System and the Intermountain Plateaus, was 3,760 cubic feet per second. Glen Canyon Dam on the Colorado River was closed in January, and all three reservoirs in the upper Colorado River Project stored water—Lake Powell on the Colorado, Flaming Gorge Reservoir on the Grun, and Navajo Reservoir on the San Juan.

No widespread drought of disastrous intensity developed during the year, but near drought conditions persisted for many months in the south midcontinent, in Mississippi, and in parts of the States bordering the Great Lakes. The deficient streamflow in Utah, Colorado, Arizona, and New Mexico that had persisted for many months was largely alleviated by rain in August and September.

Water storage in the major power reservoirs was above average except in the West-Central United States. Storage for irrigation was generally slightly below average. The municipal and industrial storage of water was well below average. Storage in major multiple-use reservoirs in the West was above average except for Lakes Mead and Mojave. The water level of the Great Salt Lake dropped to an alltime low.

Ground-water levels at the end of the year were generally below average and in many areas of heavy pumping were the lowest on record. In two-thirds of the key observation wells, water levels were lower than in 1962; in the remaining one-third of the wells the levels were higher.

CONSUMPTION AND USES

Total water use from streams, lakes, reservoirs, and wells continued to increase. Total requirements of water during the year were about 340 billion gallons, compared with 135 billion gallons in 1940, and 40 billion gallons 60 years ago. Estimates are that 600 billion gallons of water will be needed by 1980. Each person has a quota of 15,000 gallons of water per day. Although each person does not use that much personally, it must be available if he is to lead a normal life. To produce wheat for a 2.5-pound loaf of bread requires 300 gallons of water. Plants eaten by animals to produce 1 pound of beef require 2,300 gallons. More than 100 gallons of water is needed to produce 1 pound of vegetables. About 4.2 gallons, or 35 pounds, of water is required to produce 1 pound of steel.

In a study made in New Mexico under a grant made to the University of New Mexico by Resources for the Future, Inc., it was found that each acre-foot of water would generate $51 in gross State product if used in farming, $3,041 if used for municipal and industrial purposes,

Geological Survey (in collaboration with Canada Department of Northern Affairs and National Resources). Water Resources Review: Annual Summary, Water Year 1963. 22 pp.

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and $2,793 if used for a combination of manufacturing and recreation.[7]

As reported [8] by the Bureau of Mines in a study of the water requirements and uses in Arizona mineral industries, the mineral-product value of copper, lead, zinc, and byproducts was equivalent to $15.27 for each 1,000 gallons, or $4,980 per acre-foot, of new water and $26.29 for each 1,000 gallons, or $8,570 per acre-foot, of consumed water. New water for the mineral-industry operations was obtained as follows: 87.8 percent was "self-supplied" from ground-water sources, 10.9 percent was "self-supplied" from surface-water sources, and 1.3 percent was purchased. At many operations, inadequacy of the supply necessitated large-scale recirculation.

A national survey of water use in the mineral industry in 1962 was conducted by the Bureau of Mines during 1963. Included in the survey were operators of metal and nonmetal mines, mills, and quarries; coal preparation plants and associated mines; oil-well drilling, secondary oil-recovery operations, and natural gas processing plants. Metal smelters and refineries, stockpile and assessment work operations, cement and lime plants, natural-brine operations, sand and gravel operations using suction dredges without preparation plants, and coal mines were excluded from the survey.

Summary data for new water intake and water used by major components of the mineral industry are shown in tables 1–4. New water intake is water introduced for the first time in the operation, regardless of quality and source. Water used is the total of the new water intake and the water recirculated in the operation. It is contemplated that the survey shall be conducted once every 5 years so that trend of water use in the mineral industry can be indicated.

PRICES

Prices paid for water varied widely, depending on the area and type of use. The national average value of water was estimated at $135 per acre-foot, or 40 cents per 1,000 gallons. Conventional water costs ranged from 20 to 75 cents per 1,000 gallons. The cost of converting sea water to fresh water in 1963 ranged from $1 to $1.50 per 1,000 gallons, compared with $4 to $5 in 1962. Two major factors in the cost of converting water are size of plant and cost of heat. Studies indicated that the optimum plant size is about 25 to 30 million gallons per day. It was reported that using waste heat from an existing powerplant or building a combination powerplant and waterplant may make this low-cost converted water competitive with high-cost conventional water in the near future.

Cost for new water at 14 mineral industry operations in Arizona, as reported [9] by the Bureau of Mines, ranged from 1.0 cent to 57.7 cents per 1,000 gallons, with an average of 12.5 cents, including power, labor, and supplies costs. Recirculation costs for power, labor, and supplies at three copper operations ranged from 1.0 cent to 1.8 cents per 1,000 gallons.

The U.S. Atomic Energy Commission (AEC) operated the Savannah River heavy water plant, Arken, S.C., at one-third capacity through-

[7] Wollman, Nathaniel. The Value of Water in Alternative Uses. The University of New Mexico Press. Albuquerque, New Mexico, 1962, 426 pp.

[8] Work cited in footnote 4.

[9] Work cited in footnote 4.

TABLE 1.—New water intake by major components of the mineral industry in the United States, in 1962 [1]

(Million gallons)

Mineral industry	Fresh water	Saline water	Other low quality water	Total water
Metals: [2]				
Aluminum	1,174			1,174
Copper	33,441	2,638	44,942	81,021
Ferroalloys	2,401		100	2,501
Iron	12,214		100,355	112,569
Lead and zinc	15,560		7,315	22,875
Uranium-vanadium	2,464	1,362	3,385	7,211
Other metals	65,284		2,255	67,539
Total	132,538	4,000	158,352	294,890
Nonmetals: [3]				
Clays	4,934		1,143	6,077
Fluorspar	105		700	805
Mica	503		481	984
Phosphate rock	65,947		51,218	117,165
Salt	16,561	5,030	7,339	28,930
Sand and gravel	120,726	4,390	92,260	217,376
Stone	18,955	2,196	32,318	53,469
Sulfur	12,191	1,815	3,598	17,604
Magnesite and brucite	974	59	660	1,693
Other nonmetals	12,252	1,883	4,062	18,197
Total	253,148	15,373	193,779	462,300
Petroleum [4]	63,019	58,261	231	121,511
Natural gas processing	53,050	16,146	33,163	102,359
Bituminous coal [5]	12,528	314	18,965	31,806
Anthracite coal [5]	3,575		13,359	16,934
Total	517,858	94,094	417,849	1,029,800

[1] Includes new water introduced for the first time in mining and milling operations, regardless of quality or source. Excludes operations using less than 1 million gallons in all components except for petroleum and natural gas processing.
[2] Excludes metal smelters and refineries and stockpile and assessment work operations.
[3] Excludes cement and lime plants, natural-brine operations, and sand and gravel operations using suction dredges without preparation plants.
[4] Includes oil-well drilling and secondary oil recovery operations only.
[5] Includes wet-washing coal cleaning plants only.

out the year. Reevaluation of the service life of the plant's process equipment resulted in cost reductions that permitted a 12.5-percent decrease in the heavy water price. Sales to U.S. customers during the year increased to over 4,000 pounds—about 1.5 times the 1962 sales. Foreign shipments totaled 54 tons of heavy water.

WORLD REVIEW

Canada.—Four articles on water pollution in Canada, giving the Government's policy and role, results of a cooperative approach, and industries viewpoint, were published.[10]

Hong Kong.—Hong Kong's new $41.2 million Shek Pik Reservoir, Southeast Asia's largest and most costly reservoir built to date, will give the chronically water-short British Crown Colony a 35-million-gallon-per-day increase in water supply until completion of the 30-

[10] Cooke, Norman E. Industry's Viewpoint on Industrial Water. Eng. J. (Montreal, Canada). V. 46 No. 3, March 1963, pp. 48–49.
Jones, Douglas. A Pollution Policy, Eng. J. (Montreal, Canada). V. 46, No. 3, March 1963, pp. 41–43.
Roy, L. P. Results of a Co-Operative Approach to a Water Survey. Eng. J. (Montreal, Canada). V. 46, No. 3, March 1963, pp. 46–47.
Van Luven, A. L. Government's Role in Pollution Control. Eng. J. (Montreal, Canada). V. 46 No. 3, March 1963, pp. 43–46.

TABLE 2.—Sources of new water intake by major components of the mineral industry in the United States in 1962 [1]

(Million gallons)

Source	Metals [2]	Nonmetals [3]	Petroleum [4]	Natural gas processing	Bituminous coal [5]	Anthracite coal [5]
Purchased from others	2,435	10,121	(6)	(6)	593	1,561
Self-operated systems:						
Stream or river	92,637	207,213	(6)	(6)	17,161	4,609
Lake or reservoir	123,597	55,746	(6)	(6)	7,899	1,627
Ocean or estuary		8,640	(6)	(6)		
Ground water	52,868	152,938	(6)	(6)	1,838	299
Mine water	22,618	24,640	(6)	(6)	4,239	8,189
Transferred from other plants	675	669	(6)	(6)	53	649
Total self-operated	292,395	449,846	(6)	(6)	31,190	15,373
Sewage effluent	60	2,333	(6)	(6)	23	
Total new water	294,890	462,300	121,511	102,359	31,806	16,934

[1] Includes new water introduced for the first time in mining and milling operations, regardless of quality or source. Excludes operations using less than 1 million gallons in all components except for petroleum and natural gas processing.
[2] Excludes metal smelters and refineries and stockpile and assessment work operations.
[3] Excludes cement and lime plants, natural-brine operations, and sand and gravel operations using suction dredges without preparation plants.
[4] Includes oil-well drilling and secondary oil recovery operations only.
[5] Includes wet-washing coal cleaning plants only.
[6] Data not available; included with total.

billion-gallon-per-day Plover Cove Reservoir, scheduled to be started early 1964. The first two of four large covered concrete reservoirs that will store 84 million gallons of water for the coastal city of Kowloon were completed. The reservoirs, conforming to the shape of the valleys, will be covered with earth to provide a large recreational park and playground over the reservoirs.

Iran.—The mid-March dedication of the $67 million Mohammed Reza Shah Phalavi Dam marks the completion of the first major step in Iran's long-range development program for that country's vast Khuzestan Province. The dam rises 647 feet out of the Dez River Canyon, 47 feet higher than the Karadj Dam, which previously was the highest dam in the Middle East. Thirteen more multipurpose dams are proposed in the overall development plan for the five rivers in Khuzestan Province.

Israel.—It was announced that sweet water will be produced from the sea at a cost of less than $1 per 1,000 gallons by the desalination plant now under construction near the port of Eilat. The plant will have an initial capacity of 250,000 gallons per day.

Thailand.—The 508-foot-high Bhumiphol (Yanhee) Dam in Thailand, Southeast Asia's highest dam, was completed in midyear. It is a concrete arch-gravity dam on the Ping River, 250 miles north of Bangkok, and is part of Thailand's $100-million multipurpose hydropower project.

U.S.S.R.—Water and sewage treatment in the Soviet Union was described.[11] It was concluded that the country places a higher priority

[11] Gilbertson, Wesley E., and Dwight F. Metzler. Water and Sewage Treatment in the Soviet Union. Engineering News-Record, v. 171, No. 19, Nov. 7, 1963, pp. 42–44.

TABLE 3.—New water intake by major components of the mineral industry, by State, in 1962 [1]

(Million gallons)

State	Metals [2]	Non-metals [3]	Petroleum [4]	Natural gas processing	Bituminous coal [5]
Alabama	3,304	1,004	11		2,329
Alaska	16,279	714	52		1,344
Arizona	26,203	1,085	5		
Arkansas	1,240	7,986	870	312	
California	38,758	27,811	9,397	2,276	18
Colorado	7,668	2,181	2,717	281	5
Connecticut		2,267			
Delaware		112			
Florida	5,699	69,705	2		
Georgia	211	14,547			
Hawaii		326			
Idaho	8,893	1,133			
Illinois	1,183	7,994	8,829	(6)	5,302
Indiana		7,714	592		1,190
Iowa		1,999			
Kansas	61	13,177	6,299	668	147
Kentucky		1,087	2,264	[6] 738	8,092
Louisiana		19,986	4,705	54,499	
Maine		199			
Maryland		5,186	1		
Massachusetts		2,604			
Michigan	25,160	22,080	252	(6)	
Minnesota	98,216	4,090			
Mississippi		6,871	768	201	
Missouri	3,161	12,380	1		225
Montana	7,558	2,013	498	[7] 278	2
Nebraska		1,687	1,989	121	
Nevada	7,507	1,057	1		
New Hampshire		642			
New Jersey	2,796	10,086			
New Mexico	4,380	5,570	2,005	3,076	41
New York	1,822	18,324	1,462		
North Carolina	49	7,843			
North Dakota		2,107	961	78	
Ohio		32,041	186		644
Oklahoma	36	5,172	22,725	3,362	26
Oregon	24	2,875	2		
Pennsylvania	3,095	18,971	6,940	260	[8] 19,611
Rhode Island		505			
South Carolina		3,883			
South Dakota	3,302	37	1		
Tennessee	4,310	52,988	10		
Texas	464	36,951	40,109	28,645	
Utah	18,938	3,214	514	(7)	995
Vermont		578			
Virginia	934	4,423	1		1,591
Washington	820	7,043	3		16
West Virginia		6,452	130	6,842	7,163
Wisconsin	801	1,049			
Wyoming	2,018	2,551	7,209	722	
Total	294,890	462,300	121,511	102,359	48,741

[1] Includes new water introduced for the first time in mining and milling operations, regardless of quality or source. Excludes operations using less than 1 million gallons in all components except for petroleum and natural gas processing.
[2] Excludes metal smelters and refineries and stockpile and assessment work operations.
[3] Excludes cement and lime plants, natural-brine operations, and sand and gravel operations using suction dredges without preparation plants.
[4] Includes oil-well drilling and secondary oil recovery operations only.
[5] Includes wet-washing coal cleaning plants only.
[6] Illinois and Michigan included with Kentucky.
[7] Utah included with Montana.
[8] Includes 16,934 million gallons water used in preparing anthracite coal.

and therefore more of its resources on the conservation of human health than on the conservation of water. This was not surprising in view of the generally abundant supply of water in Soviet streams and lakes, and the well-known emphasis that had been placed upon medical care and preventative medicine.

TABLE 4.—Water use by major components of the mineral industry, by States, in 1962 [1]

(Million gallons)

State	Metals [2]	Nonmetals [3]				Petroleum [4]	Natural gas processing	Bituminous coal [5]	Total
		Sand and gravel	Quarries	Other	Total				
Alabama	4,157	959	1,063	616	2,638	11		9,693	16,499
Alaska	19,008	1,220			1,220	52		1,476	21,756
Arizona	76,163	1,316	27	(6)	1,343	5			77,511
Arkansas	2,057	8,089	1,055	1,771	10,915	1,585	11,623		26,180
California	46,058	29,922	2,249	5,566	37,737	20,522	126,519	36	230,872
Colorado	11,179	4,375	1	738	5,114	3,900	22,940	20	43,153
Connecticut		2,220	284	480	2,984				2,984
Delaware		153			153				153
District of Columbia				(6)	(6)				(6)
Florida	17,079	1,705	11,860	223,894	237,459	2			254,540
Georgia	259	5,503	3,689	7,192	16,384				16,643
Hawaii			328	(6)	328				328
Idaho	9,130	499	2	2,259	2,760				11,890
Illinois	1,263	16,699	1,160	665	18,524	17,753	(7)	27,713	65,253
Indiana		12,210	4,639		16,849	1,055		9,875	27,779
Iowa		5,493	455	(6)	5,948				5,948
Kansas	121	11,300	601	4,789	16,690	14,211	27,221	1,862	60,105
Kentucky		785	4	330	1,119	2,547	[7] 33,281	22,719	59,666
Louisiana		13,065		14,806	27,871	5,566	185,762		219,199
Maine		211	8	(6)	219				219
Maryland		7,061	446	1	7,508	1			7,509
Massachusetts		3,267	1,125	(6)	4,392				4,392
Michigan	51,002	23,411	7,008	2,467	32,886	286	(7)		84,174
Minnesota	195,907	4,175	1,456		5,631				201,538
Mississippi		10,524	(6)	5	10,529	804	3,304		14,637
Missouri	4,777	11,478	338	8,056	19,872	1		1,293	25,943
Montana	11,264	1,240	40	3,779	5,059	612	[8] 19,325	22	36,282
Nebraska		2,855	190		3,045	2,118	5,293		10,456
Nevada	10,796	919	(6)	679	1,598	1			12,395
New Hampshire		1,061	12		1,073				1,073
New Jersey	6,188	15,783	82	132	15,997				22,185
New Mexico	7,127	470	(6)	39,019	39,489	2,737	136,582	341	186,276
New York	10,108	9,171	4,421	7,848	21,440	1,462			33,010
North Carolina	61	4,227	2,034	5,352	11,613				11,674
North Dakota		5,446		38	5,484	1,202	1,751		8,437
Ohio		30,849	2,902	11,021	44,772	412		7,736	52,920
Oklahoma	854	14,089	648	2	14,739	47,501	174,483	158	237,735
Oregon	27	2,707	210	(6)	2,917	2			2,946
Pennsylvania	9,388	11,903	13,267	36	25,206	6,940	341	[9] 58,033	99,908
Rhode Island		525	67		592				592
South Carolina		2,631	1,928	1,284	5,843				5,843

South Dakota	4,352	241	3	----------	244	1	----------	----------	4,597
Tennessee	7,056	1,058	207	146,150	147,415	49	----------	(6)	154,520
Texas	2,202	33,529	2,695	13,869	50,093	54,965	934,975	----------	1,042,235
Utah	33,910	4,025	(6)	5,831	9,856	608	(8)	2,394	46,768
Vermont	----------	149	522	58	729	----------	----------	----------	729
Virginia	1,173	4,269	1,724	1,341	7,334	1	----------	9,603	18,111
Washington	838	7,413	91	687	8,191	3	----------	42	9,074
West Virginia	----------	7,661	913	1,736	10,310	130	22,327	49,193	81,960
Wisconsin	801	1,894	343	(6)	2,237	----------	----------	----------	3,038
Wyoming	10,971	575	51	8,379	9,005	8,578	3,467	(6)	32,021
Total	555,276	340,330	70,148	520,876	931,354	195,623	1,709,194	202,209	3,593,656

[1] Includes all users of water regardless of size and all water used regardless of quality or source. Water use includes new water intake and water recirculated.
[2] Excludes metal smelters and refineries and stockpile and assessment work operations.
[3] Excludes cement and lime plants, natural-brine operations, and sand and gravel operations using suction dredges without preparation plants.
[4] Includes oil-well drilling and secondary oil recovery operations only.
[5] Includes wet-washing coal cleaning plants only.
[6] Less than 1 million gallons.
[7] Illinois and Michigan included with Kentucky.
[8] Utah included with Montana.
[9] Includes 16,934 million gallons water used in preparing anthracite coal.

TECHNOLOGY

Rain and snow that falls on land each year is estimated at 32,000 tons per inhabitant of the globe, more than 10 times the normal requirement. Only a small fraction of this water becomes available; 71 percent evaporates or is transpired back to the air near the place it fell. The remaining 29 percent runs off or sinks into the ground; some becomes contaminated. Underground deposits are being drained more rapidly than they can be replenished. With the probable doubling of the world population by A.D. 2000 and the growing needs for water by each household, by industry, and by agriculture, water shortages could well be one of the most important restrictions on society's development in the near future. One way by which this possible catastrophe might be averted is to make use of the salt water that is nearly 3,000 times more abundant and covers more than two-thirds of the earth's surface.

Research and development programs on saline water conversion by the Office of Saline Water (OSW) continued to expand.[12] At the request of the U.S. Department of State, OSW assumed a greater role in worldwide efforts to use nuclear power as a source of heat for desalting. The Office of Saline Water agreed to participate in an International Atomic Energy Commission-sponsored study of a project to develop a large nuclear-powered saline water conversion plant on the Gulf of California in cooperation with the Government of Mexico.

A 40-percent increase in output, to a daily capacity of 1.4 million gallons, with virtually no increase in capital investment and only a slight increase in operating expenses was achieved at the saline water conversion demonstration plant at San Diego, Calif. This plant utilizes a multistage flash distillation process. On July 1, the 1.0-million-gallon-per-day demonstration plant utilizing the forced circulation vapor compression process was dedicated at Roswell, N. Mex. Other demonstration plants, at Freeport, Tex., San Diego, Calif., and Webster, S. Dak., were operated successfully during the year. Data obtained from these operations are providing information that is being studied and evaluated to form the basis for the design of larger and more efficient plants.

The new Research and Development Test Station at Wrightsville Beach, N.C., containing a number of applied-research pilot plants, began operating. A 200,000-gallon-per-day freezing process plant, currently being constructed and scheduled for completion in 1964, will supply fresh water to the city of Wrightsville Beach to augment its present limited sources of natural fresh water.

Increased emphasis was placed on basic research to expand the fundamental knowledge of the nature of water in itself and of its solutions.

Two preliminary appraisal reports indicated that larger demonstration plants produced favorable results. The preliminary report of one study indicated that a nuclear-fired combination electric power and sea water desalting plant would provide fresh water for the Florida Keys at an economically competitive price. A preliminary report was released on another study on an oil-fired combination

[12] Work cited in footnote 3.

electric power plant and desalting plant to serve municipal requirements at Tijuana, Mex. It was recommended that a 72-million-gallon-per day desalting plant would be the most practical source of water for Tijuana and that a detailed feasibility study be made of the project. The desalting plant would be integrated with the recently completed steam electric plant at Rosarito, Mex.

Two research programs were being conducted by universities for the Branch of Inorganic Chemistry, Division of Research, OSW, to recover minerals from sea water. Research was directed on one program toward precipitation of potassium from sea water as magnesium potassium phosphate. Another program was investigating a process to recover potassium from concentrated brine by chelation. It was reported that potash is the mineral of greatest economic potential in sea water; the value of potash in 1,000 gallons of sea water ranges from 10 to 20 cents. Larger markets exist for potash than for any other mineral in sea water except salt.

Listed in the OSW report for 1963 [13] are the research and development progress reports for use by research scientists and engineers working on developing new and improving existing saline water conversion processes. Many of these reports were published during the year and are available from the Office of Technical Service, U.S. Department of Commerce. Fourteen scientific papers, covering a variety of saline water conversion topics, were compiled and published by the American Chemical Society [14] as a sequel to a publication [15] in 1960 that was widely read and that reportedly stimulated new interest in the saline water conversion program.

Many advances were made in the technology of treating water to use or reuse more of it and thus conserve and increase the water supply. An example is the increased use of synthetic organic flocculants (cationic polyelectrolytes) instead of chemical coagulants in water and sewage treatment.[16] They have been used since 1952 in industrial water clarification and solids concentration, such as in uranium processing, but it is predicted that they will comprise a larger part (up to 25 percent) of the total coagulant usage in water and sewage treatment. It was announced that a dual-purpose filter developed and marketed during the year opened the path to clearer water.[17] The advantages of this filter are a smaller investment, lower operating cost, and a low-turbidity output; turbidity is removed by coagulation as in conventional systems, but the floc, is separated from the water in the voids of coarse filter media rather than by settling.

Automatic electronic monitoring systems that continuously measure and record the quality of water were installed and operated at several locations, enabling authorities to promptly spot pollution sources.[18]

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[13] Work cited in footnote 3.
[14] American Chemical Society. Saline Water Conversion—II. Advances in Chemistry Series No. 38, June 1963, 200 pp.
[15] American Chemical Society. Saline Water Conversion. Advances in Chemistry Series No. 27, 1960, 246 pp.
[16] Chemical Engineering. Synthetic Flocculants Set for Plunge into Water. V. 70, No. 8, Apr. 15, 1963, pp. 98, 100, 102.
[17] Chemical Engineering. Dual-Purpose Filter Opens Path to Clearer Water. V. 70, No. 10, May 13, 1963, pp. 90-92.
[18] Chemical and Engineering News. Monitor System Continuously Records River Water Quality. V. 41, No. 18, May 6, 1964, pp. 54-56.
Chemical Engineering. Automatic Analyzers Help Combat River Pollution. V. 70, No. 3, Feb. 4, 1963, pp. 48-50.

The Illinois Department of Public Health developed a method using radioactive formic acid to identify polluted waters.[19]

Long-chain aliphatic alcohols (for example, cetyl) have been used for covering water in reservoirs to slow evaporation. A new approach, developed during the year, was to add approximately 10 percent of a shorter chain alcohol (for example, hexanol) to the solid, forming a homogeneous mass that becomes self-dispersing at a rate of 1 square foot in 5 to 10 seconds. A 5-pound block is said to cover 3 acres and will inhibit evaporation for 3 months in the absence of strong winds.[20]

Studies made by the U.S. Forest Service and water engineers indicated that a monomolecular layer of hexadecanol sprayed on mountain snowfields and moisture-laden soil would reduce evaporation by as much as 90 percent.[21]

In the face of rapidly mounting State and Federal pressures, the detergent industry has decided to switch from detergents based on alkyl benzene sulfonates (ABS) to soft (biodegradable) detergents.[22] This move was strongly influenced by the apparent lack of success in efforts to discover an economically feasible method of removing ABS from waste water that created water-pollution problems.

Major research activities supported by the U.S. Department of Health, Education, and Welfare, Public Health Service, in the field of water supply and pollution control were continued throughout the year. Included were both intramural research projects conducted within the Service and extramural research performed in universities and other institutions with Federal aid.

The Bureau of Mines through its Industrial Water Laboratory continued to provide consulting boiler-water service to requesting Federal agencies operating heating and power plants; 14,144 water and condensate samples were analyzed from more than 10,000 boilers. These analyses were helpful in spotting and correcting corrosion problems in boilers and condensate return lines. This service was described in an Information Circular.[23]

Heavy water (D_2O), water incorporating deuterium instead of normal hydrogen, absorbs fewer neutrons than ordinary light water. Reactors moderated with heavy water can operate efficiently on natural or slightly enriched uranium fuel. Different types of heavy-water-moderated reactors have been studied in the United States for several years. Recent studies by du Pont and Combustion Engineering for the Atomic Energy Commission have shown that the concept has good potential for reduction in unit power costs in sizes of 500,000 electrical kilowatts or higher. The concept also has a potential application in the production of large amounts of heat for industrial processes such as desalting of sea water.[24]

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[19] Chemical Week. A Quick Method of Identifying Polluted Waters. V. 92. No. 16, Apr. 20, 1963, p. 75.

[20] Chemical Week. A New Approach to Slowing Evaporation of Water in Reservoirs. V. 92, No. 18, May 4, 1963, p. 56.

[21] Chemical Week. Now Its Evaporation Control of Snow. V. 93, No. 10, Sept. 7, 1963, p. 74.

[22] Chemical Engineering. A Big Debut Nears for Biodegradable Detergents. V. 70, No. 16, Aug. 5, 1963, pp. 52–54.

[23] Berk. A. A. Bureau of Mines Boiler-Water Service. BuMines Inf. Circ. 8176, 1963, 8 pp.

[24] U.S. Atomic Energy Commission. Annual Report to Congress of the Atomic Energy Commission for 1963, January 1964, p. 92.

Zinc

By H. J. Schroeder [1]

Contents

THE DOMESTIC zinc industry in 1963 recorded a slab zinc consumption of 1.1 million tons, 7 percent above 1962 and the largest since 1955. Mine production increased 5 percent to 529,000 tons, and slab zinc output was up 2 percent to 953,000 tons. Producer stocks declined from 145,000 to 48,000 tons, the lowest yearend level since 1955. Consumer stocks increased from 80,000 tons to 97,000 tons during the year.

The quoted price of Prime Western grade zinc, East St. Louis, advanced from 11.5 to 13.0 cents per pound in three ½-cent increases during the year.

Import quotas, established in 1958, remained in effect. General imports of ores and concentrates decreased 20 percent to 373,000 tons and for metal increased 2 percent to 145,000 tons. Exports of slab zinc decreased 6 percent to 34,000 tons.

Government stockpiles contained 1.6 million tons of zinc. No additions or withdrawals were made during 1963.

The International Lead-Zinc Study Group held a meeting at Geneva in November.

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[1] Commodity specialist, Division of Minerals.

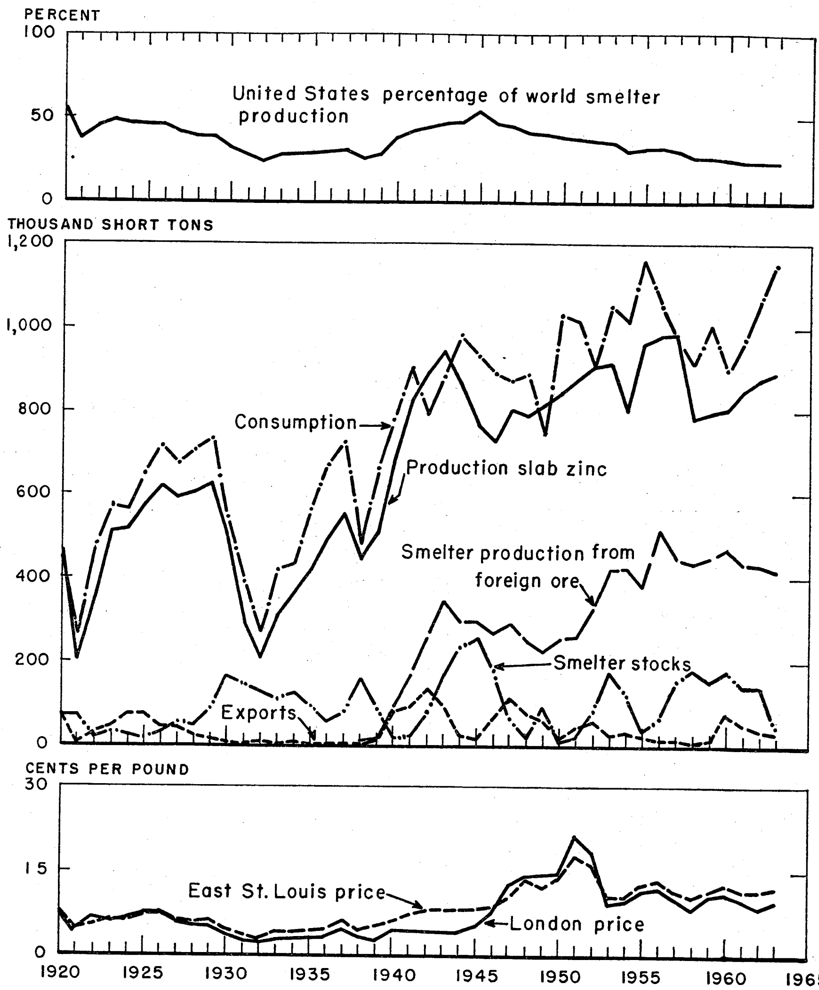

FIGURE 1.—Trends in the zinc industry in the United States, 1920–63. Consumption figures represent primary slab zinc plus zinc contained in pigments made directly from ore.

LEGISLATION AND GOVERNMENT PROGRAMS

The International Lead-Zinc Study Group held a meeting at Geneva, Switzerland during the first week in November. For 1963 it was estimated that free world zinc consumption would reach a record level of 3.2 million short tons with about an 85,000-ton shortfall of new supplies. Further rises in both consumption and production but with a smaller shortfall were forecast for 1964. Through a Special Working Group which met in Geneva during the last week in March, the principles, objectives, and possible forms of intergovernmental arrangements for lead and zinc were examined. The Study Group decided that this subject should be kept under review.

TABLE 1.—Salient zinc statistics

	1954-58 (average)	1959	1960	1961	1962	1963
United States:						
Production:						
Domestic ores, recoverable content-------short tons--	494, 844	425, 303	435, 427	464, 390	505, 491	529, 254
Value------thousands--	$116, 928	$97, 787	$112, 365	$106, 848	$116, 413	$122, 533
Slab zinc:						
From domestic ores short tons--	463, 850	348, 443	334, 101	413, 282	448, 095	474, 007
From foreign ores--do----	439, 466	450, 223	465, 415	433, 513	431, 300	418, 577
From scrap--------do----	65, 054	57, 818	68, 731	55, 237	58, 880	60, 303
Total-----------do----	968, 370	856, 484	868, 247	902, 032	938, 275	952, 887
Secondary zinc [1]-------do----	206, 035	219, 027	197, 810	183, 357	203, 800	208, 715
Imports (general):						
Ores (zinc content)----do----	489, 279	500, 115	457, 155	415, 700	467, 398	372, 769
Slab zinc-------------do----	212, 348	156, 963	120, 767	127, 562	141, 957	144, 757
Exports of slab zinc-------do----	12, 947	11, 629	75, 144	50, 055	36, 102	33, 853
Stocks, December 31:						
At producer plants----do----	113, 878	156, 210	185, 882	146, 887	144, 746	47, 910
At consumer plants---do----	103, 237	[2] 103, 156	[2] 70, 361	[2] 97, 155	[2] 79, 934	96, 607
Consumption:						
All classes [3]-----------do----	1, 269, 303	1, 278, 376	1, 158, 938	1, 207, 469	[2] 1, 333, 311	1, 414, 216
Price, Prime Western, East St. Louis--------cents per pound--	11. 64	11. 46	12. 95	11. 55	11. 63	12. 01
World:						
Production:						
Mine-------------short tons--	3, 330, 000	[2] 3, 440, 000	[2] 3, 660, 000	[2] 3, 810, 000	[2] 3, 890, 000	3, 970, 000
Smelter---------------do----	3, 020, 000	[2] 3, 150, 000	[2] 3, 350, 000	[2] 3, 590, 000	[2] 3, 750, 000	3, 830, 000
Price: Prime Western, London cents per pound--	10. 34	10. 27	11. 05	9. 78	8. 43	9. 60

[1] Excludes redistilled slab zinc.
[2] Revised figure.
[3] Includes slab zinc, recoverable zinc content of ores and secondary zinc.

Import quotas on zinc metal and ore, established October 1, 1958, were in effect throughout 1963. The annual quotas were set at 80 percent of the U.S. average annual commercial import rate from 1953 through 1957—379,840 tons of zinc in ore and 141,120 tons of zinc in pigs, slabs, and certain other forms.

On October 1, the Commission submitted to the President its fourth periodic report on the escape clause action imposing quotas and advised that conditions had not changed enough to warrant a formal inquiry into the question of relaxing existing regulations on imports of unmanufactured lead and zinc.

General Services Administration continued operation of the stabilization program for small domestic producers of lead and zinc. The program was authorized for the years 1962 through 1965 by Public Law 87–347 enacted in October 1961. The principal provisions of the law were included in the 1962 Zinc Chapter. As of December 31, 1963, 125 applications from 13 States had been received of which 98 were certified as eligible, 18 were denied, 4 were withdrawn, and 5 were in process. Stabilization payments in 1963 for the 14,318 tons of zinc produced under the qualifying provisions of the Act amounted to $416,226. Zinc produced under the Act was approximately 2.7 percent of 1963 domestic mine production.

Zinc was removed effective July 1, 1962, from the list of metals eligible for exploration assistance through the Office of Minerals Exploration program. However, five contracts involving zinc awarded prior to July 1, 1962, were in force at the start of 1963. One was terminated and certified as a mineral discovery during the year. The other four remained in force at yearend.

DOMESTIC PRODUCTION

MINE PRODUCTION

Mines in the United States produced 529,300 tons of recoverable zinc, an increase of 5 percent over that of 1962 and the highest annual output since 1957. The only pronounced variation in the year's production pattern was a slightly higher than average rate during the last quarter. States east of the Mississippi River produced 51 percent of the total output; Western States, 46 percent; and West Central States, 3 percent.

The sources of zinc production, classified according to types of ore in 1963 were: 44.7 percent from zinc ores; 43.6 percent from lead-zinc ores; 0.4 percent from lead ore; 6.0 percent from copper-lead, copper-zinc, and copper-lead-zinc ores; and 5.3 percent from all other classifications. Details of this breakdown are in table 3 of the Lead chapter in this volume.

TABLE 2.—Mine production of recoverable zinc in the United States, by States

(Short tons)

State	1954–58 (average)	1959	1960	1961	1962	1963
Arizona	26,432	37,325	35,811	29,585	32,888	25,419
Arkansas	----	49	50	37	211	----
California	3,864	78	465	304	322	101
Colorado	38,976	35,388	31,278	42,647	43,351	48,109
Idaho	54,392	55,699	36,801	58,295	62,865	63,267
Illinois	21,458	26,815	29,550	26,795	27,413	20,337
Kansas	19,133	1,017	2,117	2,446	3,943	3,508
Kentucky	594	673	869	1,147	1,172	1,461
Missouri	3,476	92	2,821	5,847	2,792	321
Montana	56,764	27,848	12,551	10,262	37,678	32,941
Nevada	3,315	217	420	453	281	571
New Jersey	13,373	----	----	112	15,309	32,738
New Mexico	18,401	4,636	13,770	22,900	22,015	12,938
New York	56,600	43,464	66,364	54,763	53,654	53,495
North Carolina	----	----	----	----	----	13
Oklahoma	26,489	1,049	2,332	3,148	10,013	13,245
Oregon	----	----	----	3	----	3
Pennsylvania	2,162	16,718	13,746	23,428	24,308	27,389
Tennessee	46,752	89,932	91,394	81,734	71,548	95,847
Texas	----	----	----	----	----	----
Utah	41,158	35,223	35,476	37,239	34,313	36,179
Virginia	19,163	20,334	19,885	29,163	26,479	23,988
Washington	24,049	17,111	21,317	20,217	21,644	22,270
Wisconsin	18,293	11,635	18,410	13,865	13,292	15,114
Total	494,844	425,303	435,427	464,390	505,491	529,254

Tennessee maintained its rank as the leading producing State with output increasing 34 percent to a record 95,800 tons. American Zinc, Lead and Smelting Co. operated its Mascot, Young and Grasselli mines at capacity; continued development of the New Market mine and mill, a joint venture with Tri-State Zinc Co., Inc., and authorized rehabilitation of the North Friends Station mine and development of a new property to be known as the Immel mine. A total of 1,933,000 tons of ore was milled to yield 93,877 tons of zinc concentrate. When

TABLE 3.—Mine production of recoverable zinc in the United States, by months

(Short tons)

Month	1962	1963	Month	1962	1963
January	38,092	43,776	August	44,616	45,120
February	36,927	41,580	September	42,202	41,439
March	42,929	44,819	October	47,621	47,098
April	42,160	44,882	November	44,280	45,346
May	43,824	45,543	December	42,033	46,094
June	42,551	42,632			
July	38,256	40,925	Total	505,491	529,254

expansion plans are completed the milling capacity will be approximately 3 million tons of ore. The company increased its proven and indicated reserve during the year to approximately 5 million tons of 60 percent zinc concentrate.[2] The New Jersey Zinc Co. operated its Jefferson City mine at near capacity production. The company's Flat Gap mine was idle but scheduled to resume operation in 1964.[3] United States Steel Corp., Tennessee Coal & Iron Division, operated its Zinc Mine Works mine and mill unit during the year. The copper-zinc mines of Tennessee Copper Co. contributed a substantial quantity of zinc output to the State total.

Production in Idaho increased slightly to 63,300 tons of zinc, the largest quantity since 1953; this amount was sufficient to make Idaho the leading producer in the Western States and second in the nation. The Bunker Hill Co. reported 25,345 tons of zinc in concentrate recovered from milling 253,500 tons of ore from its Star Unit mines and 17,694 tons of zinc in concentrate from milling 450,900 tons of ore from its Bunker Hill mine.[4] The Page mine of American Smelting and Refining Company was a substantial producer of zinc.

New York production of recoverable zinc declined slightly to 53,500 tons. St. Joseph Lead Co., the only zinc producer in the State, operated its Balmat and Edwards mines and mills in St. Lawrence County on a 5-day week throughout the year. An expansion program with a target date of July 1, 1965, was in progress at the Edwards mine and mill to increase daily ore capacity from 410 to 600 tons per day.[5]

In Colorado zinc production increased 11 percent to 48,100 tons. Leading zinc producing mines were the Eagle of The New Jersey Zinc Co., and the Idarado of Idarado Mining Co. The Emperius mine operated by Emperius Mining Co. reopened in May after being closed since December 31, 1962. McFarland and Hullinger leased and began operating the Keystone mine of American Smelting and Refining Company. This mine had been closed since 1957.

Zinc production in Utah increased 5 percent to 36,200 tons but was 3 percent below the 1961 output. The United States and Lark mine of United States Smelting, Refining and Mining Co. was the leading zinc producer in the State. Other substantial producers were the United Park City mines of United Park City Mines Co., Mayflower mine of Hecla Mining Co., and the Ophir mine of United States Smelting, Refining and Mining Co. According to its annual report,

[2] American Zinc, Lead and Smelting Co. Annual Report. 1963, 24 pp.
[3] The New Jersey Zinc Co. Annual Report. 1963, pp. 6–7.
[4] The Bunker Hill Co. Annual Report. 1963, p. 12.
[5] St. Joseph Lead Co. Annual Report. 1963, p. 14.

the United Park City Mines Co. mined 54,000 tons of ore yielding 8,557 tons of zinc plus quantities of lead, copper, silver, and gold.

In Montana, zinc production decreased 4,700 tons to 32,900 tons. The Anaconda Company reduced output from the Elm Orlu-Black Rock block caving project at the Badger State mine more than offsetting increased zinc output from its slag-fuming operation at East Helena. Construction of a zinc concentrator at Butte was postponed.[6] The zinc mining operations of Trout Mining Co. and Taylor-Knapp Co. in Granite County were idle during 1963, contributing to the reduced State total.

Zinc production in New Jersey more than doubled to reach 32,700 tons as the Sterling mine of The New Jersey Zinc Co. accelerated operations during the second full year of operation since reopening late in 1961.

Pennsylvania output of zinc increased 13 percent to 27,400 tons, the largest quantity since zinc production was resumed in 1958. The only operating mine was the Friedensville of The New Jersey Zinc Co.

Arizona mine output decreased 23 percent to 25,400 tons. The Iron King mine of Shattuck Denn Mining Corp. continued to be the largest zinc producer in the State. The Old Dick and Copper Queen mines of Cyprus Mines Corp. mined and milled 112,500 tons of ore, yielding 17,600 tons of zinc concentrate and 18,200 tons of copper concentrate. Unless exploration reveals additional ore, the ore deposit will probably be depleted in 1965.[7] Other zinc-producing properties in the State included the Atlas mine of B. S. & K. Mining Co., and the Flux mine of Nash and McFarland. The Johnson Camp mine of McFarland and Hullinger terminated operations in January.

Virginia zinc mine production decreased 9 percent to 24,000 tons. The New Jersey Zinc Co. operated the Austinville and Ivanhoe mines throughout the year. Tri-State Zinc Co. closed its Bowers-Campbell mine at Timberville in July because the orebody was depleted.

In Washington, zinc mine output increased from 21,600 to 22,300 tons. The Pend Oreille mine, Pend Oreille Mines and Metals Co. yielded 16,687 tons of zinc in concentrate and 5,004 tons of lead in concentrate from 651,900 tons of ore mined and milled.[8] American Zinc, Lead and Smelting Co. operated the Grandview and Mineral Rights mines which produced 11,325 tons of zinc plus lead concentrates compared with 12,405 in 1962. The character of the orebody in the Mineral Rights mine was found to be different from that in the Grandview mine, resulting in reduced output and the necessity to materially increase underground development.[9]

Illinois mine output declined 26 percent to 20,300 tons. In northern Illinois, Tri-State Zinc Co., Inc. ceased operations in April at the Gray mine due to depletion of the ore, leaving the Graham operation of The Eagle-Picher Co. as the only producer. Three companies in the southern Illinois fluorspar district continued to recover zinc as a byproduct.

Zinc production in Wisconsin increased 14 percent to 15,100 tons. American Zinc, Lead and Smelting Co. operated its Wisconsin proper-

[6] The Anaconda Company. Annual Report. 1963, 23 pp.
[7] Cyprus Mines Corp. Annual Report. 1963, pp. 11–12.
[8] Pend Oreille Mines and Metals Co. Annual Report. 1963, p. 3.
[9] Pages 10–11 of work cited in footnote 2.

ties at capacity, mining 252,000 tons of ore yielding 16,403 tons of zinc plus lead concentrates compared with 13,926 tons in 1962.[10] The Shullsburg mine of The Eagle-Picher Co. was closed from January 15 to June 21 due to a fire which damaged the headframe and crushing equipment. Ivey Construction Co. started operations at the Linden mine.

In the Tri-State District of Oklahoma, Kansas and Missouri production increased from 14,000 to 16,800 tons. The Oklahoma portion of the district accounted for 79 percent of the production, and Kansas produced the remainder. The southwest Missouri portion of the district last reported production in 1957.

Production in New Mexico declined 41 percent to 12,900 tons, the lowest level since 1959. American-Peru Mining Co. mined and milled ore from the Kearney mine plus purchased ore amounting to 154,000 tons averaging 8.19 percent zinc yielding 20,787 tons of zinc concentrate.[11] In October, The New Jersey Zinc Co. began operations at the Hanover mine, which had been closed since December 1, 1962.

Kentucky produced 1,500 tons of zinc as a byproduct from fluorspar mining operations.

Mine production of zinc from Missouri, all as a byproduct from lead mining in southeast Missouri, dropped from 2,800 to 300 tons. The decline resulted from an 8-month strike, settled in March 1963, and a lower zinc content in the mined ore.

The 25 leading zinc-producing mines in the United States listed in table 4, yielded 81 percent of the total domestic output. The four leading mines supplied 25 percent, and the first eight contributed 43 percent.

SMELTER AND REFINERY PRODUCTION

The zinc smelting and refining industry operated 15 primary and 8 secondary reduction plants producing slab zinc. Producers of slab zinc also made zinc compounds, alloys, zinc dust, and rolled zinc.

Domestic smelters had no significant interruption to operation by labor strikes during the year. Increased demand for zinc as the year progressed resulted in a substantially higher output rate in the last quarter compared with the first three quarters of the year.

Actual or projected changes in zinc producing facilities listed in company annual reports were: American Zinc, Lead and Smelting Co. announced intentions to increase the capacity of its Monsanto electrolytic plant by 15 percent by the end of 1964; The Bunker Hill Co. completed installation of a sixth electrolytic cell line; Blackwell Zinc Co. at the Blackwell, Okla. plant closed down the zinc refining unit late in 1963 for rebuilding, modification, and enlargement; Blackwell also nearly completed modification of four furnaces (about one-third of capacity) to a single condenser unit as replacement of the multicondenser furnaces; The New Jersey Zinc Co. completed construction of three new vertical retort slab zinc furnaces at the Depue, Ill. plant; and St. Joseph Lead Co. had construction in progress at the Joseph-

10 Pages 10-11 of work cited in footnote 2.
11 Page 11 of work cited in footnote 2.

TABLE 4.—Twenty-five leading zinc-producing mines [1] in the United States in 1963 in order of output

Rank	Mine	District or region	State	Operator	Source of zinc
1	Balmat	St. Lawrence County.	New York	St. Joseph Lead Co.	Lead-zinc ore.
2	Sterling Hill	New Jersey	New Jersey	The New Jersey Zinc Co.	Zinc ore.
3	Young	Eastern Tennessee	Tennessee	American Zinc Co. of Tennessee.	Do.
4	Friedensville	Lehigh County	Pennsylvania	The New Jersey Zinc Co.	Do.
5	Eagle	Red Cliff (Battle Mountain).	Colorado	do	Lead-zinc-copper ore.
6	Zinc Mines (Anselmo Badger State, Orphan Girl dump, Orphan Girl pit, Colorado Dump).	Summit Valley	Montana	The Anaconda Company.	Zinc ore.
7	Star and Morning Unit.	Coeur d' Alene	Idaho	The Bunker Hill Co. and Hecla Mining Co.	Lead-zinc ore.
8	Austinville and Ivanhoe.	Austinville	Virginia	The New Jersey Zinc Co.	Do.
9	Jefferson City	Eastern Tennessee	Tennessee	do	Zinc ore.
10	United States and Lark.	West Mountain (Bingham).	Utah	United States Smelting, Refining and Mining Co.	Lead-zinc ore.
11	Bunker Hill	Coeur d' Alene	Idaho	The Bunker Hill Co.	Do.
12	Pend Oreille	Metaline	Washington	Pend Oreille Mines and Metals Co.	Do.
13	Iron King	Big Bug	Arizona	Shattuck Denn Mining Corp.	Do.
14	Zinc Mine Works	Eastern Tennessee	Tennessee	United States Steel Corp., Tennessee Coal and Iron Division.	Zinc ore.
15	Page	Coeur d' Alene	Idaho	American Smelting and Refining Company.	Lead-zinc ore.
16	Idarado	Upper San Miguel and Eureka (Red Mountain).	Colorado	Idarado Mining Co.	Copper-lead-zinc ore.
17	Mascot No. 2	Eastern Tennessee	Tennessee	American Zinc Co. of Tennessee.	Zinc ore.
18	Kearney	Central	New Mexico	American-Peru Mining Co.	Do.
19	Edwards	St. Lawrence County.	New York	St. Joseph Lead Co.	Do.
20	Boyd, Callaway, Eureka and Mary.	Eastern Tennessee	Tennessee	Tennessee Copper Co.	Copper-zinc ore.
21	United Park City	Park City Region	Utah	United Park City Mines Co.	Lead-zinc ore.
22	Coy	Eastern Tennessee	Tennessee	American Zinc Co. of Tennessee.	Zinc ore.
23	Mayflower Unit	Park City Region	Utah	Hecla Mining Co.	Lead-zinc ore.
24	Graham-Snyder-Spillane, Faehan.	Upper Mississippi Valley.	Illinois	The Eagle-Picher Co.	Zinc ore.
25	Grasselli	Eastern Tennessee	Tennessee	American Zinc Co. of Tennessee.	Do.

[1] Excludes old slag dumps.

town plant to increase capacity for production of Special High Grade zinc from 2,200 to 3,700 tons per month.

Slab Zinc.—Domestic smelter output of slab zinc increased for the fifth consecutive year and was the highest for any year since 1957. Included in the 952,900 tons of slab zinc output was molten zinc which was used directly in alloying operations. Of the total output, 892,600 tons was primary metal and 60,300 tons was redistilled secondary zinc. Primary output was 53 percent from domestic ores and 47 percent from foreign ores; 40 percent was electrolytic, and 60 percent was distilled slab zinc. Of the 60,300 tons of redistilled secondary slab zinc, primary smelters produced 78 percent of the total, and the remainder was obtained from secondary smelters.

TABLE 5.—Primary and redistilled secondary slab zinc produced in the United States

(Short tons)

	1954-58 (average)	1959	1960	1961	1962	1963
Primary:						
From domestic ores	463,850	348,443	334,101	413,282	448,095	474,007
From foreign ores	439,466	450,223	465,415	433,513	431,300	418,577
Total	903,316	798,666	799,516	846,795	879,395	892,584
Redistilled secondary	65,054	57,818	68,731	55,237	58,880	60,303
Total (excludes zinc recovered by remelting)	968,370	856,484	868,247	902,032	938,275	952,887

TABLE 6.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by method of reduction

(Short tons)

	1954-58 (average)	1959	1960	1961	1962	1963
Electrolytic primary	369,495	280,813	319,777	324,399	354,138	358,093
Distilled	533,821	517,853	479,739	522,396	525,257	534,491
Redistilled secondary:						
At primary smelters	29,228	28,451	40,009	35,319	41,732	47,214
At secondary smelters	35,826	29,367	28,722	19,918	17,148	13,089
Total	968,370	856,484	868,247	902,032	938,275	952,887

In 1963, Special High Grade was the principal grade produced, furnishing 43 percent of the total (42 percent in 1962). Prime Western Grade constituted 33 percent (38 percent in 1962); High Grade 11 percent (10 percent); Brass Special 11 percent (8 percent); Intermediate and Select 2 percent (2 percent).

TABLE 7.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by grades

(Short tons)

	1954-58 (average)	1959	1960	1961	1962	1963
Special High Grade	331,523	331,312	357,205	353,466	392,901	411,254
High Grade	134,644	71,792	71,332	89,496	94,185	104,301
Intermediate	26,484	17,493	15,841	15,368	14,101	18,372
Brass Special	79,059	75,305	83,507	69,681	75,951	98,190
Select	1,997	1,414	73	----------	130	3,909
Prime Western	394,663	359,168	340,289	374,021	361,007	316,861
Total	968,370	856,484	868,247	902,032	938,275	952,887

Pennsylvania was the leading producing State, with Texas ranking second and Oklahoma third. The slab zinc output of Pennsylvania, West Virginia, Oklahoma, and Arkansas 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.

TABLE 8.—Primary slab zinc produced in the United States, by States where smelted

(Short tons)

	1954–58 (average)	1959	1960	1961	1962	1963
Arkansas	19,748	15,964	1,521	12,342	14,446	11,143
Idaho	57,223	61,191	26,449	74,736	76,756	81,296
Illinois [1]	98,347	102,708	88,291	78,814	99,055	108,971
Montana	184,620	86,620	132,290	111,223	129,144	118,090
Oklahoma	152,150	152,072	161,894	164,319	147,384	142,707
Pennsylvania and West Virginia	225,621	217,368	194,514	214,308	234,038	248,584
Texas	165,607	162,743	194,557	191,053	178,572	181,793
Total	903,316	798,666	799,516	846,795	879,395	892,584
Value (thousand)	$213,983	$183,214	$205,476	$193,916	$201,733	$206,187

[1] Includes production for Missouri for 1955, 1956, 1957, and 1960.

Primary Smelters and Electrolytic Plants.—Primary reduction plants processed zinc ores and concentrates, zinc fume from Waelz kilns and slag-fuming plants, other primary zinc-bearing materials, and zinc-base scrap. A list of primary plants is given in the Zinc chapter of the 1962 yearbook.

Production at primary zinc plants totaled 939,800 tons of slab zinc; 47,200 tons was redistilled. In addition to slab zinc, primary plants produced zinc oxide, zinc dust, and zinc-base alloys.

Primary plant capacity for slab zinc at the 15 operating zinc plants at yearend was reported to be 1,226,300 tons. Five electrolytic plants reported 3,020 of their 4,232 electrolytic cells in use at the end of the year and an output of 358,100 tons (71 percent of the 507,500 tons of capacity). The 6 horizontal-retort plants reported 33,312 of their 43,568 retorts in use during 1963. Four remaining primary smelters were continuous-distilling vertical-retort plants at Meadowbrook, W. Va.; Depue, Ill.; Palmerton, Pa.; and Josephtown, Pa. The first three used The New Jersey Zinc Co. externally gas-fired vertical retorts, and the one at Josephtown used electrothermic distillation retorts. Combined horizontal- and vertical-retort production of 581,700 tons was 81 percent of the reported 1963 capacity of 718,800 tons.

Slag-Fuming Plants.—Many lead smelters recover a zinc-fume-product from lead blast-furnace slags containing 7.5 to 12.5 percent zinc. Such slags were treated to extract zinc and remaining lead by the following companies in 1963:

Company:	*Plant location*
American Smelting and Refining Company	Selby, Calif.
Do	El Paso, Tex.
The Anaconda Co	East Helena, Mont.
The Bunker Hill Co	Kellogg, Idaho.
International Smelting & Refining Co	Tooele, Utah.

These five plants treated 705,300 tons of hot and cold lead slag (including some crude ore and zinc residue), which yielded 122,300 tons of oxide fume, containing 87,000 tons of recoverable zinc. Corresponding figures for 1962 were 688,600, 122,300, and 83,900 (revised) tons, respectively.

Secondary Zinc Smelters.—Zinc-base scrap (a term that includes skimmings and drosses, die-cast alloys, old zinc, engravers' plates, new clippings, and chemical residues) was smelted chiefly at secondary smelters, although about one-fourth was usually reduced at primary smelters and most sal ammoniac skimmings were processed at chemical plants. Secondary smelters depended on the galvanizers and scrap dealers for their supply of scrap materials.

A list of secondary zinc plants is shown in the Zinc chapter of the 1962 yearbook.

TABLE 9.—Stocks and consumption of new and old zinc scrap in the United States in 1963

(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	218	1,828	1,839	----------	1,839	207
Old zinc	611	3,409	----------	3,501	3,501	519
Engravers' plates	335	2,805	----------	2,700	2,700	440
Skimmings and ashes	6,744	46,029	41,895	----------	41,895	10,878
Sal skimmings	223	929	1,007	----------	1,007	145
Die-cast skimmings	820	5,192	4,552	----------	4,552	1,460
Galvanizers' dross	8,289	59,688	60,177	----------	60,177	7,800
Diecastings	5,040	30,490	----------	32,976	32,976	2,554
Rod and die scrap	221	1,158	----------	644	644	735
Flue dust	713	6,271	5,993	----------	5,993	991
Chemical residues	1,276	6,427	6,892	----------	6,892	811
Total	24,490	164,226	122,355	39,821	162,176	26,540
Chemical plants, foundries and other manufacturers:						
New clippings	1	64	65	----------	65	----------
Old zinc	3	4	----------	4	4	3
Engravers' plates	----------	67	----------	67	67	----------
Skimmings and ashes	2,283	10,318	9,821	----------	9,821	2,780
Sal skimmings	6,722	9,316	8,755	----------	8,755	7,283
Die-cast skimmings	----------	----------	----------	----------	----------	----------
Galvanizers' dross	----------	----------	----------	----------	----------	----------
Diecastings	33	836	360	481	841	28
Rod and die scrap	----------	72	----------	55	55	17
Flue dust	47	368	329	----------	329	86
Chemical residues	2,567	17,938	19,431	----------	19,431	1,074
Total	11,656	38,983	38,761	607	39,368	11,271
Grand total:						
New clippings	219	1,892	1,904	----------	1,904	207
Old zinc	614	3,413	----------	3,505	3,505	522
Engravers' plates	335	2,872	----------	2,767	2,767	440
Skimmings and ashes	9,027	56,347	51,716	----------	51,716	13,658
Sal skimmings	6,945	10,245	9,762	----------	9,762	7,428
Die-cast skimmings	820	5,192	4,552	----------	4,552	1,460
Galvanizers' dross	8,289	59,688	60,177	----------	60,177	7,800
Diecastings	5,073	31,326	360	33,457	33,817	2,582
Rod and die scrap	221	1,230	----------	699	699	752
Flue dust	760	6,639	6,322	----------	6,322	1,077
Chemical residues	3,843	24,365	26,323	----------	26,323	1,885
Total	36,146	203,209	161,116	40,428	201,544	37,811

[1] Figures partly revised.

Primary and secondary smelting plants produced 60,300 tons of redistilled zinc, 4,300 tons of remelted products, and 23,700 tons of zinc dust from zinc-base scrap. The zinc content of these products totaled 87,300 tons.

TABLE 10.—Production of secondary zinc and zinc-alloy products in the United States

(Short tons)

Product	1954–58 (average)	1959	1960	1961	1962	1963
Redistilled slab zinc	65,054	[1] 57,818	[1] 68,731	[1] 55,237	[1] 58,880	60,303
Zinc dust	44,443	26,421	26,681	22,878	24,863	23,749
Remelt spelter	5,803	4,718	4,883	4,260	3,540	3,740
Remelt die-cast slab	11,671	13,150	7,800	9,548	10,834	10,168
Zinc-die and diecasting alloys	5,448	5,864	6,945	5,894	5,531	5,894
Galvanizing stocks	274	245	222	117	369	611
Rolled zinc	1,598	14	18	19	14	4
Secondary zinc in chemical products	30,303	40,204	38,007	35,639	36,331	35,210

[1] Includes redistilled slab made from remelt die-cast slab.

Additional details on the zinc recovered in processing copper-base scrap (table 13) may be obtained in the secondary copper and brass section of the Copper chapter of this volume.

TABLE 11.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1962	1963	Form of recovery	1962	1963
New scrap:			As metal:		
Zinc-base	109,324	110,886	By distillation:		
Copper-base	87,893	91,592	Slab zinc [1]	58,217	59,540
Aluminum-base	2,994	3,144	Zinc dust	24,497	23,417
Magnesium-base	53	69	By remelting	3,892	4,317
Total	200,264	205,691	Total	86,606	87,274
Old scrap:			In zinc-base alloys	15,183	14,940
Zinc-base	33,588	32,572	In brass and bronze	118,487	125,087
Copper-base	25,929	27,634	In aluminum-base alloys	5,256	5,543
Aluminum-base	2,192	2,302	In magnesium-base alloys	154	201
Magnesium-base	44	56	In chemical products:		
			Zinc oxide (lead-free)	18,985	18,591
Total	61,753	62,564	Zinc sulfate	(2)	(2)
			Zinc chloride	11,753	10,768
Grand total	262,017	268,255	Miscellaneous	5,593	5,851
			Total	175,411	180,981
			Grand total	262,017	268,255

[1] Includes zinc content of redistilled slab made from remelt die-cast slab.
[2] Included with "Miscellaneous."

BYPRODUCT SULFURIC ACID

Sulfuric acid was made from sulfur dioxide gases produced in roasting zinc sulfide concentrate at some primary zinc smelters. At several plants, elemental sulfur was burned to increase acid-making capacity. Acid production at zinc-roasting plants from zinc sulfide was 861,800 short tons, valued at $11.9 million, and from elemental sulfur, 101,100 tons, valued at $1.5 million.

ZINC DUST

Zinc dust data included in tables 12, 13, and 14 is restricted to commercial grades that comply with close specifications as to percentage of unoxidized metal, evenness of grading, and fineness of particles; it does not include blue powder. Zinc content of the dust produced ranged from 94.99 to 99.69 percent, averaging 98.60 percent. Total shipments of zinc dust were 40,700 tons; 600 tons was shipped abroad. Producer stocks of zinc dust were 3,100 tons at the end of the year.

Most of the zinc dust was made from zinc scrap, chiefly galvanizers' dross, but some was recovered from refined metal.

TABLE 12.—Zinc dust produced in the United States

Year	Short tons	Value	
		Total	Average per pound
1954–58 (average)	27,621	$8,192,723	$0.148
1959	32,758	9,683,265	.148
1960	30,788	10,283,192	.167
1961	34,772	$10,570,688	$0.152
1962	40,978	12,539,268	.153
1963	40,362	12,592,944	.156

CONSUMPTION AND USES

Zinc consumed as refined metal in slab or other forms totaled 1.1 million tons; the recoverable zinc content of ore and concentrate consumed to make pigments and salts and used directly in galvanizing totaled 104,700 tons; and the recoverable zinc content of scrap used to make alloys, zinc dust, pigments, and salts totaled 204,400 tons. Overall consumption of primary and secondary zinc was 6 percent more than in 1962.

TABLE 13.—Consumption of zinc in the United States

(Short tons)

	1954–58 (average)	1959	1960	1961	1962	1963
Slab zinc	963,370	956,197	877,884	931,213	1,031,821	1,105,113
Ores (recoverable zinc content)	[1] 107,196	[1] 108,070	[1] 88,275	[1] 97,251	[1] [2] 101,582	[1] 104,705
Secondary (recoverable zinc content) [3]	198,737	214,109	192,779	179,005	199,908	204,398
Total	1,269,303	1,278,376	1,158,938	1,207,469	[2] 1,333,311	1,414,216

[1] Includes ore used directly in galvanizing.
[2] Revised figure.
[3] Excludes redistilled slab and remelt zinc.

Slab zinc consumption, as reported by approximately 700 plants, was 7 percent higher than 1962 consumption and only 1 percent below the record of 1,119,800 tons used in 1955. The quantity of zinc used for zinc-base alloys increased 11 percent to a historically high record. Consumption of zinc in galvanizing rose 8 percent to 420,300 tons. Zinc consumed in rolled zinc was 42,200 tons, unchanged from 1962; for brass products there was a recorded decrease of 1 percent to 128,200 tons; and 16,000 tons was produced for zinc oxide, a 13-percent decrease.

TABLE 14.—Reported slab zinc consumption in the United States, by industry use

(Short tons)

Industry and product	1954–58 (average)	1959	1960	1961	1962	1963
Galvanizing: [1]						
Sheet and strip	189,618	175,691	196,057	211,300	213,970	238,919
Wire and wire rope	41,619	35,602	35,262	37,608	38,203	39,466
Tubes and pipe	79,831	59,830	56,680	54,957	54,003	56,563
Fittings	10,124	10,239	9,258	6,540	8,039	7,787
Other	87,355	[2] 79,665	[2] 74,332	[2] 71,672	[2] 74,355	[2] 77,552
Total	408,547	361,027	371,589	382,077	388,570	420,287
Brass products:						
Sheet, strip, and plate	55,176	61,234	45,870	60,018	61,210	61,462
Rod and wire	36,684	40,286	29,971	41,018	41,875	43,517
Tube	12,537	11,808	8,504	10,168	10,627	10,786
Castings and billets	5,919	4,967	4,699	4,061	4,923	3,969
Copper-base ingots	7,247	10,276	9,412	12,874	10,884	7,784
Other copper-base products	893	707	567	384	286	719
Total	118,456	129,278	99,023	128,523	129,805	128,237
Zinc-base alloy: [3]						
Die castings	343,890	383,358	331,112	337,227	419,042	462,543
Alloy dies and rod	9,096	3,745	3,442	1,629	850	720
Slush and sand castings	2,020	2,228	3,819	2,910	3,716	5,356
Total	355,006	389,331	338,373	341,766	423,608	468,619
Rolled zinc	45,664	42,949	38,696	41,204	42,233	42,166
Zinc oxide	18,811	18,248	15,593	18,137	18,517	16,037
Other uses:						
Wet batteries	1,242	1,244	1,152	1,058	1,133	1,216
Desilverizing lead	2,737	1,949	2,521	2,630	2,302	2,095
Light-metal alloys	4,291	3,363	3,181	4,347	4,920	5,660
Other [4]	8,616	8,808	7,756	11,471	20,733	20,796
Total	16,886	15,364	14,610	19,506	29,088	29,767
Total consumption [5]	963,370	956,197	877,884	931,213	1,031,821	1,105,113

[1] Includes zinc used in electrogalvanizing and electroplating, but excludes sherardizing.
[2] Includes 31,521 tons used in job galvanizing in 1959, 31,616 tons in 1960, 30,954 tons in 1961, 34,871 tons in 1962, and 39,223 tons in 1963.
[3] After 1957 figures include zinc used in direct alloying operations.
[4] Includes zinc used in making zinc dust, bronze powder, alloys, chemicals, castings, and miscellaneous uses not elsewhere mentioned.
[5] Includes 5,209 tons of remelt zinc in 1959, 6,622 tons in 1960, 7,528 tons in 1961, 7,518 tons in 1962, and 6,900 tons in 1963.

Of the 1,105,100 tons of slab zinc used, 49 percent was Special High Grade, 28 percent Prime Western, 11 percent High Grade, 10 percent Brass Special, 1 percent Intermediate, and 1 percent for Select and Remelt combined. All grades were used in galvanizing and in brass and bronze products. Of the 468,600 tons of slab zinc used in zinc-base alloys, 99 percent was Special High Grade.

Rolling mills used 42,200 tons of slab zinc and remelted and rerolled 12,100 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.

Output of salable rolled zinc increased to 41,000 tons. Stocks of rolled zinc at the mills declined to 2,500 tons by yearend. Besides shipments of 19,900 tons of rolled zinc, the rolling mills consumed 33,500 tons of rolled zinc in manufacturing 21,900 tons of semifabricated and finished products.

TABLE 15.—Reported slab zinc consumption in the United States in 1963, by grades and industry use

(Short tons)

Industry	Special High Grade	High Grade	Intermediate	Brass Special	Select	Prime Western	Remelt	Total
Galvanizing	26,254	23,506	1,541	87,353	395	277,947	3,291	420,287
Brass and bronze [1]	25,099	77,428	164	4,070	2,575	16,740	2,161	128,237
Zinc-base alloys [2]	463,987	2,031	99			1,588	914	468,619
Rolled zinc	14,674	12,968	5,157	8,887		480		42,166
Zinc oxide	3,481					12,556		16,037
Other	11,173	1,521	365	9,382		6,792	534	29,767
Total	544,668	117,454	7,326	109,692	2,970	316,103	6,900	1,105,113

[1] Includes brass mills, brass ingotmakers, and brass foundries.
[2] Includes producers of zinc-base die castings, zinc-alloy dies, and zinc-alloy rods.

Rolled zinc was produced in the forms of sheet, strip, ribbon, foil, plate, rod, and wire. Major domestic use was for dry cell battery cases and similar cases for radio condensers and tube shields. Weather-stripping, roof flashing, photoengraving plates, and household electric fuses were other uses.

TABLE 16.—Rolled zinc produced and quantity available for consumption in the United States

	1962			1963		
	Short tons	Value		Short tons	Value	
		Total	Average per pound		Total	Average per pound
Production:						
Sheet zinc not over 0.1 inch thick	13,442	$7,739,555	$0.288	13,787	$7,743,180	$0.281
Boiler plate and sheets over 0.1 inch thick	241	98,966	.206	159	64,238	.202
Strip and ribbon zinc [1]	25,301	10,445,238	.206	25,117	9,806,651	.195
Foil, rod, and wire	1,723	823,362	.239	1,955	1,058,159	.271
Total rolled zinc	40,707	19,107,121	.235	41,018	18,672,228	.228
Imports	1,316	367,210	.140	1,532	413,331	.135
Exports	3,547	2,390,712	.337	3,756	2,741,874	.365
Available for consumption	38,746			39,032		
Value of slab zinc (all grades)			.115			.115
Value added by rolling			.120			.113

[1] Figures represent net production. In addition, 13,556 tons of strip and ribbon zinc and sheet zinc in 1962 and 12,137 tons in 1963 were rerolled from scrap originating in fabricating plants operating in connection with zinc rolling mills.

CONSUMPTION OF SLAB ZINC BY GEOGRAPHIC AREAS

Ohio, Indiana, Pennsylvania, and Illinois accounted for 58 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 the 21 States in the consumption of slab zinc in making zinc-base alloys. Other large consuming States were Illinois, Ohio, New York, and Indiana.

TABLE 17.—Reported slab zinc consumption in the United States in 1963, by industries and States

(Short tons)

State	Galvanizers	Brass mills [1]	Die casters [2]	Other [3]	Total
Alabama	(4)	(4)	—	(4)	37,238
Arizona	(4)	—	—	(4)	(4)
Arkansas	—	—	—	(4)	(4)
California	24.091	1,821	8,883	731	35,526
Colorado	(4)	(4)	—	(4)	(4)
Connecticut	2,732	38,862	(4)	(4)	46,127
Delaware	—	(4)	(4)	(4)	(4)
Florida	(4)	—	(4)	—	1,656
Georgia	(4)	—	—	—	(4)
Hawaii	(4)	—	—	—	(4)
Idaho	—	—	(4)	(4)	(4)
Illinois	46,770	16,569	75,397	20,100	158,836
Indiana	56,921	(4)	30,715	(4)	109,220
Iowa	(4)	—	—	(4)	1,681
Kansas	—	—	(4)	(4)	(4)
Kentucky	(4)	(4)	—	—	(4)
Louisiana	(4)	—	—	(4)	1,367
Maine	(4)	—	—	—	(4)
Maryland	(4)	(4)	—	(4)	32,160
Massachusetts	2,786	(4)	—	(4)	6,545
Michigan	(4)	15,975	128,727	(4)	149,742
Minnesota	(4)	—	—	(4)	2,199
Mississippi	(4)	—	—	—	(4)
Missouri	4,822	(4)	7,756	(4)	13,429
Nebraska	(4)	(4)	—	(4)	1,696
New Hampshire	—	(4)	—	—	(4)
New Jersey	2,886	5,958	(4)	(4)	29,675
New York	13,702	(4)	44,239	(4)	75,034
North Carolina	—	—	(4)	—	(4)
Ohio	83,083	(4)	51,857	(4)	145,132
Oklahoma	2,259	—	(4)	(4)	6,136
Oregon	491	(4)	(4)	(4)	891
Pennsylvania	54,041	8,879	23,616	(4)	114,471
Rhode Island	(4)	(4)	—	(4)	725
South Carolina	(4)	—	—	—	(4)
South Dakota	(4)	—	—	—	(4)
Tennessee	719	—	(4)	(4)	1,528
Texas	13,553	(4)	(4)	(4)	42,360
Utah	(4)	(4)	—	(4)	(4)
Virginia	(4)	19	(4)	(4)	1,364
Washington	889	—	—	597	1,486
West Virginia	7,315	(4)	—	(4)	8,377
Wisconsin	2,195	(4)	(4)	(4)	14,374
Undistributed	97,741	37,993	96,515	66,008	59,238
Total [5]	416,996	126,076	467,705	87,436	1,098,213

[1] Includes brass mills, brass ingotmakers, and brass foundries.
[2] Includes producers of zinc-base diecastings, zinc-alloy dies, and zinc-alloy rods.
[3] Includes slab zinc used in rolled-zinc products and in zinc oxide.
[4] Figure withheld to avoid disclosing individual company confidential data; included with "Undistributed".
[5] Excludes remelt zinc.

ZINC PIGMENTS AND SALTS

Production of zinc pigments and salts increased 2 percent to 262,300 tons. Shipments increased 7 percent to 268,800 tons, principally to the rubber, paint, and ceramic industries.

Production.—Output of lead-free zinc oxide decreased 1 percent to 157,400 tons, and production of leaded zinc oxide increased 5 percent to 15,100 tons. Zinc chloride (50° Baumé) production decreased 7 percent to 49,700 tons and zinc sulfate output increased 31 percent to 40,100 tons.

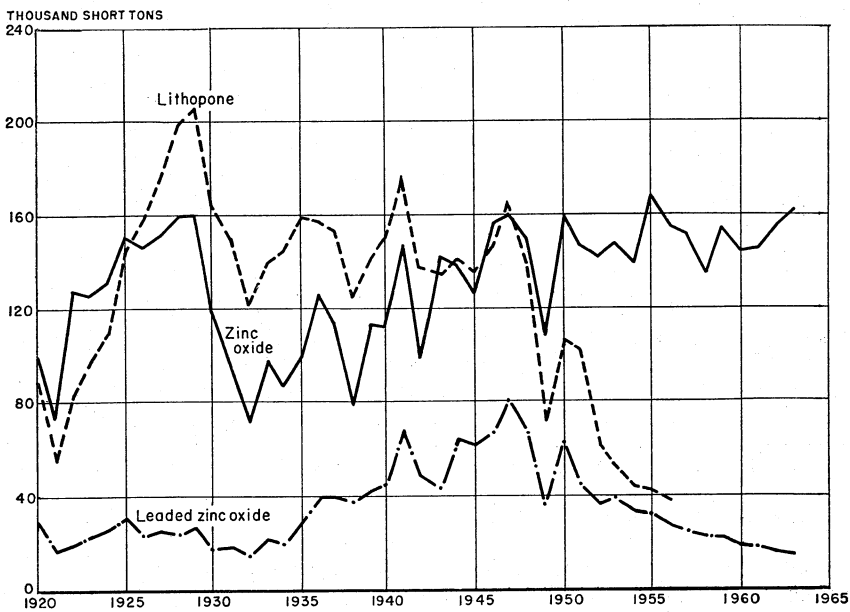

FIGURE 2.—Trends in shipments of zinc pigments, 1920–63.

TABLE 18.—Production and shipments of zinc pigments and salts [1] in the United States

Pigment or salt	1962				1963			
	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]	158,844	154,849	$35,627,808	$230	157,371	162,271	$37,747,259	$233
Leaded zinc oxide [3]	14,377	15,694	3,652,330	233	15,060	15,473	3,508,621	227
Zinc chloride, 50° B [4]	53,733	50,438	(5)	(5)	49,728	50,922	(5)	(5)
Zinc sulfate	30,539	31,231	(5)	(5)	40,109	40,111	5,450,019	136

[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.
[5] Figure withheld to avoid disclosing individual company confidential data.

Pigments and salts were made from various zinc-bearing materials, including ore, slab zinc, scrap, and residues. Zinc contained in pigments and salts made directly from ore, both domestic and foreign, exceeded 90,000 tons; zinc in zinc oxide and zinc chloride from slab zinc exceeded 16,000 tons; and the zinc in products derived from secondary materials in zinc pigments and salts exceeded 39,000 tons.

TABLE 19.—Zinc content of zinc pigments[1] and salts produced by domestic manufacturers, by sources

(Short tons)

Pigment or salt	1962					1963				
	Zinc in pigments and salts produced from—				Total zinc in pigments and salts	Zinc in pigments and salts produced from—				Total zinc in pigments and salts
	Ore		Slab zinc	Secondary material		Ore		Slab zinc	Secondary material	
	Domestic	Foreign				Domestic	Foreign			
Zinc oxide	63,565	17,256	18,297	27,622	126,740	65,245	16,250	16,037	28,026	125,558
Leaded zinc oxide	5,232	3,378			8,610	5,165	4,087			9,252
Total pigments	68,797	20,634	18,297	27,622	135,350	70,410	20,337	16,037	28,026	134,810
Zinc chloride[2]			(3)	11,715	11,715			(3)	11,130	11,130
Zinc sulfate	(3)	(3)		(3)	10,922	(3)	(3)		(3)	13,372

[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.
[3] Figure withheld to avoid disclosing individual company confidential data.

Lead-free zinc oxide was made by several processes; 67 percent was made from ores and residues by the American process, 18 percent from metal by the French process, and 15 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.

Four grades of leaded zinc oxide, classified according to lead content, were produced. Only a very small quantity of 5 percent or less leaded zinc oxide was produced; the more than 5 to 35 percent grade constituted most of the production. Small quantities of the more than 35 through 50 percent and over 50 percent grades were produced.

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 162,300 tons, 5 percent greater than in 1962. The quantity received by the rubber, paint, and ceramic industries accounted for 78 percent of the total shipped.

The paint industry accounted for 96 percent of the 15,500 tons of leaded zinc oxide shipped.

Lithopone was used in paint, varnish and lacquer, coated fabrics and textiles, rubber, and floor covering.

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 manufacture and agriculture. Other uses were in glue manufacture, flotation reagents, rubber, and medicine.

Prices.—American-process zinc oxide was quoted at 13.50 cents per pound in carlots, freight allowed, throughout 1963. Quotations for Red-seal, Green-seal, and White-seal French-process zinc oxide

TABLE 20.—Distribution of zinc oxide shipments, by industries

(Short tons)

Industry	1954–58 (average)	1959	1960	1961	1962	1963
Rubber	77,623	79,505	75,120	71,534	80,247	82,776
Paints	32,703	33,708	31,610	30,405	31,381	34,382
Ceramics	9,464	10,486	9,840	10,058	11,092	9,381
Coated fabrics and textiles [1]	6,397	2,125	1,331	1,185	202	(2)
Floor coverings	1,537	1,207	1,316	1,174	457	(2)
Other	22,484	27,203	25,561	30,852	31,470	35,732
Total	150,208	154,234	144,778	145,208	154,849	162,271

[1] Figures for zinc oxide used for rayon are withheld to avoid disclosing individual company confidential data.
[2] Included with "Other."

TABLE 21.—Distribution of leaded zinc oxide shipments, by industries

(Short tons)

Industry	1954–58 (average)	1959	1960	1961	1962	1963
Paints	27,924	20,748	17,616	16,533	14,959	14,899
Rubber, Other	334	1,878	1,662	1,474	735	574
Total	28,258	22,626	19,278	18,007	15,694	15,473

TABLE 22.—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
1954–58 (average)	15,626	13,927	8,730	7,520	4,134	3,369	28,490	24,816
1959	26,062	23,354	5,262	4,696	9,346	7,428	40,670	35,478
1960	15,727	14,097	4,320	3,848	8,749	7,882	28,796	25,827
1961	12,284	11,007	5,673	5,086	10,934	9,926	28,891	26,019
1962	(1)	(1)	8,544	7,313	22,687	20,359	31,231	27,672
1963	(1)	(1)	10,785	9,407	29,326	23,674	40,111	33,081

[1] Figure withheld to avoid disclosing individual company confidential data, included with "Other."

in carlots, freight allowed, remained unchanged at 15.25 cents per pound, 15.25 cents, and 15.50 cents, respectively.

Leaded zinc oxide of the 35 percent grade was quoted at 14.30 cents per pound for carlots, freight allowed, throughout 1963.

Zinc chloride (50° Baumé) was quoted at 5.15 cents per pound until July when it increased to 5.25 where it remained for the balance of the year. Zinc sulfate (Monohydrate, 36 percent) in less than carlots was quoted at 9.25 cents per pound, increased to 9.50 cents in October, and remained at this level the balance of the year.

Foreign Trade.—Imports of zinc pigments and salts increased 7 percent in quantity and value over that in 1962. Imports of zinc oxide increased 8 percent and decreased 6 percent for zinc chloride.

TABLE 23.—U.S. imports for consumption of zinc pigments and salts

Kind	1962		1963	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Zinc oxide	12,890	$2,325	13,957	$2,532
Zinc sulfide	461	140	423	133
Lithopone	98	13	159	22
Zinc arsenate	1	(1)	(2)	(1)
Zinc chloride	1,000	168	936	140
Zinc sulfate	832	83	885	84
Total	15,282	2,729	16,360	2,911

[1] Less than $1,000.
[2] Less than 1 ton.

Source: Bureau of the Census.

TABLE 24.—U.S. exports of zinc pigments

Kind	1962		1963	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Zinc oxide	2,061	$590	2,962	$827
Lithopone	350	68	839	136
Total	2,411	658	3,801	963

Source: Bureau of the Census.

STOCKS

National Stockpile.—There was 1,257,000 tons of zinc in the national (strategic) stockpile and 324,000 tons in the supplementary stockpile at the end of the year. On June 17, the Office of Emergency Planning (OEP) established a conventional war stockpile objective of zero for zinc. The previous maximum objective, based on different criteria, had been 178,000 tons. Studies continued by OEP to determine stockpile needs to meet the requirements of general nuclear war including reconstruction.

Producer Stocks.—Stocks of slab zinc at producer plants were 144,700 tons at the beginning of the year, increased about 4,000 tons by the end of March, and then rapidly declined to 47,900 tons by yearend. This was the lowest yearend stocks recorded since 1955.

TABLE 25.—Stocks of zinc at zinc-reduction plants in the United States, Dec. 31

(Short tons)

	1959	1960	1961	1962	1963
At primary reduction plants	152,410	178,209	143,494	142,059	46,374
At secondary distilling plants	3,800	7,673	3,393	2,687	1,536
Total	156,210	185,882	146,887	144,746	47,910

Consumer Stocks.—Stocks of slab zinc at consumer plants of 79,900 tons at the start of the year were drawn down about 12,000 tons by the end of May, followed by a generally upward trend resulting in yearend stocks of 96,600 tons. An additional 8,400 tons of slab zinc was in transit to consumer plants on December 31.

TABLE 26.—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
Dec. 31, 1962 [3]	42,754	8,780	24,957	1,297	271	1,875	[4] 79,934
Dec. 31, 1963	55,935	9,846	21,851	4,849	233	3,893	[4] 96,607

[1] Includes brass mills, brass ingotmakers, and foundries.
[2] Includes producers of zinc-base diecastings, zinc-alloy dies, and zinc-alloy rods.
[3] Figures partly revised.
[4] Stocks on Dec. 31, 1962 and Dec. 31, 1963 include 198 and 302 tons, respectively, of remelt spelter.

PRICES

Prices.—The quoted price of Prime Western grade zinc, East St. Louis, was 11.5 cents a pound at the start of the year. Three price increases of ½-cent each on July 2, July 30, and December 2 resulted in the yearend price of 13.0 cents per pound.

On the London Metal Exchange, the yearly average quotation was £76.766 per ton (equivalent to 9.60 cents per pound computed at the exchange rate recorded by the Federal Reserve Board). For January the average was £67.585 (8.45 cents per pound). The average quotation rose for the next four successive months to reach £76.016 (9.50 cents) for May, declined slightly in June and July, then resumed the upward trend, reaching an average quotation in December of £94.709 (11.84 cents).

TABLE 27.—Average monthly quoted prices of 60-percent zinc concentrate at Joplin, and of common zinc (prompt delivery or spot), East St. Louis and London [1]

Month	1962			1963		
	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	$72.00	12.00	8.78	$68.00	11.50	8.45
February	72.00	12.00	8.67	68.00	11.50	8.69
March	72.00	12.00	8.74	68.00	11.50	8.96
April	68.00	11.51	8.75	68.00	11.50	9.27
May	68.00	11.50	8.62	68.00	11.50	9.50
June	68.00	11.50	8.37	68.00	11.57	9.49
July	68.00	11.50	8.26	72.46	12.06	9.29
August	68.00	11.50	8.07	76.00	12.50	9.55
September	68.00	11.50	8.01	76.00	12.50	9.58
October	68.00	11.50	8.25	76.00	12.50	10.02
November	68.00	11.50	8.56	76.00	12.50	10.51
December	68.00	11.50	8.38	79.68	12.98	11.84
Average for year	69.00	11.63	8.43	72.01	12.01	9.60

[1] Joplin: Metal Statistics, 1964, p. 503. East St. Louis: Metal Statistics, 1964, p. 501. London: E&MJ Metal and Mineral Markets.
[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.

During 1963 the quoted price for new clippings ranged from 5.00 to 7.75 cents per pound, averaging 5.85 cents. For old zinc, the quotation ranged from 3.00 to 4.50 cents and averaged 3.80 cents per pound.

TABLE 28.—Average price received by producers of zinc, by grades

(Cents per pound)

Grade	1959	1960	1961	1962	1963
Special High Grade	11.78	13.68	11.58	11.43	11.66
High Grade	11.42	13.19	11.42	11.47	11.61
Intermediate	11.85	13.34	12.12	11.84	11.79
Brass Special	11.39	12.89	11.52	11.76	11.80
Select	10.93	12.64	11.60	12.88	11.29
Prime Western	11.18	12.15	11.32	11.45	11.35
All grades	11.47	12.85	11.45	11.47	11.55
Prime Western; spot quotation at St. Louis [1]	11.46	12.95	11.55	11.63	12.01

[1] Metal Statistics, 1964, p. 501.

FOREIGN TRADE

Import quotas imposed October 1, 1958 remained in effect through 1963. Quantitative country quotas are given in detail in the 1962 Minerals Yearbook chapter.

TABLE 29.—U.S. imports of zinc, by countries

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
Ores (zinc content):						
North America:						
Canada	164,160	152,134	120,336	119,113	192,423	134,303
Guatemala	7,867	8	6,063	13,870	2,511	1,430
Honduras	1,707	1,427	4,714	6,851	7,048	8,234
Mexico	181,258	182,409	190,621	186,174	165,005	138,185
Other	1,259	189	78	---	---	---
Total	356,251	336,167	321,812	326,008	366,987	282,152
South America:						
Bolivia	7,106	2,530	1,214	572	1,791	4,395
Chile	1,876	479	30	(1)	518	---
Peru	99,533	86,672	80,100	74,369	77,501	73,788
Other	138	167	58	53	13	8
Total	108,653	89,848	81,402	74,994	79,823	78,191
Europe:						
Germany, West	---	5,756	2	11	---	---
Italy	---	14,766	---	---	---	---
Spain	---	16,479	18,913	---	---	---
Other	2,266	3,613	100	109	19	---
Total	2,266	40,614	19,015	120	19	---
Asia:						
Philippines	521	48	4,774	3,203	24	9
Other	77	1	24	---	---	79
Total	598	49	4,798	3,203	24	88
Africa:						
South Africa, Republic of [2]	13,076	7,957	12,300	7,551	9,589	8,614
Other	586	787	39	2	---	---
Total	13,662	8,744	12,339	7,553	9,589	8,614

See footnotes at end of table.

TABLE 29.—U.S. imports of zinc, by countries—Continued

(Short tons)

Country	1954-58 (average)	1959	1960	1961	1962	1963
Ore (zinc content)—Continued						
Oceania: Australia	[3] 7,849	24,693	17,789	3,822	10,956	3,724
Grand total: Ores	489,279	500,115	457,155	415,700	467,398	372,769
Blocks, pigs, or slabs:						
North America:						
Canada	106,574	88,414	74,168	71,628	72,825	73,817
Mexico	18,630	9,338	8,950	8,598	12,334	13,219
Total	125,204	97,752	83,118	80,226	85,159	87,036
South America: Peru	11,159	12,337	7,517	7,519	7,615	7,574
Europe:						
Austria	685	220	--	--	--	--
Belgium-Luxembourg	22,702	7,666	5,724	12,854	23,232	21,904
Germany, West	7,296	55	2,680	779	1,162	6,103
Italy	8,228	7,459	3,517	1,820	992	907
Netherlands	2,706	--	--	120	--	--
Norway	798	168	--	--	--	--
Spain	--	--	2,986	6,756	2,572	6,270
United Kingdom	635	841	333	(1)	--	1,183
Yugoslavia	3,438	3,643	4,520	3,198	3,310	1,185
Other	22	--	--	441	640	440
Total	46,510	20,052	19,760	25,968	31,908	37,992
Asia: Japan	1,962	--	--	--	--	--
Africa:						
Congo, Republic of the, and Ruanda-Urundi [4]	20,181	12,790	9,307	11,420	10,882	9,590
Rhodesia and Nyasaland, Federation of [5]	1,825	4,667	615	1,400	4,643	1,982
Other	275	--	--	--	--	--
Total	22,281	17,457	9,922	12,820	15,525	11,572
Oceania: Australia	5,232	9,365	450	1,029	1,750	583
Grand total: Blocks, pigs, or slabs	212,348	156,963	120,767	127,562	141,957	144,757

[1] Less than 1 ton.
[2] Effective Jan. 1, 1962; formerly Union of South Africa.
[3] Includes 10 tons imported from French Pacific Islands.
[4] Effective July 1, 1960; formerly Belgian Congo.
[5] Effective July 1, 1954; formerly Northern Rhodesia.

Source: Bureau of the Census.

Imports.—General imports (imports for immediate consumption plus entries into bonded warehouses) presented in table 31 show all physical entries of unmanufactured zinc into the United States. General imports of zinc in ores and concentrates decreased 20 percent to the lowest level since 1951. Canada, Mexico, and Peru supplied 93 percent of these imports. Zinc metal imports increased 2 percent to 144,800 tons; Canada, Belgium-Luxembourg, and Mexico supplied 75 percent of the total.

Imports for consumption (imports for immediate consumption plus withdrawals from bonded warehouses for consumption) given in table 33 give a close approximation of dutiable imports of unmanufactured zinc entering the United States. Imports of zinc fume, excluded from the quota restrictions, amounted to approximately 29,000 tons, averaging 77.4 percent zinc (33,000 tons in 1962). Mexico was the source of this material.

TABLE 30.—U.S. imports for consumption of zinc, by classes

Year	Ore (zinc content)		Blocks, pigs, slabs		Sheets	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1954-58 (average)	509,012	$55,632	210,888	[1] $48,968	555	[1] $188
1959	424,134	37,475	164,462	33,996	951	311
1960	382,938	38,704	120,925	29,639	904	302
1961	357,653	31,920	125,186	27,540	1,183	354
1962	387,321	31,817	135,995	28,478	[2] 1,303	[2] 365
1963	371,919	30,757	132,332	27,942	1,532	413

Year	Old and worn out		Dross and skimmings		Zinc dust		Total value[3]
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	
1954-58 (average)	319	$39	488	$46	70	[1] $16	[1] $104,889
1959	183	26	955	116	44	6	71,930
1960	106	14	1,099	175	19	7	68,841
1961	303	32	1,107	146	86	28	60,020
1962	861	120	1,907	286	909	207	[2] 61,273
1963	1,461	231	1,415	215	2,608	589	60,147

[1] Data known to be not comparable with other years.
[2] Revised figure.
[3] In addition manufactures of zinc were imported as follows: 1954-58 (average) $234,608; 1959-$811,916; 1960-$836,871; 1961-$787,496; 1962-$1,138,940; 1963-$978,619.

Source: Bureau of the Census.

TABLE 31.—U.S. imports for consumption of zinc, by countries

(Short tons)

Country	1954-58 (average)	1959	1960	1961	1962	1963
Ores (zinc content):						
North America:						
Canada	172,406	137,426	133,080	110,312	135,430	131,125
Guatemala	7,919	10	1,811	7,244	8,375	3,692
Honduras	1,228	1,116	2,140	1,574	4,154	8,613
Mexico	196,330	147,877	142,478	140,057	139,374	138,419
Other	588	73	17	(1)	(1)	----------
Total	378,471	286,502	279,526	259,187	287,333	281,849
South America:						
Bolivia	7,308	1,704	790	1,018	681	3,492
Chile	2,151	34	5	7	216	324
Peru	99,221	80,616	71,391	69,473	75,333	67,113
Other	92	(1)	94	81	22	30
Total	108,772	82,354	72,280	7 ,579	76,252	70,959
Europe:						
Germany, West	2	7,290	----------	12	1	----------
Italy	732	9,930	4,241	2,189	695	----------
Spain	----------	13,476	10,405	8,122	947	----------
Other	2,407	2,344	982	----------	----------	----------
Total	3,141	33,040	15,628	10,323	1,643	----------
Asia:						
Philippines	552	29	679	4,426	2,663	43
Other	170	----------	1	16	(1)	59
Total	722	29	680	4,442	2,663	102

See footnotes at end of table.

TABLE 31.—U.S. imports for consumption of zinc, by countries—Continued

(Short tons)

Country	1954-58 (average)	1959	1960	1961	1962	1963
Ores (zinc content)—Continued						
Africa:						
South Africa, Republic of[2]	11,647	4,331	5,333	6,218	10,391	11,438
Other	105	1,140	131	9	11	766
Total	11,752	5,471	5,464	6,227	10,402	12,204
Oceania: Australia	[3] 6,154	16,738	9,360	6,895	9,028	6,805
Grand total: Ores	509,012	424,134	382,938	357,653	387,321	371,919
Blocks, pigs, or slabs:						
North America:						
Canada	106,544	88,414	74,168	71,628	72,850	73,817
Mexico	18,292	9,718	8,675	8,527	12,334	12,619
Total	124,836	98,132	82,843	80,155	85,184	86,436
South America: Peru	11,601	12,337	7,517	7,582	7,615	7,574
Europe:						
Austria	674	305	2	----------	----------	----------
Belgium-Luxembourg	21,955	11,648	5,724	12,380	16,829	16,070
Germany, West	7,163	662	1,619	1,431	1,889	1,585
Italy	8,129	7,173	4,237	1,820	992	907
Netherlands	2,348	1,705	----------	----------	----------	81
Norway	764	329	7	----------	----------	----------
Spain	----------	----------	2,809	4,560	2,429	4,666
United Kingdom	872	1,363	373	(1)	----------	623
Yugoslavia	3,216	3,384	5,640	3,277	2,750	1,564
Other	22	----------	----------	417	642	221
Total	45,143	26,569	20,411	23,885	25,531	25,717
Asia: Japan	1,896	355	----------	----------	----------	----------
Africa:						
Congo, Republic of the, and Ruanda-Urundi[4]	20,181	12,790	9,308	11,420	10,882	9,590
Rhodesia and Nyasaland, Federation of[5]	1,724	4,840	396	1,107	5,033	2,305
Other	275	298	----------	8	----------	----------
Total	22,180	17,928	9,704	12,535	15,915	11,895
Oceania: Australia	5,232	9,141	450	1,029	1,750	710
Grand total: Blocks, pigs, or slabs	210,888	164,462	120,925	125,186	135,995	132,332

[1] Less than 1 ton.
[2] Effective Jan. 1, 1962; formerly Union of South Africa.
[3] Includes 10 tons imported from French Pacific Islands.
[4] Effective July 1, 1960; formerly Belgian Congo.
[5] Effective July 1, 1954; formerly Northern Rhodesia.

Source: Bureau of the Census.

Exports.—Exports of slab zinc decreased 6 percent to 33,900 tons. India received 89 percent, and the Republic of Korea received about 6 percent of total exports.

Tariff.—New tariff schedules of the United States which went into effect August 31, 1963, revised the method of computing duties on zinc ores and concentrates. Under the new schedules the rate of duty is 0.67 cent per pound imposed on the zinc content after certain allowable deductions for processing losses. Formerly, the rate of duty was 0.6 cent per pound imposed on the total zinc content. For a given importation the net result is that the total duty is approximately the same using the new or the old method.

All other duties on unmanufactured zinc and zinc containing materials remained unchanged and were: Slab zinc, 0.7 cent per pound; zinc scrap, 0.75 cent per pound; zinc fume, 15 percent ad valorem; and zinc dust, at 0.7 cent per pound.

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TABLE 32.—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.s.			
	1960	1961	1962	1963	1960	1961	1962	1963
North America:								
Canada	11	382	495	337	1,516	1,356	1,512	1,541
Mexico	1,119		1		283	56	21	25
Other	106	19	16	16	106	65	80	60
Total	1,236	401	512	353	1,905	1,477	1,613	1,626
South America:								
Argentina		61			17	35	36	48
Brazil	2,414	4,598	262	128	28	27	12	15
Chile	10	314	39	163	53	36	43	35
Colombia	1,045	404		663	55	55	213	37
Venezuela	10	161	7	13	75	78	119	86
Other	463	233	110	1	12	18	24	12
Total	3,942	5,771	418	968	240	249	447	233
Europe:								
Belgium-Luxembourg	340				3	21	20	34
Denmark	140	56			107	173	164	230
Germany, West	3,364	336	2	14	121	63	32	59
Italy	560	224			12	33	29	113
Netherlands	2,522	2,252			42	170	127	123
Sweden	4,847	1,993			84	140	231	227
Switzerland	336				142	165	221	205
United Kingdom	25,394	12,265	112		302	335	242	261
Other	700	1,806	733		103	229	228	369
Total	38,203	18,932	847	14	916	1,329	1,294	1,621
Asia:								
India	11,172	10,490	32,625	30,155	3	10	19	16
Japan	18,125	7,353	1	147		29		
Korea, Republic of	75	3,139	903	1,969		1	1	8
Philippines	979	1,685	10	6	54	22	37	31
Other	1,403	2,274	680	163	97	9	40	86
Total	31,754	24,941	34,219	32,440	154	71	97	141
Africa:								
South Africa, Republic of					74	76	80	89
Other	9	8	106	78	2	4	3	6
Total	9	8	106	78	76	80	83	95
Oceania		2			33	13	13	40
Grand total	75,144	50,055	36,102	33,853	3,324	3,219	3,547	3,756

Source: Bureau of the Census.

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NORTH AMERICA

Canada.—Zinc production in 1963 from domestic ores plus the recoverable zinc content of concentrates totaled 457,500 tons, 1 percent lower than 1962. Production of two new producers—Mattagami Lake Mines, Ltd., and Orchan Mines, Ltd.—in Northwestern Quebec was not sufficient to offset the effects of the October 1962 closure of the Waite Amulet mine, strikes at the Solbec and Reeves MacDonald mines, and reduced output at a number of other

TABLE 33.—U.S. exports of zinc ore and manufactures of zinc

Year	Zinc ore, concentrates (zinc content)		Slabs, pigs, or blocks		Sheets, plates, strips, or other forms n.e.s.		Zinc scrap and dross (zinc content)		Semifabricated forms, n.e.c.		Zinc dust	
	Short tons	Value (thousands	Short tons	Value (thousands)	Short tons [1]	Value (thousands)[1]	Short tons [1]	Value (thousands)	Short tons [1]	Value (thousands)	Short tons	Value (thousands)
1954-58 (average)	172	$32	12,947	$3,058	4,004	$2,599	12,807	$1,400	2,686	$329	488	$163
1959	1	(2)	11,629	2,673	3,529	2,708	11,332	1,053	1,071	612	521	182
1960	13	3	75,144	18,122	3,324	2,443	12,169	1,499	2,569	1,195	777	267
1961	1,670	124	50,055	11,196	3,219	2,271	5,900	871	3,036	1,317	717	224
1962	136	46	36,102	8,050	3,547	2,391	7,940	956	1,613	1,254	676	240
1963	17	6	33,853	7,506	3,756	2,742	1,794	539	1,532	1,163	759	261

[1] Owing to changes in classification by the Bureau of the Census, beginning with 1959 data not strictly comparable with earlier years.
[2] Less than $1,000.

Source: Bureau of the Census.

mines.[12] Slab zinc output increased 1 percent to 283,400 tons, reflecting commencement of production by Canadian Electrolytic Zinc, Ltd., in September and the normal continuation of operations at the zinc plants of Consolidated Mining & Smelting Co. of Canada, Ltd. (Cominco), and Hudson Bay Mining & Smelting Co., Ltd.

TABLE 34.—World mine production of zinc (content of ore) recoverable where indicated, by countries [1] [2] [3]

(Short tons)

Country [2]	1954-58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	414,264	[4] 396,008	[4] 406,873	[5] 443,099	[5] 501,937	[5] 497,180
Cuba	[6] 908	[7] 188	[7] 77	----------	----------	----------
Greenland [8]	[9] 7,400	8,400	11,000	8,800	4,400	----------
Guatemala [4]	8,506	----------	11,069	8,746	899	1,289
Honduras [7]	1,707	1,427	4,713	6,851	7,048	8,234
Mexico	266,535	290,938	289,274	296,492	276,330	265,763
United States [4]	494,844	425,303	435,427	464,390	505,491	529,254
Total	1,194,164	1,122,264	1,158,433	1,228,378	1,296,105	1,301,720
South America:						
Argentina	28,594	44,974	39,022	35,502	34,686	31,600
Bolivia (exports)	20,417	3,740	4,439	5,878	4,021	5,124
Chile	2,381	1,117	1,159	179	547	536
Colombia [8]	----------	770	330	1,400	300	100
Peru	174,049	[4] 157,739	[4] 196,346	[4] 191,658	[4] 178,839	[4] 200,030
Total	225,441	208,340	241,296	234,617	218,393	237,390
Europe:						
Austria [4]	5,918	6,522	7,250	6,651	7,264	7,816
Bulgaria	44,974	75,508	84,878	81,461	69,125	63,831
Finland	34,050	59,588	46,328	51,363	57,509	73,142
France	13,711	17,616	18,933	17,284	15,735	17,734
Germany:						
East [8]	7,600	7,700	7,700	7,700	7,700	7,700
West	101,114	90,566	95,159	96,189	95,991	102,722
Greece	10,400	13,200	16,200	19,342	18,939	20,100
Ireland	1,709	1,303	1,377	184	----------	----------

See footnotes at end of table.

[12] Patterson, J. W. Miner. Res. Division, Dept. of Mines and Tech. Surveys (Ottawa, Canada), Miner. Inf. Bull. MR-71, 1964, p. 33.

TABLE 34.—World mine production of zinc (content of ore) recoverable where indicated, by countries—Continued

(Short tons)

Country [2]	1954–58 (average)	1959	1960	1961	1962	1963
Europe—Continued						
Italy	138,750	146,089	143,985	147,954	145,596	117,900
Norway	7,617	10,907	11,395	10,285	12,566	13,700
Poland	166,184	142,529	158,843	153,857	159,961	162,150
Spain	95,011	94,645	94,920	96,983	86,554	98,786
Sweden	70,870	86,549	81,824	87,558	69,856	73,700
U.S.S.R. [8]	[10] 300,000	[4] 370,000	[4] 380,000	[4] 440,000	[4] 450,000	[4] 450,000
United Kingdom	2,001					
Yugoslavia	64,501	66,882	62,150	66,009	67,367	56,511
Total [2] [8]	1,075,000	1,204,000	1,225,000	1,297,000	1,275,000	1,276,000
Asia:						
Burma	9,200	12,100	11,000	8,100	9,000	8,900
China [8]	37,000	70,000	90,000	110,000	110,000	110,000
India	3,800	6,100	6,000	5,600	6,099	6,460
Iran [11]	6,430	7,440	9,400	14,900	8,300	[8] 8,300
Japan	136,695	156,899	172,769	185,474	212,174	218,195
Korea:						
North [8]	70,000	95,000	95,000	100,000	100,000	120,000
Republic of	224	4	46	496	463	1,245
Philippines	276	6	5,487	3,652	4,916	4,701
Thailand	2,202	838	1,168	992	[8] 1,000	[8] 990
Turkey	4,928	4,001	3,682	9,127	6,801	5,044
Total [8]	271,000	352,000	395,000	438,000	459,000	484,000
Africa:						
Algeria	34,538	42,774	44,240	46,448	46,215	40,000
Congo, Republic of			661	1,411	786	786
Congo, Republic of the (formerly Belgian)	108,137	78,313	120,352	109,828	105,530	114,139
Morocco	48,053	61,301	54,199	44,951	37,942	36,420
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	36,866	46,497	49,242	45,100	45,100	42,100
South-West Africa [4]	21,124	12,394	13,119	14,905	25,201	36,871
Tunisia	5,130	3,656	4,697	4,596	4,727	4,806
Total	253,848	244,935	286,510	267,239	265,501	275,122
Oceania: Australia	[12] 307,470	308,373	355,497	348,496	378,042	394,326
World total (estimate) [2]	3,330,000	3,440,000	3,660,000	3,810,000	3,890,000	3,970,000

[1] Data derived in part from the Yearbook of the American Bureau of Metal Statistics, the United Nations Statistical Yearbook, and the Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London).
[2] Czechoslovakia and Rumania also produce zinc, but production data are not available; estimates for these countries are included in totals.
[3] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[4] Recoverable.
[5] Data for 1961, 1962, and 1963 not strictly comparable to previous years.
[6] Average annual production 1955–58.
[7] United States imports.
[8] Estimate.
[9] Average annual production 1956–58.
[10] Smelter production.
[11] Year ended March 20 of year following that stated.
[12] Data for 1954–57 not strictly comparable with later years.

Cominco recorded zinc metal production of 194,159 tons compared with a record high of 199,393 tons in 1962. Approximately 73 percent of the combined zinc-lead production came from the company's Sullivan mine, 14 percent from other company mines, 9 percent from purchased ores and concentrates, and 4 percent from lead-blast furnace slag. Extraction of ore from company properties was 2,595,000 tons at the Sullivan mine (2,583,000 tons in 1962), 256,000 tons from the Bluebell lead-zinc mine (238,000 tons in 1962), and 474,000 tons at the H. B. mine (469,000 tons in 1962). Pine Point Mines, Ltd., a

TABLE 35.—World smelter production of zinc by countries [1] [2] [3]

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	252,976	255,306	260,968	268,007	280,158	283,380
Mexico [4]	62,035	61,362	58,318	57,119	62,730	62,557
United States	903,316	798,666	799,516	846,795	879,395	892,584
Total	1,218,327	1,115,334	1,118,802	1,171,921	1,222,283	1,238,521
South America:						
Argentina	15,355	14,440	17,637	15,873	18,487	21,716
Peru	22,134	29,595	35,712	35,006	35,566	60,312
Total	37,489	44,035	53,349	50,879	54,053	82,028
Europe:						
Austria	[5] 6,283	12,608	12,700	13,302	13,325	13,074
Belgium [6]	243,859	247,250	272,891	270,670	227,248	227,437
Bulgaria	[5] 6,323	10,024	18,639	24,385	57,017	61,800
France	135,446	164,817	168,709	183,615	185,388	186,392
Germany:						
East	----------	----------	----------	1,102	5,512	[7] 11,000
West	187,232	152,046	156,299	155,373	143,127	115,969
Italy	77,856	81,517	88,040	86,424	85,618	81,093
Netherlands	30,880	35,445	39,771	43,643	40,839	39,421
Norway	51,285	53,767	48,460	51,287	49,576	49,214
Poland	170,414	185,263	193,501	200,633	199,935	199,739
Spain	25,741	27,039	49,565	57,865	68,981	70,778
U.S.S.R.[7]	300,000	400,000	435,000	470,000	510,000	510,000
United Kingdom	88,598	81,722	83,220	104,031	108,949	110,911
Yugoslavia	23,804	35,220	39,612	40,640	43,325	46,566
Total [1] [7]	1,355,000	1,498,000	1,617,000	1,714,000	1,747,000	1,732,000
Asia:						
China (refined) [7]	35,000	65,000	75,000	100,000	100,000	100,000
Japan	138,818	175,642	198,920	234,163	270,402	291,381
Korea, North [7]	[8] 13,000	27,000	55,000	65,000	65,000	70,000
Total [7]	187,000	268,000	329,000	399,000	435,000	461,000
Africa:						
Congo, Republic of the (formerly Belgian)	46,448	60,418	58,817	62,788	61,759	58,118
Rhodesia and Nyasaland, Federation of: Northern Rhodesia	32,159	33,483	33,369	33,444	44,576	54,509
Total	78,607	93,901	92,186	96,232	106,335	112,627
Oceania: Australia	142,270	130,436	134,658	155,270	188,079	201,349
World total (estimate)	3,020,000	3,150,000	3,350,000	3,590,000	3,750,000	3,830,000

[1] Czechoslovakia and Rumania also produce zinc, but production data are not available; estimates are included in the totals.
[2] Data derived in part from the Yearbook of the American Bureau of Metal Statistics, the United Nations Monthly Bulletin and Statistical Yearbook, and the Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London).
[3] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[4] In addition, other zinc-bearing materials were as follows: 1954–58 (average), 29,013 short tons; 1959, 314; 1960, 1,246; 1961, 1,992; 1962, 1,890; and 1963, 3,400.
[5] Average annual production 1955–58.
[6] Includes production from reclaimed scrap.
[7] Estimate.
[8] Average annual production 1957–58.

subsidiary, proceeded with mill and townsite construction and preparation for mining at their large lead-zinc property south of Great Slave Lake. The property is planned to be in production coincident with completion of railroad facilities by the end of 1965. In order to provide for treatment of Pine Point concentrates, Cominco has authorized expansion of zinc plant facilities at Trail to increase annual slab zinc capacity to 235,000 tons.[13]

[13] Consolidated Mining & Smelting Co. of Canada, Ltd. Annual Report. 1963, pp. 4–6.

According to the annual report of Reeves MacDonald Mines, Ltd., the company mined and milled 146,000 tons of ore at its Remac, British Columbia mine and produced concentrates containing 4,823 tons of zinc (14,600 tons in 1962), plus values in lead, silver, and cadmium. Operations were closed the last 7 months of the year due to a strike from May 5 to December 20.

Sheep Creek Mines, Ltd., Windermere, British Columbia, reported production for the year ending May 31, 1963, to be 208,800 tons of ore grading 5.44 percent zinc and 2.52 percent lead. Milling yielded 17,819 tons of 56.96 percent zinc concentrate plus recovered lead and silver. Reserves at the end of the year totaled 403,000 tons of ore compared with 488,000 tons at the start of the year.[14]

Hudson Bay Mining & Smelting Co., Ltd., the second largest producer of zinc in Canada, operated its zinc-copper-lead mines along the Manitoba-Saskatchewan boundary. The mill treated 1,619,000 tons of ore—57.1 percent from the Flin Flon mine, 47.7 percent from other company mines, and 1.2 percent purchased—which yielded 132,338 tons of 49.2 percent zinc concentrates plus copper and lead concentrates. Exploration disclosed more ore than was mined during the year and proven reserves at yearend totaled 15,115,500 tons averaging 4.7 percent zinc. The company electrolytic plant at Flin Flon treated 135,581 tons of zinc concentrate and 49,242 tons of zinc fume and stack dust from the copper smelter to produce 79,596 tons of slab zinc, the second highest quantity in the history of the plant.[15]

Willroy Mines, Ltd., at its Manitouwadge, Ontario, operation milled 483,800 tons of ore averaging 3.32 percent zinc, 2.02 percent copper, and 1.14 ounces silver per ton. The concentrates produced contained 12,524 tons of zinc and quantities of copper and silver. Development included deepening the main shaft 407 feet to a total depth of 2,855 feet, drifting 1,100 feet towards the Nama Creek mine, and drilling the lower mine horizons. The ore reserve at yearend was 1,572,000 tons, averaging 3.13 percent zinc, 1.36 percent copper, and 1.05 ounces of silver per ton.[16]

Geco Mines, Ltd., at its Manitouwadge, Ontario operations milled 1,281,000 tons of ore with a calculated grade of 5.72 percent zinc, 1.88 percent copper, and 2.44 ounces of silver per ton. The ore yielded 110,040 tons of 54.1 percent zinc concentrate, an increase of 20 percent from the quantity produced in 1962. There was a net increase of 812,000 tons in the ore reserve to a total of 22,858,000 tons, averaging 4.62 percent zinc, 2.06 percent copper, and 2.25 ounces of silver per ton.[17]

In Quebec, Quemont Mining Corp., Ltd., milled 803,000 tons of ore grading 2.21 percent zinc plus values in copper, silver, gold, and pyrite, yielding 24,466 tons of 53.1 percent zinc concentrate. Reserves at yearend were estimated to total 3,360,000 tons, averaging 2.86 percent zinc.[18] According to its annual report for the year ending August 31, 1963, Solbec Copper Mines, Ltd., mined and milled 191,000 tons of ore yielding concentrates containing 7,185 tons of zinc plus values in copper, lead, gold, and silver. Mining operations were

[14] Sheep Creek Mines, Ltd. Annual Report. 1963, 12 pp.
[15] Hudson Bay Mining & Smelting Co., Ltd. Annual Report. 1963, pp. 6–12.
[16] Willroy Mines, Ltd. Annual Report. 1963, pp. 2–3.
[17] Geco Mines, Ltd. Annual Report. 1963, pp. 8–10.
[18] Quemont Mining Corp., Ltd. Annual Report. 1963, p. 4.

suspended by a strike from March 1 to July 25. The ore reserve at yearend was 1,023,000 tons, averaging 3.79 percent zinc, 3.79 percent copper, 0.51 percent lead, and 1.33 ounces of silver per ton. Cupra Mines, Ltd., continued development work including sinking a shaft 1,658 feet to a depth of 1,856 feet. Drilling at the 1,650 and 1,900 foot levels disclosed continuity of the orebody and plans are to continue shaft sinking to a depth of 2,250 feet.[19] Sullico Mines, Ltd., mined and milled, 1,018,000 tons of ore yielding concentrates containing 1,771 tons of zinc. Reserves at yearend amounted to 1,560,000 tons grading 0.84 percent copper and 0.25 percent zinc.[20] Other Quebec producers of zinc included Normetal Mining Corp., Ltd., which mined and milled ore yielding concentrates containing 14,744 tons of zinc plus copper, gold, and silver.[21] Coniagas Mines, Ltd., in fiscal year 1963 treated 111,400 tons of ore averaging 13.72 percent zinc of which 90.0 percent was recovered in concentrates.[22] Manitou-Barvue Mines, Ltd., and Vauze Mines, Ltd., continued operating zinc producing mines.

In the Mattagami Lake district of Quebec, Mattagami Lake Mines began production in October and reached mill capacity of 3,000 tons of ore per day by yearend. Orchan Mines started milling custom ore from New Hosco Mines in October and ore from its own mines in November, attaining daily milling rates of 900 and 950 tons of ore, respectively, by yearend. Concentrates from both mills were shipped to the new zinc reduction plant of Canadian Electrolytic Zinc at Valleyfield, Quebec, which began operations in late September. Slab zinc production in 1963 was 10,300 tons with a daily output of 150 tons achieved by yearend, and the rated capacity of 200 tons per day was anticipated by March 1964.[23]

In the Atlantic Provinces, Heath Steele Mines, Ltd., mined and milled zinc-lead-copper ore from its mine near Bathurst, New Brunswick. Magnet Cove Barium Corp., Ltd., produced a zinc-silver concentrate in its 125-ton mill at Walton, Nova Scotia. Brunswick Mining & Smelting Corp., Ltd., is developing the Brunswick No. 12 mine for scheduled output of 3,000 tons per day early in 1964. The Associated East Coast Smelting and Chemical Co. commenced construction of a lead-zinc Imperial Smelting Furnace scheduled for completion in 1966 for treatment of the concentrates.[24]

In Newfoundland, Buchans Mining Co., Ltd., milled 376,000 tons of ore, yielding 124,414 tons of copper, lead, and zinc concentrates. Two-thirds of the output was from the new MacLean mine and the balance from the Buchans mine.[25]

Mexico.—Zincamex, S.A., a company formed by the Mexican Government, continued construction of a zinc reduction plant at Saltillo, Coahuila. The facility, scheduled for completion in October 1964, is designed for annual slab zinc output of 30,000 tons.[26]

Compañia Minera Asarco, S.A., wholly owned subsidiary of American Smelting and Refining Company, operated its mines and plants

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19 Cupra Mines, Ltd. Annual Report. 1963, p. 37.
20 Sullico Mines, Ltd. Annual Report. 1963, p. 17.
21 Noranda Mines, Ltd. Annual Report. 1963, p. 18.
22 Canadian Mining Journal. V. 85, No. 3, March 1964, p. 13.
23 Page 23 of work cited in footnote 21.
24 Patterson, J. W. Miner. Res. Division, Dept. of Mines and Tech. Surveys (Ottawa, Canada), Miner. Inf. Bull. MR-71, 1964, p. 36.
25 Page 13 of work cited in footnote 2.
26 Chemical Engineering. V. 70, No. 16, Aug. 5, 1963, p. 148.

in Mexico without interruption during 1963. The company made application to the Mexican Government to place 51 percent of its shares in an irrevocable trust with a Mexican banking institution to be held for sale to qualified Mexican investors. This procedure, permitted by new mining regulations issued by the Government in July, would qualify Compañia Minera Asarco as a Mexicanized company eligible for tax benefits provided under the Mining Law of 1961.[27]

Metalurgica Mexicana Peñoles, S.A. (49 percent owned by American Metal Climax), continued to operate their lead-zinc properties in Mexico.

According to the annual report of San Francisco Mines of Mexico, Ltd., for the 9 months ending June 30, 1963, a total of 648,000 tons of ore was milled from the company's San Francisco and Clarines mines and produced 78,100 tons of 56.96 percent zinc concentrate plus values in lead, copper, silver, and gold. The operations closed June 13 due to a strike. The ore reserve at the end of the fiscal year was 6,800,000 tons, averaging 7.69 percent zinc, 5.37 percent lead, and 0.56 percent copper.

The Fresnillo Co. operated lead-zinc mining and milling units at Fresnillo in Zacatecas and at Naica in Chihuahua. In the year ending June 30, 1963, the company milled a total of 873,000 tons of ore. The Fresnillo mill produced 28,428 tons of 51.4 percent zinc concentrate, and the Naica mill produced 36,676 tons of 54.0 percent zinc concentrate. The company also mined lead-zinc at its Zimapan Unit in Hidalgo and had 27,000 tons of ore treated by a custom flotation mill. This ore yielded 3,645 tons of 51.4 percent zinc concentrate. Ore reserves at yearend at the Fresnillo and Naica mines totaled 4,415,000 tons containing 5.0 percent zinc, 5.3 percent lead, and 5.4 ounces of silver per ton.[28]

SOUTH AMERICA

Argentina.—Cia. Minera Aguilar, S.A., a subsidiary of St. Joseph Lead Co., produced 54,663 tons of zinc concentrates from its lead-zinc-silver mine in the Province of Jujuy in Northern Argentina. Through affiliated companies Aguilar operated a zinc smelter and electrolytic zinc plant.[29]

As a result of its exploration program Cia. Minera Castaño Viejo, S.A., developed sufficient ore as extensions to its lead-zinc-copper mine in the Province of San Juan to warrant a resumption of operations.[30]

Bolivia.—An agreement reportedly was reached between the Overseas Mineral Resources Development Co. of Japan and the State-owned Mineral Corporation of Bolivia to form a new company for reopening the Matilde zinc-lead-silver mine near Lake Titicaca. Substantial production is not anticipated before 1966.[31]

Brazil.—Cia. Mercantil e Industrial Inga anticipated completion and initial production at an annual rate of 8,000 tons of slab zinc from a new zinc reduction plant at Itaguai, State of Rio de Janeiro.

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27 Pages 13-14 of work cited in footnote 2.
28 The Fresnillo Co. Annual Report. 1963, pp. 13-15.
29 Page 19 of work cited in footnote 5.
30 Mining Journal (London). V. 262, No. 6702, Jan. 31, 1964, p. 86.
31 Mining Journal (London). V. 262, No. 6702, Jan. 31, 1964, p. 85.

The plant was designed to process zinc silicate ores from the Januaria and Vazante deposits in Minas Gerais.[32]

Peru.—Cerro de Pasco Corp. produced a record 60,465 tons of slab zinc from concentrate of its own mines. In addition 102,307 tons of zinc concentrate was sold for export. Cerro's La Oroya electrolytic zinc plant was expanded from a capacity of 55,000 tons per year to 63,000 tons, principally by improvement in operating techniques. The full capacity of the Paragsha concentrator has been applied to milling lead-zinc ore from the McCune mine after termination in 1963 of concentrating copper ore from the Cerro de Pasco mine at the mill.[33]

Cia. Minerales Santander, Inc., a St. Joseph Lead Co. subsidiary, operated an open pit lead-zinc-silver mine in the Peruvian Andes and produced 33,954 tons of zinc concentrates compared with 29,356 tons in 1962.[34]

Other zinc producers included Cia. Minera Atacocha, S.A., Cia. des Mines de Huaron, and Northern Peru Mining Corp.

EUROPE

Bulgaria.—The Combine for Nonferrous Metals in Plovdiv operated the zinc section completed in 1961 and had construction underway to increase capacity in 1964. A description of Bulgarian lead-zinc mining methods and metal recovery processes used was published.[35]

Finland.—The Vihanti mine continued as the leading zinc producer in Finland, yielding 86,518 tons of 55.3 percent zinc concentrate from 465,000 tons of ore. The Pyhasalmi copper-zinc mine produced 33,470 tons of 55.1 percent zinc concentrates from 565,000 tons of ore.

Greece.—A lead-zinc smelter to produce 15,000 tons of each metal is planned by the Industrial Development Corp. The Davy-Ashmore Co., a British firm, has reportedly proposed to undertake construction of the smelter.[36]

Ireland.—Northgate Exploration Co., Ltd., a Canadian company, planned development of an open cast mine and construction of an ore concentrating plant to bring into production in 1965 their lead-zinc-silver ore body at Tynagh discovered in 1962. Another Canadian company, Consolidated Mogul, was actively exploring for base metal deposits at Silvermines, County Tipperary.

Italy.—Monteponi e Montevecchio Societi per Azioni announced a major investment program to be used at the Monteponi and Montevecchio mines and construction of a flotation plant.[37]

Sweden.—Mines of the Boliden Mining Co., Ltd., yielded 95,200 tons of zinc concentrate containing 51,500 tons of zinc. Construction progressed on a new slag fuming plant to extract zinc and lead from copper-furnace slag. This facility was scheduled for operation during the first half of 1964.[38]

Yugoslavia.—A new flotation plant 25 miles southeast of the Trepca lead-zinc complex at Zvecan was planned to treat ores from

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[32] Bureau of Mines. Mineral Trade Notes. V. 56, No. 6, June 1963, p. 40.
[33] Cerro Corp. Annual Report. 1963, p. 4.
[34] Page 19 of work cited in footnote 5.
[35] Mine and Quarry Engineering (London) Lead and Zinc Mining in Bulgaria. V. 29, No. 11, November 1963, pp. 466–474.
[36] Mining Journal (London). V. 262, No. 6701, Jan. 24, 1964, p. 69.
[37] Foreign Trade (Ottawa). V. 120, No. 5, Sept. 7, 1963, p. 11.
[38] Boliden Mining Co., Ltd. Annual Report. 1963, pp. 4–6.

the Apalija, Kisnica, and Novo Brdo mines. Initial capacity of 600,000 tons per year of ore is expected, with ultimate capacity in excess of 1 million tons. No completion schedule was announced.[39]

ASIA

India.—Cominco-Binani Zinc Ltd., a joint venture of Metal Corporation of India, Ltd., and The Consolidated Mining and Smelting Co. of Canada, was building an electrolytic zinc smelter near Cochin in Kerala State. The completion target date was mid-1966 with a planned capacity of 22,000 tons of zinc per year and 125 tons per day of sulfuric acid.

Iran.—A U.S. survey team, under contract with the U.S. Agency for International Development, completed in September 1963 a diamond drilling program at the Shahkuh operation of the Bama Company near Isfahan. Based on the drilling, the reserves were estimated to be 1.2 million tons of measured and indicated carbonate ore averaging about 35 percent of combined lead and zinc plus 600,000 tons of indicated zinc-lead sulfide ore.[40] Rio Tinto-Consolidated Zinc announced in London that they have joined with Iranian interests in exploration of lead and zinc deposits at Bafq, near Yezd, and at Anguran.[41]

Korea, North.—The Polish Government will reportedly build a 15,000 ton per year zinc smelting plant in North Korea.[42]

AFRICA

Algeria.—Most of the zinc production continued to come from the mines at El Abed (Societe Algerienne du Zinc) and Oued Zounder (Societe Nouvelle des Mines d'Ain Arko), both near the Moroccan frontier. The lead, zinc, and copper mining work force increased from 995 at the end of 1962 to 1,020 by mid-1963.[43]

Morocco.—The French mining company, Societe des Mines de Zellidja resumed operations in mid-year with 1,300 miners after a 3 months' strike.[44]

Congo, Republic of the.—Union Miniere du Haut Katanga's Prince Leopold copper-zinc mine supplied 996,800 tons of ore to the concentrator at Kipushi to produce 193,227 tons of 59.1 percent zinc concentrate. A subsidiary of the company, Societe Generale Industriell at Chimique du Katanga, roasted 119,234 tons of the Kipushi concentrate, producing sulfuric acid and 98,753 tons of roasted concentrate. During the year 98,293 tons of roasted concentrate was sold to Societe Metallurgique du Katanga (Metalkat) for reduction to zinc, and 72,153 tons of raw and roasted concentrates were delivered for export. Metalkat produced 58,128 tons of electrolytic zinc.[45]

Rhodesia and Nyasaland, Federation of.—Broken Hill Development Co., Ltd., operated the Broken Hill mine and treated 151,000

[39] Engineering and Mining Journal. V. 165, No. 4, April 1964, pp. 155–157.
[40] Bureau of Mines. Mineral Trade Notes. V. 59, No. 1, July 1964, pp. 23–24.
[41] Mining Journal (London). V. 262, No. 6707, Mar. 6, 1964, p. 177.
[42] Engineering and Mining Journal. V. 14, No. 1, January 1963, p. 2.
[43] Bureau of Mines. Mineral Trade Notes. V. 58, No. 2, February 1964, p. 22.
[44] Mining Journal (London). V. 260, No. 6665, May 17, 1963, p. 477.
[45] Union Miniere du Haut Katanga. Annual Report. 1963, 44 pp.

tons of the ore in the heavy-medium plant which yielded 104,000 tons of sink product. The flotation plant treated 102,700 tons of the sink product plus 2,300 tons of fines and slimes, yielding 28,873 tons of 59.8 percent zinc concentrate. The leach plant treated roasted zinc concentrate, flotation plant tailing, and zinc silicate ore, totaling 86,800 tons averaging 42.5 percent zinc. Leach solution was processed in the elecrolytic plant to yield 33,114 tons of slab zinc. The Imperial-type vertical furnace, completed in 1962, treated 148,600 tons of sintered mill fines, slags, residues, and other material to produce 24,996 tons of slab zinc. The reserve of ore at yearend was 5.7 million tons grading 26.7 percent zinc and 13.3 percent lead.[46]

South-West Africa.—Tsumeb Corp., Ltd., in the year ending June 30, 1963, mined and milled 659,000 tons of complex copper-lead-zinc sulfide and oxide ore averaging 4.24 percent zinc. The reserves of proven and probable ore were estimated at yearend to be 9.8 million tons at Tsumeb and 3.6 million tons at Kombat.[47]

OCEANIA

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.; Consolidated Zinc Corp., Ltd.; North Broken Hill, Ltd.; and Broken Hill Consolidated, Ltd. Combined output was 2.7 million tons of zinc-lead-silver ore, yielding 499,000 tons of zinc concentrate averaging 53.2 percent zinc.

Sulphide Corp. Pty. Ltd. operated its Imperial Smelting type furnace at Cockle Creek, New South Wales for the second full year since construction. Output increased 25 percent for slab zinc to 48,200 tons and 26 percent to 23,400 tons for lead bullion.[48]

Mount Isa Mines, Ltd., during the fiscal year ended June 30, 1963, milled 3,709,000 tons of silver-lead-zinc ore and produced 34,245 tons of zinc in concentrates. Mine development and mill construction work continued during the year towards attaining capacity for treatment of 16,000 tons of ore per day.[49]

The Electrolytic Zinc Co. of Australasia, Ltd., produced a record 151,500 tons of slab zinc at its Risdon Tasmania electrolytic plant during the fiscal year ending June 30, 1963 (144,500 tons in 1962). The company mining-milling operations in the Read-Rosebery district milled a record 217,000 tons of ore yielding 116,000 tons of zinc, lead, and copper concentrates, each an increase of 6 percent.[50]

TECHNOLOGY

A comprehensive coverage of zinc technology reported in the scientific and technical press is included in the 2,085 items contained in the monthly issues of the 1963 Zinc Abstracts, jointly published by the Zinc Development Association and the American Zinc Institute.

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[46] The Rhodesia Broken Hill Development Co., Ltd. Annual Report. 1963, pp. 6–9.
[47] Newmont Mining Corp. Annual Report. 1963, p. 11.
[48] The Rio Tinto-Zinc Corp. Annual Report. 1963, p. 25.
[49] Pages 16–17 of work cited in footnote 2.
[50] E Z Industries, Ltd. Annual Report. 1963, pp. 3–4.

Effective July 1, 1963, the name of the Expanded Research Program of the American Zinc Institute and the Lead Industries Association was changed to International Lead-Zinc Research Organization (ILZRO). The new name reflects the growing support for this research organization by many of the major lead and zinc producers throughout the world. ILZRO sponsors a large number of research projects promoting the utilization of zinc and releases progress reports bi-annually by means of the ILZRO Research Digest.

Results of several research investigations were published by the Bureau of Mines [51] and Geological Survey.[52]

In extractive metallurgy, patents were granted on a method of recovering zinc values from leach residues,[53] proper proportioning of a furnace charge to obtain desirable slag formation in a zinc blast furnace [54] and the improved oxidation in roasting zinc sulfide concentrates by addition of 0.5 to 1.0 percent of zinc sulfate.[55] Articles described studies of sintering single crystal spheres of zinc oxide;[56] full scale tests of roasting zinc concentrates;[57] test work on use of borides of titanium, zirconium, tungsten and chromium for refractories in zinc smelting;[58] a process to convert a horizontal retort furnace to produce zinc dust;[59] operation of an electrothermic zinc plant;[60] and a zinc refiner of novel design.[61] Use of a molybdenum-tungsten alloy appears to be a satisfactory solution to the corrosion problems associated with handling high-purity molten zinc.[62]

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[59] Chemical Trade Journal and Chemical Engineer. New Belgian Zinc Dust Process. V. 152, No. 3955, Mar. 29, 1963, p. 507.

[60] Dietrich, Alfred. Electrothermal Recovery of Zinc. J. Metals, v. 15, No. 11, November 1963, pp. 830-834.

[61] Enterline, S. M. and J. F. Pierce, Sr. Amax Zinc Refiner. Trans. AIME, v. 227, (Met. Soc.), 1963, pp. 509-515.

[62] Burman, R. W., and G. Litchfield. Severe Molten Zinc Corrosion is Reduced by Improved Molybdenum-Tungsten Alloy. Eng. and Min. J. V. 164, No. 4, April 1963, pp. 88-91.

A comparative evaluation of metal coatings included a survey of the respective merits of hot-dip galvanized, sprayed, and electroplated zinc coatings.[63] Other articles described coating steel by shotblasting with zinc powder[64] and operation of a modern continuous hot-dip galvanizing line.[65] Books were published on methods of testing metallic coatings[66] and on corrosion behavior of zinc.[67] Patents were granted on a method of applying phosphate and chromate coatings to zinc surfaces;[68] nickel plating zinc and zinc alloys;[69] and zinc plating aluminum surfaces.[70]

Research on zinc alloyed with 0.25 to 3.0 percent cadmium and other elements showed no age-hardening due to precipitation of the alloying elements from solid solution.[71] The influence of impurities and inclusions on machinability of die-castings indicated that higher silicon and iron contents increased tool wear.[72] Aluminum alloyed with 4 to 5 percent zinc and 0.5 to 2.0 magnesium is claimed to have outstanding weldability and mechanical properties.[73] A zinc alloy containing 11.5 to 12.5 percent aluminum, 2.0 to 3.0 percent copper and 0.1 to 0.3 percent magnesium is designed for uses such as bushings and gears.[74] Numerous articles on the die-casting process appear in the "Transactions" of the 1962 National Die-casting Congress. A patent was granted for the addition of up to 0.6 percent of zinc containing compounds to steel to improve the machinability.[75] Patents were granted for producing electrically conductive zinc oxide,[76] photoconductive zinc oxide,[77] and for use of zinc oxide in a glass sealing compound.[78] Articles described use of zinc in the reduction of aldehydes and ketones[79] and an autoclave method to grow zinc oxide crystals up to ¾-inch wide by ⅜-inch thick for desirable electrical and acoustical properties.[80]

Basic data, including phase diagrams, were reported on the zinc-vanadium system[81] and the yttrium-zinc system.[82] Other articles

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63 Leonard, C. D. Electroplating Metal Finishing. V. 16, No. 9, September 1963, pp. 300–308.
64 Sandford, J. E. Zinc Coating Blasted on Steel. Iron Age, v. 192, No. 5, Aug. 1, 1963, pp. 53–55.
65 Metal Industry. High Ductility Galvanized Strip. V. 103, No. 11, September 1963, pp. 354–355.
66 Kutzelnigg, A. Testing Metallic Coatings. Robert Draper, Ltd., Teddington, 1963, 200 pp.
67 Schikorr, G. Corrison Behavior of Zinc (in German). Metall-Verlag GMBH, Berlin, 72 pp.
68 Hoover, George R. (assigned to Armco Steel Corp.). Rust Inhibitive and Paint Holding Treatment for Alloyed Zinc Iron Surfaces. U.S. Pat. 3,074,827, Mar. 22, 1960.
69 Brown, Richard C. (assigned to American Zinc Institute Inc., New York). Nickel Plating On Zinc. U.S. Pat. 3,082,156, Aug. 19, 1960.
70 Sheridan, James V. Electroplating Zinc On Aluminum. U.S. Pat. 3,079,310, Aug. 26, 1960.
71 Swanson, C. J. Age-Hardening of Zinc-Cadmium Alloys. J. Institute of Metals, v. 91, June 1963, pp. 349–350.
72 Scacciati, G. Machinability of Zinc Die-castings. Foundry, v. 91, No. 9, September 1963, pp. 108–120.
73 Taylor, Ian. Introducing Two Weldable Aluminum Alloys: 74 S and C74 S. Metal Prog., v. 84, No. 5, November 1963, pp. 74–77.
74 Nikolaichik, N. P. New Bearing Alloys. Russ. Castings Prod., November 1962, p. 525.
75 Nachtman, Elliot S. (assigned to La Salle Steel Co.) Steels Having Zinc Additives For Improved Machinability. U.S. Pat. 3,094,440, Aug. 5, 1960.
76 Cyr, Howard M., and Nicholas S. Nonovic. (assigned to The New Jersey Zinc Co., New York). Production of Conductive Zinc Oxide. U.S. Pat. 3,089,856, Nov. 10, 1963.
77 Stewart, Paul H. (assigned to Eastman Kodak Co., Rochester, N.Y.). Merocyanine Sensitized Photoconductive Compositions Comprising Zinc Oxide. U.S. Pat. 3,110,591, Apr. 22, 1960.
78 Pirooz, P. P. (assigned to Owens-Illinois Glass Co.). Sealing Glass. U.S. Pat. 3,088,834, May 7, 1963.
79 Risinger, G. E., and C. W. Eddy. Studies in the Zinc Reduction Series: A Mechanism for the Zinc and Alkali Reduction of Aromatic Ketones. Chem. and Ind. (London), v. 14, Apr. 6, 1963, pp. 570–571.
80 Bell Laboratories Record. Large Zinc Oxide Crystals Grown From Seeds. V. 41, No. 3, March 1963, p. 105.
81 Chasanov, M. G., R. Schablaske, P. D. Hunt, and B. Tani. The Zinc-Vanadium Phase Diagram. Trans. AIME, v. 227 (Met. Soc.), 1963, pp. 485–488.
82 Chiotti, P., J. T. Mason, and K. J. Gill. Phase Diagram and Thermodynamic Properties of the Yttrium-Zinc System. Trans. AIME, v. 227 (Met. Soc.), 1963, pp. 910–916.

published results of studies on zinc crystals [83] and on various physical properties of the metal, alloys or compounds of zinc.[84]

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[83] Bullen, F. P. The Cleavage of Zinc Single Crystals. Trans. AIME, v. 227 (Met. Soc.), 1963, pp. 1069-1077.

Damiano, V. V., G. S. Tint, and M. Herman. Three Dimensional Aspects of Dislocations and Substructures in Bulk Zinc Crystals. Trans. AIME, v. 228 (Met. Soc.), 1963, pp. 994-999.

Partridge, P. G., and E. Roberts. The Microhardness Anisotropy of Magnesium and Zinc Single Crystals. J. Inst. Metals, October 1963, pp. 50-55.

[84] Baba, Hideo. Some Effects of Zinc Atmospheres on Zinc Sulfide. J. Electrochem. Soc., v. 110, No. 1, January 1963, pp. 79-81.

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O'Brien, R. N., W. F. Yakymshyn, and J. Leja. Interferometric Study of Zn/ZnSO/Zn System. J. Electrochem. Soc., v. 110, No. 7, July 1963, pp. 820-825.

Pfahnl, Arnold. Properties of ZnO Phosphors Doped with Li, Ni, and Cu. J. Electrochem. Soc., v. 110, No. 5, May 1963, pp. 381-384.

Thronton, W. A. Some Aspects of Electroluminescence in ZnS. J. Electrochem. Soc., v. 110, No. 5, May 1963, pp. 370-374.

Weinberg, F. Growth Substructure in Rapidly Solidified Zn-2 Pct Au Alloys. Trans. AIME, v. 227 Met. Soc.), 1963, pp. 276-277.

Zirconium and Hafnium

By Donald E. Eilertsen[1]

DOMESTIC zircon production was only slightly larger in 1963 than in 1962, while Australian output rose sharply. Outputs of zirconium sponge and zirconium ingot decreased substantially while the output of hafnium oxide increased sharply over 1962.

LEGISLATION AND GOVERNMENT PROGRAMS

During 1963, a total of 4,930 tons of zircon was sold from stocks of zircon and baddeleyite acquired for the national strategic stockpile.

U.S. Atomic Energy Commission (AEC) contracts for zirconium sponge and hafnium oxide terminated in 1963, except for 26.5 tons of zirconium sponge scheduled for delivery in 1964. During the fiscal year ending June 30, 1963, the AEC acquired 740.5 tons of zirconium sponge and 18.5 tons of hafnium oxide from domestic producers.

TABLE 1.—Salient zirconium and hafnium statistics in the United States

	1962	1963
Zircon:		
Production.....short tons..	(1)	(1)
Imports.....do....	30,872	52,543
Exports.....do....	1,666	1,418
Consumption [2].....do....	33,600	37,500
Consumers and dealers stocks [2].....do....	23,738	21,673
Prices:		
Domestic, quoted.....per short ton..	$47.25	$47.25
Foreign, at port of exportation.....do....	$27.37	$32.66
Zirconium sponge:		
Production.....short tons..	1,272	1,022
Producers stocks.....do....	1,485	216
Hafnium oxide:		
Production [3].....do....	[4] 26	55
Producers stocks.....do....	13	26

[1] Figure withheld to avoid disclosing company confidential information.
[2] Excludes foundries.
[3] Metal content of oxide produced.
[4] Revised figure.

DOMESTIC PRODUCTION

Domestic zircon was recovered as a coproduct in mining sands for ilmenite and rutile in Florida. Producers were the E. I. du Pont de Nemours & Co., Inc. at its Trail Ridge mine near Starke; Titanium Alloy Manufacturing Division of National Lead Co. at the Skinner

[1] Commodity specialist, Division of Minerals.

mine near Jacksonville; and Florida Mineral Co. at its Vero mine at Vero Beach. Zircon production was slightly larger than in 1962 (figures are withheld to avoid disclosing company confidential data).

Zirconium sponge was produced by U.S. Industrial Chemicals Co., Division of National Distillers & Chemical Corp., Ashtabula, Ohio; Wah Chang Corp., Albany Division, Albany, Oreg.; The Carborundum Metals Co. Division, The Carborundum Co., Parkersburg, W. Va.; and Columbia-National Division, Pittsburgh Plate Glass Co., Pace, Fla. The latter firm placed its zirconium production facilities in a standby condition in mid-1963. The same firms produced hafnium oxide, and except for Columbia-National they all produced hafnium sponge. Output for the industry was 1,022 tons zirconium sponge and 65 tons of hafnium oxide.

Zirconium sponge was converted to ingot by two sponge producers, The Carborundum Metals Co., and Wah Chang Corp., and also by Bridgeport Brass Co., Niles, Ohio; U.S. Industrial Chemicals Co. (divisions of National Distillers and Chemical Corp.); Harvey Aluminum, Inc., Torrance, Calif.; and Oregon Metallurgical Corp., Albany, Oreg. Production of zirconium ingot was 928 tons.

Zirconium powder was produced by Foote Mineral Co., Exton, Pa.; Nuclear Materials & Equipment Corp., Appolo, Pa.; and Herrick Labs., Watchung, N.J. Zirconium powder production was almost 22 tons.

Melters and fabricators generated 285 tons of zirconium scrap and 228 tons was reused.

The principal producers of zirconium alloys were Union Carbide Corp., Metals Division, Alloy, W. Va., and Niagara Falls, N.Y.; Titanium Alloy Manufacturing Division of National Lead Co., Niagara Falls, N.Y.; and Vanadium Corporation of America, Cambridge, Ohio.

Hafnium crystal bar producers were Foote Mineral Co., Exton, Pa.; Wah Chang Corp., Albany, Oreg.; Nuclear Materials & Equipment Corp., Appolo, Pa.; and U.S. Industrial Chemicals Co., Ashtabula, Ohio.

Zirconium oxide output, excluding that produced for zirconium metal production, was approximately 5,283 tons. The principal producers of this oxide were Titanium Alloy Manufacturing Division of National Lead Co., Niagara Falls, N.Y.; Harbison-Carborundum Corp., Falconer, N.Y.; and The Norton Co., Huntsville, Ala.

Twelve firms processed zircon to refractories. The largest producers of refractories were Corhart Refractories Co. at Louisville, Ky., and Buckhannon, W. Va.; Harbison-Carborundum Corp., Falconer, N.Y.; The Charles Taylor Sons Co., Cincinnati, Ohio, and South Shore, Ky.; Walsh Refractories, St. Louis, Mo.; and Remmey Division of A. P. Green Fire Brick Co., Philadelphia, Pa. Zircon and zirconia refractory production was an estimated 21,000 tons.

Titanium Alloy Manufacturing Division of National Lead Co., Niagara Falls, N.Y.; The Norton, Co., Huntsville, Ala.; and Titanium, Zirconium Co., Flemington, N.J., were the principal processors of zircon to primary zirconium chemicals, which consisted mainly of zirconium oxide.

CONSUMPTION AND USES

Zircon was used as foundry sand and in the production of ceramics, refractories, abrasives, and zirconium and hafnium metal, alloys, and compounds.

Consumption, except for foundries, was approximately as follows: 15,900 tons for refractory production; 9,850 tons for metal and alloy production; and 11,750 tons for chemical, ceramic, and abrasive production. The largest use for zircon was probably in foundries, but consumption data are not available for this industry.

Zirconium and hafnium were reported to be used chiefly in nuclear submarines and in the development of nuclear power reactors for civilian use. In nuclear power reactors zirconium was used as fuel cladding material and hafnium was used for control rods. Zirconium was used in industry in heat exchangers, valves, and pump parts to resist the corrosive attack of mineral and organic acids and strong alkaline solutions. Zirconium also had applications in the manufacture of photo flashbulbs and in the production of alloys for high-temperature applications. Certain super conductive magnets for microwave applications were reported to contain columbium-zirconium wire. Fur and wool felt hats were waterproofed with a complex organozirconium derivative. Porous zirconia impregnated with resin was tested in nose cones for wingless reentry space vehicles.

STOCKS

Yearend stocks were as follows:

	Short tons
Zircon concentrate:	
Dealers	5,710
Consumers, except foundries[1]	15,963
Zirconium sponge:	
Producers	216
Zirconium oxide:	
Producers of zirconium	1,213
Hafnium oxide:	
Producers	31

[1] Data for foundries not available.

In addition to commercial stocks the additional government stocks were as follows:

	Short tons
Zircon concentrate:	
National (strategic) stockpile	2,152
Baddeleyite concentrate:	
National (strategic) stockpile	16,533
Zirconium sponge:	
AEC, equivalent sponge as of June 30, 1963	2,921.1
Hafnium:	
AEC, equivalent crystal bar as of June 30, 1963	43.9

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PRICES

Quoted prices for zircon concentrate, zirconium, and hafnium, unchanged since 1962, were as follows:

	Price
Zircon:[1]	
Domestic, containing 66 percent ZrO_2, f.o.b. Starke, Fla., per short ton	$47.25
Imported, containing 65 percent ZrO_2, c.i.f. Atlantic Ports, per long ton	50
Zirconium:[1]	
Flash grade powder, per pound	10
Sponge, per pound	4.25 to 5
Sheets, strip, and bars, per pound	10 to 14
Hafnium:[2]	
Sponge, per pound	75
Rolled bar and plate, per pound	138

[1] E&MJ Metal and Mineral Markets. V. 34, Nos. 1–52, January–December 1963.
[2] American Metal Market. V. 70, Nos. 1–249, January–December 1963.

FOREIGN TRADE

Imports.—Imports for consumption of zircon increased 70 percent compared with that of 1962. Imports of zirconium metal were 645 pounds, valued at $4,106, from West Germany. Import data on zirconium alloys and compounds were incomplete because a new system of reporting began September 1. Imports of zirconium silicon for the first 8 months of 1963 were 60,000 pounds, valued at $5,307, from Japan, and 60 pounds, valued at $275, from West Germany. Imports separately classified from other materials since September 1 were: Zirconium oxide, 1,049 pounds, valued at $264, from Canada, and 19,936 pounds, valued at $11,531, from United Kingdom; other zirconium compounds, 47,334 pounds, valued at $6,581, from Canada, and 49,733 pounds, valued at $9,916, from United Kingdom; unwrought zirconium alloys, 60,000 pounds, valued at $5,638, from Japan, and 550 pounds, valued at $4,156, from West Germany; and 131 pounds of wrought hafnium, valued at $1,131, from Austria.

TABLE 2.—U.S. imports for consumption of zircon, by countries
(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
Australia[1]	27,195	53,650	29,183	31,225	27,001	50,004
Austria	---	---	---	---	---	11
Brazil[2]	658	---	---	4	---	---
Canada[3]	63	24	2	---	1	24
Nigeria	10	868	1,850	---	544	981
South Africa, Republic of	---	280	3,133	2,576	3,326	1,523
United Kingdom[3]	35	56	112	---	---	---
Total: Quantity	27,961	54,878	34,280	33,805	30,872	52,543
Value	[4] $740,296	$1,517,485	$1,233,815	$873,376	$844,939	$1,715,878

[1] Imports from Australia through 1954 were partly in the form of mixed concentrate containing small quantities of rutile and ilmenite.
[2] Concentrate from Brazil includes some baddeleyite.
[3] Believed to be country of shipment rather than country of origin.
[4] 1954 data known to be not comparable with other years.

Source: Bureau of the Census.

Exports.—A total of 1,418 tons of zircon, valued at $304,881, was exported to 12 countries, the largest quantity, 906 tons, valued at $141,239, shipped to Canada. Other exports were 216,451 pounds of zirconium metal and alloys in crude form and scrap, valued at $1,071,-865, to 8 countries; the largest shipment, 200,225 pounds, valued at $968,088, going to United Kingdom; and 75,341 pounds of semifabricated zirconium and zirconium alloys, valued at $1,428,395, to 9 countries; the largest shipment, 51,880 pounds, valued at $958,286, to Canada.

WORLD REVIEW

Australia.—The first large bulk shipment of zircon to the United States was in the Star Clipper which carried an estimated 4,500 tons of zircon and 3,000 tons of rutile. Usually zircon is shipped in bags.[2]

Associated Minerals Consolidated, Ltd., Sydney, reported its zircon sales at 43,527 tons for fiscal year 1963, compared with 26,865 tons for fiscal year 1962. Output for fiscal year 1963 was 49,218 tons of zircon products. The annual production level for all plants reached 60,000 tons of zircon; the Southport plant capacity alone was increased to 40,000 tons.[3]

NSW Rutile Mining Company's three dredges in New South Wales and Queensland and the separation plant at Cudgen were reported to having a capacity of 35,000 tons of rutile and 35,000 tons of zircon annually.[4]

France.—The Cuisse-Lamotte plant produced about 110 tons of zirconium containing less than 120 parts per million of hafnium in 1962; the hafnium also was recovered.

TABLE 3.—Free world production of zirconium concentrates by countries [1]

(Short tons)

Country	1954–58 (average)	1959	1960	1961	1962	1963
Australia	69,533	125,834	114,645	152,859	149,869	[2] 185,000
Brazil [3]	4,524	10,846	6,358	7,405	2,642	(4)
India	[5] 7	[2] 10	[2] 10	[2] 10	(4)	(4)
Malagasy Republic	5	50	145	353	390	(4)
Malaya, Federation of	[6] 42	130	63	[7] 63	[7] 67	(4)
Nigeria	[8] 101	1,250	1,968	832	[9] 544	886
Senegal, Republic of	2,802	9,557	11,408	5,939	2,575	----------
South Africa, Republic of	[8] 1,129	5,924	7,366	7,607	7,581	[2] 3,500
United Arab Republic (Egypt)	145	[2] 65	408	----------	188	(4)
United States	35,170	(10)	(10)	(10)	(10)	(10)

[1] This table incorporates some revisions.
[2] Estimate.
[3] Chiefly baddeleyite.
[4] Data not available.
[5] Average annual production 1955–58.
[6] Average annual production 1956–58.
[7] Exports.
[8] One year only because 1958 was the first year of commercial production.
[9] U.S. imports.
[10] Figure withheld to avoid disclosing individual company confidential data.

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[2] American Metal Market. Zircon and Rutile Arrive at Davison of Howe Sound Co. V. 70, No. 211, Oct. 31, 1963, p. 15.
[3] Associated Minerals Consolidated, Ltd. (Sydney, Australia). 1963 Eleventh Annual Report and Balance Sheet. 14 pp.
[4] Metal Bulletin (London). NSW Rutile Mining Co.'s. Progress. No. 4766, Jan. 25, 1963, p. 13.

TECHNOLOGY

Principal features of the Bureau of Mines research program on zirconium and hafnium were studies on zirconium-hafnium separation from zircon sources, electron-beam melting and purification of zirconium, casting hafnium carbide, various hafnium alloy systems, and electrorefining hafnium. In a search for a boride to withstand mechanical shock at high temperatures, mixtures of zirconium diboride and iron, cobalt, or nickel were found to be brittle and to have poor oxidation resistance.[5] A method was developed to melt and cast hafnium carbide; many of the properties of this alloy also were determined.[6] Certain columbium-hafnium alloys were found to have high strength, good oxidation resistance, machinability, and workability.[7]

Research sponsored by the AEC was concentrated to a large extent on zirconium alloying to improve corrosion resistance. Continuing programs were underway to establish the effects of alloying on zirconium in a water environment to establish hydriding characteristics of zirconium and zirconium alloys, and to determine the effect that hydride may have on the mechanical operation of a nuclear fuel element. Other work was underway and planned on zirconium oxidation and single crystal deformation. The AEC also engaged in limited work on hafnium and hafnium systems. Hafnium carbon alloys were investigated as to their preparation and property measurements. Additional phase diagram work on hafnium-iridium and hafnium-vanadium moved toward completion.

Numerous patents were issued in connection with zirconium, and most were in the fields of processing and alloying.[8] Several patents

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[5] Tyrrell, M. E., and C. W. Houck. Mettallic Binders for Zirconium Diboride: Iron, Cobalt,and Nickel. BuMines Rept. of Inv. 6262, 1963, 17 pp.

[6] Adams, R. P., and R. A. Beall. Preparation and Evaluation of Fused Hafnium Carbide. BuMines Rept. of Inv. 6304, 1963, 17 pp.

[7] Babitzke, H. R., G. Asai, and H. Kato. Columbium-Hafnium Binary Alloys for Elevated-Temperature Service. BuMines Rept. of Inv. 6101, 1962, 17 pp.

[8] Cain, Francis M., and John E. Eck (assigned to U.S. Atomic Energy Commission). Dispersion Element Consisting of Chromium Coated UO_2 Particles Uniformly Distributed in Zircaloy Matrix. U.S. Pat. 3,088,892, May 7, 1963.

Dickson, Clayton D., Stanley Abkowitz, and Ronald J. Nylen (assigned to National Distillers & Chemical Corp.). High Strength Titanium Base Zirconium Aluminum Alloy. U.S. Pat. 3,114,632, Nov. 17, 1963.

Donlevy, Alfred L., and Jack K. Y. Hum (assigned to Stauffer Chemical Co., New York). Alloy. U.S. Pat. 3,075,840, Jan. 29, 1963.

Droegkamp, Robert E., Edward R. Slaughter, and Alfred B. Thomas (assigned to Westinghouse Electric Corp., East Pittsburgh, Pa.). Zirconium-Base Brazing Alloys. U.S. Pat 3,104,972, Sept. 24, 1963.

Horrigan, Robert V. (assigned to National Lead Co., New York). Tanning With Silicated Sodium Zirconyl Sulfate. U.S. Pat. 3,096,143, July 2, 1963.

Kenneth, John (assigned to Lead Manufacturers Ltd., London). Manufacture of Zirconium Oxide From Zircon. U.S. Pat. 3,109,704, Nov. 5, 1963.

Korach, Malcolm, and James K. Thomas, III (assigned to Pittsburgh Plate Glass Co. and Columbia National Corp., Florida). Method of Separating Silicon From Zirconium Sulfate Solutions. U.S. Pat. 3,095,270, June 25, 1963.

Newby, Billie J. (assigned to U.S. Atomic Energy Commission). Precipitation of Zirconium and Fluoride Ions From Solution. U.S. Pat. 3,093,452, June 11, 1963.

Olds, Geoffrey Charles Edward, and John Edwin Harris (assigned to Associated Electrical Industries Ltd., London). Zirconium Alloys. U.S. Pat. 3,072,478, Jan. 8, 1963.

Otto, George F. (assigned to Amchen Products, Inc., Ambler, Pa.). Method of Coating Zirconium. U.S. Pat. 3,076,733, Feb. 5, 1963.

Rubenstein, Lester S., and Francis L. Schubert (assigned to Westinghouse Electric Corp., East Pittsburgh, Pa.). Zirconium Alloys. U.S. Pat. 3,097,094, July 9, 1963.

Russell, James R. (assigned to Pittsburgh Plate Glass Co.). Method of Preparing an Alkali Metal Zirconate. U.S. Pat. 3,107,143, Oct. 15, 1963.

Saarivirta, Matti J. (assigned to American Metal Climax Inc., New York). Copper-Zirconium-Arsenic Alloys. U.S. Pat. 3,107,998, Oct. 22, 1963.

were issued on the recovery of hafnium.[9]

The process used by The Carborundum Metals Co. Division, The Carborundum Co., Akron, N.Y., to produce hafnium ingot from zircon was described in detail.[10]

Some physical properties and applications were discussed for various newly developed copper-base alloys which contain zirconium and/or hafnium.[11]

A number of reports on research sponsored by the AEC became available in 1963. Solid solutions in the system ZrO_2-UO_2 were found to have promise as nuclear fuels.[12] Ultrasonic tests were developed for testing the reliability of Zircaloy sheath tubing for fuel elements.[13] Tandem-extruded tubular joints were found to be cheaper and more reliable than the conventional press-fit or gaskets in joining Zircaloy pressure tubes and stainless steel piping for pressure tube reactors.[14] Research was reported for work on the corrosion mechanism of zirconium and its alloys [15], the aqueous corrosion of zirconium single crystals [16], and the development of a zirconium alloy for nuclear fuel cladding for use in steam service.[17] Studies were undertaken to investigate the effects of heat treatments on the hardness and tensile properties of cold rolled hafnium for evaluation of hafnium control material in nuclear reactors.[18] Irradiated hafnium control rods from a pressurized water reactor were tested and found to have increased strength, slight decrease in ductility, and no abnormal corrosion at the weld joint.[19]

Stambaugh, Edgel P., and Raymond A. Foos (assigned to National Distillers & Chemical Corp., New York). Zirconium Dioxide Recovery. U.S. Pat. 3,090,670, May 21, 1963.

Takao, Zenichiro, Shigeo Inomata, and Koichi Nakano (assigned to Kobe Steel Works, Ltd., Kobe, Japan). Surface Hardening of Metal Body Consisting of or Containing Titanium or Zirconium. U.S. Pat. 3,111,434, Nov. 19, 1963.

Uelzmann, Hein (assigned to General Tire and Rubber Co., Akron, Ohio). Aqueous Solution of Zirconyl Salts of Carboxyl Polymer and Substrate Coated With Same. U.S. Pat. 3,079,358, Feb. 26, 1963.

[9] Elger, Gerald W., and Richard Boubel (assigned to U.S. Atomic Energy Commission). Production of Hafnium Metal. U.S. Pat. 3,071,459, Jan. 1, 1963.

Groce, Irwin J., Robert W. Ritchey, and Russell W. Peters (assigned to National Distillers & Chemical Corp.). Recovery of Hafnium Hydroxide. U.S. Pat. 3,098,711, July 23, 1963.

Hobin, Martin A., and Raymond A. Foos (assigned to National Distillers & Chemical Corp., New York). Process for Recovery of Hafnium Values From Crude Potassium Fluohafnate Solutions. U.S. Pat. 3,114,600, Dec. 17, 1963.

[10] Guccione, Eugene. Here's Hafnium: Hardest Element to Isolate. Chem. Eng., v. 70, No. 4, Feb. 18, 1963, pp. 128–130.

[11] Saarivirta, M. J. High Conductivity Copper Alloys. I. Metal Industry (London), v. 103, No. 19, Nov. 7, 1963, pp. 685–688; II, v. 103, No. 20, Nov. 24, 1963, pp. 716–718; III, v. 103, No. 21, 1963, pp. 758–760.

[12] Handwerk, J. H., and others. Ceramic Nuclear Fuels in the Systems ZrO_2-CaO-UO_2. U.S. Atomic Energy Commission (Argonne National Laboratory), ANL–6314, September 1962, 15 pp.; OTS, U.S. Dept. of Commerce.

[13] Fitch, C. E., and others. Interim Report—Ultrasonic Testing of Zircaloy Sheath Tubing for Fuel Elements. U.S. Atomic Energy Commission (Hanford Laboratories), HW 72802, June 1962, 89 pp.; OTS, U.S. Dept. of Commerce.

[14] Joseph, Jr., J. W. Evaluation of Tandem-Extruded Joints Between Zircaloy and Stainless Steel. U.S. Atomic Energy Commission (E. I. du Pont de Nemours & Co., Inc.), DP 723, June 1962, 15 pp.; OTS, U.S. Dept. of Commerce.

[15] Douglas, D. L. Corrosion Mechanism of Zirconium and Its Alloys—Diffusion of Oxygen in Zirconium Dioxide. U.S. Atomic Energy Commission (General Electric Co.), GEAP 3999, July 1962, 22 pp.; OTS, U.S. Dept. of Commerce.

[16] Bibb, A. E., and J. R. Fascia. Aqueous Corrosion of Zirconium Single Crystals. U.S. Atomic Energy Commission (General Electric Co.), KAPL 2257, October, 1962, 11 pp.; OTS, U.S. Dept. of Commerce.

[17] Klepfer, H. H., and others. Specific Zirconium Alloy Design Program, Fourth Quarterly Progress Report. U.S. Atomic Energy Commission (General Electric Co.), GEAP 4211, March 1963, 42 pp.; OTS, U.S. Dept. of Commerce.

[18] Goodwin, J. W. The Effects of Heat Treatments on the Hardness and Tensile Properties of Cold Rolled Iodide Hafnium. U.S. Atomic Energy Commission (Bettis Atomic Power Laboratory of Westinghouse Electric Corp.), WAPD–248, June 1962, 45 pp.; OTS, U.S. Dept. of Commerce.

[19] Salvaggio, G. J., and others. In PWR Core 1. U.S. Atomic Energy Commission (Bettis Atomic Power Laboratory), WAPD–TM–337, November 1962, 38 pp.; OTS, U.S. Dept. of Commerce.

Minor Metals and Minerals

By Staff, Division of Minerals

Contents

CESIUM AND RUBIDIUM [1]

CESIUM metal production increased sharply in 1963.

Domestic Production.—Cesium metal was produced by The Dow Chemical Co., Midland, Mich., MSA Research Corp., Callery, Pa., and by Penn Rare Metals, Inc., Revere, Pa. American Potash & Chemical Corp., Trona, Calif., produced some combined cesium and rubidium. This company, Penn Rare Metals, Inc., and Rocky Mountain Research, Inc., Denver, Colo., produced various cesium compounds. Complete production data on cesium and rubidium and their compounds were not available for publication.

Consumption and Uses.—Substantially more pollucite was consumed to produce cesium metal and compounds in 1963 than in 1962 but the overall consumption of pollucite continued to be small.

The development of ionic propulsion, and thermionic power conversion continued to direct interest toward cesium. Besides these large potential applications, cesium had modest applications as salts in the production of vacuum tubes, photomultiplier tubes, and scintillation counters. Some research and development was done on the application of cesium and rubidium salts in catalysis, photography, and electrical batteries.

Prices.—American Metal Market quoted the price of cesium, 99+ percent, at $100 to $375 per pound, and rubidium, 99+ percent, at $390, to $425 per pound.

[1] Prepared by Donald E. Eilertsen.

American Potash & Chemical Corp. quoted the following prices per pound of various cesium compounds in quantities to 10 pounds: Cesium fluoride, $36; cesium chloride, $34.50; cesium bromide, $35; cesium nitrate, $50; cesium perchlorate, $40; cesium carbonate, $27.50; cesium sulfate, $32.50; and cesium hydroxide, $35 per pound of contained solids.

Foreign Trade.—Imports of pollucite came principally from Southern Rhodesia. Imports of various cesium compounds from September through December 1963 follow: Cesium chloride, less than 1 pound, valued at $104, from the United Kingdom; other cesium compounds n.e.c., 268 pounds, valued at $4,076, from West Germany, and 129 pounds, valued at $1,405, from the United Kingdom. Separate import figures were not available for cesium metal.

World Review.—*Canada.*—A chemical process for producing high-purity cesium chloride from Manitoba pollucite was described.[2]

Technology.—Bureau of Mines research on cesium and rubidium consisted of studies on the recovery of these metals from pollucite and on the purification of cesium and rubidium salts. A method to separate and concentrate pollucite from ores containing mica, feldspars, and other gangue minerals was reported and patented.[3] Low-temperature heat-capacity and entropy, enthalpy, and free-energy functions of cesium chloride and cesium iodide were determined.[4] Occurrences of rubidium in coals were reported.[5]

Patents were issued on the recovery of cesium from pollucite and from solutions containing cesium bromide and molybdenum and on preparation of cesium and rubidium amides.[6]

The compatibility of cesium with 310 stainless steel, Inconel-X zirconium, hafnium, columbium, columbium plus 1 percent zirconium alloy, molybdenum, tantalum, and tungsten was reported.[7]

Industry research consisted principally of process improvements including production of high-purity cesium and improving cesium analysis and control of carbon, nitrogen, and oxygen content. Application of cesium and rubidium salts in catalysis, photography, and electrical batteries also was studied.

A flame spectrophotometric method was developed for determining cesium and rubidium in oilfield waters. The test permits detection of less than 0.05 milligram of cesium per liter of water.[8]

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[2] Parson, H. W., J. A. Vezina, R. Simard, and H. W. Smith. Development of Chemical Process for Production of Cesium Chloride From a Canadian Pollucite Ore. Dept. Mines and Tech. Surveys (Ottawa, Canada), Tech. Bull. TB50, March 1963, 13 pp.

[3] Dean, K. C. (assigned to U.S. Department of the Interior). Flotation Process for Concentration of Pollucite Ores. U.S. Pat. 3,107,215, Oct. 15, 1963.

Dean, K. C., and I. L. Nichols. Concentration of Pollucite Ores. BuMines Rept. of Inv. 5940, 1692, 10 pp.

[4] Taylor, Jr., A. R., T. Estelle Gardner, and D. F. Smith. Thermodynamic Properties of Cesium Chloride and Cesium Iodide From 0° to 300° K. BuMines Rept. of Inv. 6157, 1963, 7 pp.

[5] Abernethy, R. F., and F. H. Gibson. Rare Elements in Coal. BuMines Inf. Circ. 8163, 1963, 69 pp.

[6] Berthold, Cornelius E., and James R. Kane (assigned to San Antonio Chemicals, Inc.). Recovery of Cesium Values From Pollucite Ore. U.S. Pat. 3,112,169, Nov. 26, 1963.

Gray, Peter R. (assigned to The Dow Chemical Co., Midland, Mich.). Separation of Cesium Values From Aqueous Solutions. U.S. Pat. 3,075,826, Jan. 29, 1963.

Lefrancois, Bernard, and Gerald Lepoutre (assigned to Houilleres du Bassin du Nord et du Pas-de-Calais and Commissariat a l'Énergie Atomique, Paris, France). Method of Preparing Amides of Potassium Rubidium or Cesium. U.S. Pat. 3,082,158, Mar. 19, 1963.

[7] Chandler, W. T., and N. J. Hoffman. Effects of Liquid and Vapor Cesium on Container Metals. Commander Aeronautical Systems Div., Air Force Systems Command, Wright-Patterson AFB, Ohio (Rocketdyne, of North American Aviation, Inc.), Tech. Documentary Rept. ASD-TDR-62-965, December 1962, 179 pp.

[8] Collins, A. Gene. Flame Spectrophotometric Determination of Cesium and Rubidium in Oil Field Waters. Anal. Chem., v. 35, No. 9, August 1963, pp. 1258–1261.

U.S. Air Force research described the development and testing of tungsten emitters for use in ion propulsion systems for space application.[9] Other disclosures included an appraisal of a cesium magnetic triode for conversion of electrical energy [10] and the use potential of hallow cathodes for the conversion of thermionic energy.[11] A literature search on various liquid metal boiling systems for heat transfer systems included studies on rubidium.[12]

The electrical resistivity of liquid cesium and rubidium [13] and the power output from the operation of many variable-heated cesium diodes connected in series and parallel circuits were measured in research related to thermionic nuclear reactor design.[14] Cesium and rubidium were included in a bibliography on liquid metal technology in nuclear and space exploration applications.[15]

GALLIUM [16]

Domestic Production.—Gallium metal was produced by Aluminum Company of America, Bauxite, Ark., and by The Eagle-Picher Co. at its Miami plant near Quapaw, Okla. The Eagle-Picher also produced gallium sesquioxide and gallium trichloride. Gallium output was substantially smaller in 1963 than in either 1961 or 1962; however, shipments reached a record high.

Uses.—No outstanding new uses requiring large quantities of gallium were reported in 1963, but gallium continued to be used in research and development, especially on semiconductors and alloys. Gallium arsenide was among many compounds under intensive study for promising applications in high-frequency transistors, in tunnel diodes, and especially in the active field of lasers. Gallium arsenide-phosphide also was under study for lasers. Smaller uses for gallium were in backing material for mirrors, additives to certain selenium rectifiers sealant for laboratory equipment, dental alloys, vapor-arc lamps, and low-resistance contact electrodes.

Prices.—Market prices per gram of various-grade gallium from bauxite sources are shown in table 1.

Foreign Trade.—Unwrought gallium and waste and scrap imported since September 1, when a new system of reporting imports began, were 1 pound, valued at $486, from France; 16 pounds, valued at $7,000, from Switzerland; and 1 pound, valued at $606, from the United Kingdom. No data were available for gallium exports.

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[9] Gerken, J. M., and others. Development and Testing of Tungsten Emitters for Ion Propulsion Systems. U.S. Air Force (Thompson Ramo Wooldridge, Inc.), October 1962, 68 pp.; U.S. Dept. of Commerce, OTS, AD 292257.

[10] Carabateas, E. N., G. Miskolczy, and A. Wolpert. An Evaluation of Cesium Magnetic Triode. U.S. Air Force (Thermo Electron Engineering Corp.), June 1962, 125 pp.; U.S. Dept. of Commerce, OTS, AD 278844.

[11] Brodie, I., and A. Niewold. Feasibility of the Use of Hollow Cathodes for Thermionic Energy Conversion. U.S. Air Force (Westinghouse Electric Corp.), June 1962, 55 pp.; U.S. Dept. of Commerce, OTS, AD 278824.

[12] Clark, J. A., and others. Literature Survey on Liquid Metal Boiling. U.S. Air Force (Univ. of Michigan), October 1962, 156 pp.; U.S. Dept. of Commerce, OTS, PB 181478.

[13] Pratt & Whitney Aircraft Division of United Aircraft Corp. The Electrical Resistivity of Sodium, Potassium, Rubidium and Cesium in the Liquid State. U.S. Atomic Energy Commission, June 1962, 31 pp.; U.S. Dept. of Commerce, OTS, PWAC-376.

[14] Holland, J. W. Performance of Cesium Thermionic Diodes Operated in Series-Parallel Circuits. U.S. Atomic Energy Commission (Atomics International), February 1963, 33 pp.; U.S. Dept. of Commerce, OTS, NAA-SR-7661.

[15] U.S. Atomic Energy Commission. Liquid Metal Technology, A Literature Search, 1963, 131 pp.; U.S. Dept. of Commerce, OTS, TID-3544 (Rev. 1).

[16] Prepared by Donald E. Eilertsen.

TABLE 1.—Market prices of gallium from bauxite sources in 1963

(Per gram)

Quantity	99.99 percent	99.999 percent	99.9999 percent
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

Technology.—Research on gallium continued in many fields, especially in the development of semiconductors and alloys.

The Bureau of Mines continued its studies on extracting germanium and gallium from coal fly ashes and metallurgical flue dusts. Gaps in themodynamic information were filled for gallium sesquioxide.[17] References on the occurrence of gallium in coals were published.[18]

Patents were issued for methods to purify gallium by halogenation and electrolysis[19] and by recrystallization.[20] Other patents were issued relating to growing single crystals of corundum and gallium oxide;[21] producing gallium arsenide;[22] methods of fabricating PN junctions in gallium arsenide semiconductor material;[23] and manufacture of high-purity indium phosphide and gallium arsenide.[24]

The phase equilibrium diagram for the scandium sesquioxide-gallium sesquioxide system was determined.[25]

The use of radiotracers to determine the effectiveness of zone-refining purification of gallium trichloride in a sealed system was described.[26]

Comprehensive bibliographies on gallium through 1962 and for 1963 were published.[27]

GERMANIUM[28]

Production of germanium from primary sources in the United States continued to decrease. While factory sales of germanium

[17] Pankratz, L. B., and K. K. Kelley. Thermodynamic Data for Gallium and Scandium Sesquioxides. BuMines Rept. of Inv. 6198, 1963, 7 pp.
[18] Abernethy, R. F., and F. H. Gibson. Rare Elements in Coal. BuMines Inf. Circ. 8163, 1963, 69 pp.
[19] Hutter, Jean-Claude, and Andre Peyron (assigned to Pechiney, Compagnie de Produits Chimiques et Electrométallurgiques, Paris, France). Purification of Gallium by Halogenation and Electrolysis. U.S. Pat. 3,075, 901, Jan. 29, 1963.
[20] Harper, James G. (assigned to Texas Instruments Inc., Dallas, Tex.). Method of Purifying Gallium by Recrystallization. U.S. Pat. 3,088,853, May 7, 1963.
[21] Remeika, Joseph P. (assigned to Bell Telephone Laboratories, Inc., New York). Growth of Single Crystals of Corundum and Gallium Oxide. U.S. Pat. 3,075,831, Jan. 29, 1963.
[22] Johnson, Rowland E., and Edward W. Mehal (assigned to Texas Instruments Inc., Dallas, Tex.). Method of Producing Gallium or Aluminum Arsenides and Phosphides. U.S. Pat. 3,094,388, June 18, 1963.
[23] Fuller, Calvin S. (assigned to Bell Telephone Laboratories, Inc., New York). Treatment of Gallium Arsenide. U.S. Pat. 3,085,032, Apr. 9, 1963.
[24] Enk, Edward, Herbert Jacob, and Julius Nickl (assigned to Wacker-Chemie G.m.b.H., Munich, West Germany). Process for Manufacturing Indium Phosphide and Gallium Arsenide of High Purity. U.S. Pat. 3,077,384, Feb. 12, 1963.
[25] Schneider, S. J., and J. L. Waring. Phase Equilibrum Relations in the Sc_2O_3–Ga_2O_3 System. NBS J. Res., v. 67A (Phys. and Chem.), No. 1, January–February 1963 pp. 19–25.
[26] Kern, Werner. Zone Refining of Gallium Trichloride. J. Electrochem. Soc., v. 110, No. 1, January 1963, pp. 60–65.
[27] De La Breteque, Pierre, and French Aluminum Industry Research Institute of Marseille in collaboration with Swiss Aluminum Industry Research Institute. Gallium Propriétés Principales Bibliographie. June 1962, 378 pp. (in French, English, and German; Supplement (Gallium Bulletin Bibliographique), June 1963, 86 pp.
[28] Prepared by Donald E. Moulds.

semiconductors, diodes, and rectifiers exceeded the 1962 level, increased manufacturing efficiency and smaller devices resulted in a decrease in metal consumption. Inventories of germanium from primary sources and reprocessed scrap were abnormally high, and imports were curtailed to approximately 50 percent of the 1962 total.

Domestic Production.—An estimated 20,000 pounds of germanium was produced from primary materials of both domestic and foreign origin. The Eagle-Picher Co., Miami, Okla., and American Zinc Co., Fairmont, Ill., recovered germanium as a byproduct of domestic zinc refining. American Metal Climax, Inc., Carteret, N.J., and Sylvania Electric Products, Inc., Towanda, Pa., processed imported germanium-bearing raw materials. All of these refineries reprocessed scrap returned by the manufacturers. In addition, United Minerals and Chemical Corp., New Brunswick, N.J., and Penn Rare Metals, Inc., Revere, Pa., a division of Kawecki Chemical Co., recovered germanium from scrap reprocessing.

Consumption and Uses.—Germanium was used predominately in production of semiconductor devices. Production of these devices—transitors, diodes, rectifiers—increased substantially compared with 1962 output. The competition of silicon, however, resulted in a slightly lower percentage share of the sales. The quantity of germanium required per unit continued to decrease as the new centerless saw and other production techniques were applied to the manufacture of these devices. A small amount of germanium is used as a color modifier in fluorescent lights, in construction of infrared optical systems, and for various experimental purposes.

Prices.—The American Metal Market quoted price for first-reduction germanium, after remaining unchanged for 3 years at 28.15 cents per gram f.o.b. Miami, Okla., was reduced on March 28 to 26.65 cents delivered to buyer's plant. It was reduced again on October 25 to 25.20 cents. Price quotations, cents per gram, for the various grades in lots of 10 kilograms delivered to buyer's works at yearend follows:

Grade	Price (cents per gram)
First reduction	25.20
Intrinsic quality	27.00
Single crystal	56.00
Dioxide, high-purity	15.10

Foreign Trade.—Imports of germanium metal and germanium dioxide totaled 4,944 pounds valued at $284,000 compared with 9,217 pounds imported in 1962. Of the total, 4,762 pounds was from West Germany, 164 pounds from Canada, 17 pounds from the United Kingdom, and 1 pound from Belgium-Luxembourg. Germanium in concentrates was not imported from the Republic of South Africa during the year. Australia supplied 353 pounds of germanium material classified as waste and scrap.

World Review.—*Belgium.*—Société Generale Metallurgique de Hoboken and the Société Vieille-Montagne de Balen continued to refine germanium in concentrates and germanium dioxide produced in the Republic of the Congo.

Japan.—Refined germanium was produced from imported germanium dioxide and scrap, and byproduct material was recovered in the refining of base metal concentrates.

South-West Africa.—Germanium contained in copper concentrates and in complex lead concentrates previously exported for refining was processed to germanium dioxide. Production of the oxide amounted to about 4,500 pounds in 1963.

Technology.—Major research work on germanium was accomplished in the fields of semiconductors in the determination of behavior fundamentals,[29] controlled growth of germanium crystal in strips,[30] surface preparation,[31] and attachment of electrical contacts.[32]

Diversification of research in germanium has indicated applications in X-ray diffraction,[33] infrared transmission,[34] and other electrochemical fields. The Germanium Information Center, Kansas City, Mo., sponsored by several leading germanium producers, continued to encourage worldwide research and dissemination of information on germanium.

GREENSAND [35]

Domestic production of greensands (glauconite) dropped another 12 percent in 1962, while the value increased 9 percent. National Soil Conservation, Inc., was reported to have closed its operation. Average annual output for the 5-year period 1959–63 was 5,700 short tons valued at $214,000.

Of the quantity sold, 55 percent was used in soil conditioning and the balance for water softening. The prices ranged from $17 to $90 per short ton, f.o.b. mine.

Glauconite beds in the upper part of the Missoula Group of the Belt Series, Flathead County, Mont., were studied and dated at 1,070 million years by potassium-argon and rubidium-strontium analyses.[36] A more detailed mineralogic and geochronologic study of glauconite and related minerals of the Belt Series in Montana was in progress.

The Commonwealth Scientific and Industrial Research Organisation laboratory, Perth, Australia, was planning to examine the possibilities of developing glauconite deposits in Western Australia as a source of potash.[37]

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[29] Brown, Allan, and J. J. Norreys. The System Thorium-Germanium. J. Less-Common Metals (The Netherlands), v. 5, No. 4, August 1963, p. 302–313.
Miller, W. S., F. Dachille, E. C. Shafer, and Rustum Roy. The System GeO_2–SiO_2. Am. Mineralogist, v. 48, No. 9–10, September–October 1963, p. 1024–1032.

[30] Brissot, J. J., and H. Raymond. Growing of Single Crystal Germanium in Strips. Electrochem. Technol., v. 1, No. 9–10, September–October 1963, p. 304–307.
Nicholson, H., and J. W. Faust, Jr. Dendritic Growth of InSb. J. Electrochem. Soc., v. 110, No. 8, August 1963, p. 940–943.

[31] Hillegas, William J., Jr., and George L. Schmable. Plating of Metals on Semiconductors. Electrochem. Technol., v. 1, No. 7–8, July–August 1963, p. 228–237.
Lyon, Donald H. The X-Factor in Germanium. Western Elec. Eng., v. 7, No. 4, October 1963, p. 3–12.

[32] Faust, J. W., Jr. The Influence of Surface Preparation on Revealing Dislocations in Germanium. Electrochem. Technol., v. 1, No. 11–12, November–December 1963, p. 377–378.

[33] Okkerse, B. Consecutive Laue and Bragg Reflections in the Same Perfect Crystal. Philips Res. Repts., v. 18, No. 5, October 1963, p. 413–431.

[34] Cleek, Given W., and Edgar H. Hamilton (assigned to the Secretary of the Navy). Infrared Transmitting Glasses. U.S. Pat. 3,119,703, Jan. 28, 1964.
Roy, Rustum (assigned to Bausch & Lomb Inc., Rochester, N.Y.). Densification of Glass, Germanium Oxide, Silica or Boric Acid. U.S. Pat. 3,098,699, July 23, 1963.

[35] Prepared by Richard W. Lewis.

[36] Science. Glauconite From the Precambrian Belt Series, Montana. V. 140, No. 3565, Apr. 26, 1963, pp. 390–391.

[37] Fertiliser and Feeding Stuffs Journal (London). Possibility of Local Potash. V. 59, No. 12, Dec. 11, 1963, p. 459.

INDIUM [38]

Domestic Production.—American Smelting and Refining Company, Perth Amboy, N.J., was the only domestic producer of indium. This firm also had plant facilities to produce indium chloride and indium sulfate. Indium production was larger and shipments somewhat smaller than in 1962.

Uses.—Indium was used in electronic devices in a variety of ways, such as soldering lead wires to germanium transistors; a property-modifying component of the intermetallic semiconductor used for germanium transistors; utilization of the magnetorestrictive and photodetective properties of indium arsenide and indium antimonide; and an injection laser using indium phosphide as a semiconductor.

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.—Market prices for indium metal were $2.25 per troy ounce up to 100 troy ounces, $1.80 per troy ounce in 100-troy-ounce lots, $1.70 per troy ounce in 1,000-troy-ounce lots, and $1.60 per troy ounce for 5,000-troy-ounce lots.

Technology.—The boiling point of indium, its liquid range density, and other physical constants were determined by Temple University scientists under a National Science Foundation grant.[39] Superconductive properties of indium antimonide between 2.1° and 1.6° K are described.[40] Bulk densities of the pure metals and 14 compositions of the lead-indium system were accurately measured.[41]

Age-hardening behavior of copper-base alloys with 8.5 to 10.0 atomic percent indium, has been studied by measuring the mechanical properties and correlating the structure revealed by the electron microscope.[42] Laser action by an indium antimonide diode operated in a high magnetic field has been reported.[43] An evaluation of the wetting and dissolution of germanium by molten indium in transistor application was discussed.[44]

Translations of Soviet research on indium includes a study of vaporization of indium sulfide,[45] influence of indium on the electrical properties of germanium,[46] and a book on the analytical chemistry of indium.[47]

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[38] Prepared by H. J. Schroeder.

[39] American Metal Market. Temple University Researchers Determine New Data on High Purity Indium. V. 70, No. 46, Mar. 8, 1963, p. 14.

[40] Science. Indium Antimonide: Superconductivity of the Metallic Form. V. 139, No. 3561, Mar. 29, 1963, pp. 1301–1302.

[41] Journal of the Institute of Metals. The Densities of Lead-Indium Alloys. V. 91, pt. 10, June 1963, pp. 328–331.

[42] Corderoy, D. J. H., and R. W. K. Honeycombe. Age-Hardening in Cooper-Base Indium Alloys. J. Inst. Metals, v. 92, pt. 3, November 1963, pp. 65–69.

[43] Connolly, Ray. Magneto-Optical InSb Laser At Lincoln Lab Confirmed. Electronic News, v. 8, No. 402, Nov. 4, 1963, p. 41.

[44] Bergh, A. A., and L. H. Holschwandner. The Uniformity of the Wetting and Dissolution of Germanium by Molten Indium. J. Electrochem. Soc., v. 110, No. 8, August 1963, pp. 904–908.

[45] Rumyantsev, V., G. M. Zhitenava, and V. P. Kochkin. Volatility of Indium Sulfide. U.S. Dept. of Commerce, OTS, UCRL Trans. 787, 16 pp.

[46] Zhurkin, B. G., and V. S. Zemskov. Solubility of Indium and Antimony in Germanium and Their Influence On Certain Electrical Properties of Germanium. U.S. Dept. of Commerce, OTS, MDF Trans. Z–126, 4 pp.

[47] Busev, A. I. The Analytical Chemistry of Indium. Pergamon Press, Ltd., London, 1962, 288 pp.

A patent was granted on a solvent extraction process to produce high-purity indium.[48] Another patent provides a design for a single-crystal indium antimonide transistor.[49]

MEERSCHAUM [50]

There was no domestic production of meerschaum in 1963. Imports from Turkey and France, which supplied domestic demands, decreased 72 percent from the 1962 figures. The principal use for meerschaum (sepiolite) was in pipe bowls and cigar and cigarette holders.

Production of meerschaum in Turkey was 23,100 pounds compared with 181,280 pounds valued at $298,300 for 1962 and 100,870 pounds for 1961.

Meerschaum production in Tanganyika was 16 tons valued at $6,518. Output had decreased to 2,655 pounds in 1962 from 40,320 pounds in 1961. Tanganyika Meerschaum Corp., Ltd., at Arusha was successful in attempts to use small pieces of waste meerschaum. Tanganyika Geological Survey exploration revealed additional reserves at the Sinya mine.[51]

Some high-grade material from sepiolite deposits at El Bur, Somali Republic, may be of meerschaum quality.[52]

[48] Dyer, John Robert Jr. (assigned to The Indium Corporation of America, Utica, New York). Method for Purifying Metallic Indium. U.S. Pat. 3,093,475, June 11, 1963.

[49] Henneke, Harry L. (assigned to Texas Instruments, Inc., Dallas, Tex.). Indium Antimonide Transistor. U.S. Pat. 3,099,776, July 30, 1963.

[50] Prepared by Clarence O. Babcock.

[51] Bureau of Mines. Mineral Trade Notes. V. 57, No. 4, October 1963, p. 42.

[52] Mining Journal (London). Somali Republic. V. 261, No. 6696, Dec. 20, 1963, p. 583.

TABLE 2.—U.S. imports for consumption of meerschaum, by countries

Country	1954–58 (average)		1959		1960		1961		1962		1963	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
Austria									101	$275		
France			1,019	$471	2,566	$1,186	821	$380	1,063	557	723	$379
South Africa, Republic of	22	$79										
Turkey	11,626	19,699	6,304	15,862	38,998	28,274	80,373	54,624	67,954	56,832	18,691	23,112
Total	11,648	19,778	7,323	16,333	41,564	29,460	81,194	55,004	69,118	57,664	19,414	23,491

Source: Bureau of the Census.

RADIUM [53]

The use of radium and radium salts, as indicated by imports, was nearly as high in the first two-thirds of 1963 as it was in the entire year of 1962. The number of supplying countries was less than half that of the previous year, and prices were greatly reduced on much of the material.

Domestic Production.—No radium production was reported in the United States, the small domestic need being met solely by imported salts. The principal distributors for radium, its derivatives, and related compounds were Canadian Radium & Uranium Division, Canrad Precision Industries, Inc., New York, N.Y.; United States Radium Corp., Morristown, N.J.; and Radium Chemical Co., Inc., New York, N.Y., which obtains radium processed by the Belgian company Union Minière du Haut-Katanga from Congolese ores. A. Bruce Edwards, Bala-Cynwyd, Pa., acted as domestic sales representative for radium stocks held by Atomic Energy of Canada, Ltd.

Consumption and Uses.—The large number of artificially produced radioisotopes, readily available in increasing quantities at decreasingly low prices from industrial and Atomic Energy Commission facilities, is slowly replacing radium from the major applications which it has had in past years. This has been prompted by the realization that radium has certain inherent disadvantages such as radiotoxicity, complex series decay, tendency to nonuniform distribution of radium salts in applicators, and susceptibility to sealed-container rupture due to pressure buildup from radon, helium, and sometimes hydrogen and oxygen gases. Cobalt 60, thulium 170, and iridium 192 are being used for industrial radiography. Hydrogen 3 (tritium) and krypton 85 are substitutable for radium in luminescent compounds. Polonium-, plutonium-, and americium-activated materials have largely replaced radium in neutron sources, and polonium and americium are now used in static elimination equipment. Some physicians still use sealed radium sources for radiation therapy, but cobalt 60 is receiving special attention.

Prices.—New radium, usually as the sulfate, bromide, or chloride, was quoted by Steel at $16.00 to $21.50 per milligram of contained radium. Used surplus radium, recovered from old appliances, was sold for as little as $2.00 per milligram when in large quantities.

Foreign Trade.—In the first 8 months of 1963, radium and radium salts were imported from Canada, Belgium-Luxembourg, and the United Kingdom. Nearly 50 percent of the imports (over 90 percent of the total value) came from Belgium. The average unit price of the Belgian material was below the lowest market quotation for new radium. Of the 10 countries from which the United States received radioactive substitutes, Canada, the United Kingdom, and Belgium-Luxembourg were the most important, providing about 95 percent of the imports. Effective the last third of 1963, new tariff regulations provided for the incorporation of useful radioactive materials, including radium and radium salts, under a new classification recorded by millicuries and value. This new class includes radioisotopes such as cobalt 60 and carbon 14, as well as enriched uranium, but does

[53] Prepared by John G. Parker.

not include metals or compounds of natural uranium and thorium. Canada, the United Kingdom, Belgium-Luxembourg, France, and the Netherlands supplied these radioactive materials. Radium metal and alloys containing 311 milligrams of radium worth $6,590 were exported to Canada and Italy.

TABLE 3.—U.S. imports for consumption of radium salts, radioactive substitutes, and useful radioactive substances

Year	Radium salts [1]		Radioactive substitutes,[2] value (thousands)	Useful radioactive substances,[3] value (thousands)
	Milligrams	Value (thousands)		
1954–58 (average)	56,254	$813	[4] $521	
1959	32,967	518	1,145	
1960	23,333	364	1,394	
1961	12,947	185	1,509	
1962	46,962	700	1,732	
1963:				
Jan.–Aug	44,660	304	1,081	
Sept.–Dec.				$426

[1] Data no longer separately classified beginning Sept. 1, 1963, included with useful radioactive substances.
[2] Includes artificial radioactive isotopes that are not substitutes for radium.
[3] Due to changes in classification by the Bureau of the Census, Sept. 1, 1963, these include elements, isotopes, and compounds, except natural metallic thorium and uranium and their compounds.
[4] Due to changes in tabulating procedures by the Bureau of the Census, data known not to be comparable with other years.

Source: Bureau of the Census.

Technology.—Leakage of radon from certain household ceramic articles, including figurines and vases, created a concentration in house air two to three orders of magnitude higher than that in outside air. It was believed that these concentrations, added to those already existing in homes built of materials with more than 0.003 percent uranium, could be a serious health hazard due to the buildup in bone and lung of ingested alpha particles.[54]

Potentially hazardous sources of water for human consumption from aquifers contaminated by a high content of radium were discussed.[55] The need for proper health standards in working with Czech and Swiss luminous radioactive paints was stressed. Almost three-quarters of the radium in these paints, which contain up to 70 milligrams of radium 226 in 1 kilogram of paint, were separated within the first 2 hours from the luminophore by elution in a buffered solution at pH 3. The toxicity of the paints in peroral contamination was said to approach that of a solution of pure radium salts.[56]

Anomalous age determinations of certain uranium deposits in New Mexico were due to the low content of radium which had migrated outside the ore bodies, thereby affecting the radioactive equilibria upon which the age calculations are based.[57]

[54] Gabrysh, A. F., H. Eyring, O. H. Bezirjian, and J. H. Merrill. Decay Products of Radium in Ceramics and Their Interaction With Matter. Mat. Res. and Standards, v. 3, No. 11, November 1963, pp. 902–905.
[55] Scott, Robert C. Radium in Natural Waters in the United States. Radioecology, Reinhold Pub. Corp., New York, N.Y., and The American Institute of Biological Sciences, Washington, D.C., 1963, pp. 237–240; Nuclear Sci. Abs., v. 17, No. 20, Oct. 31, 1963, abs. 33568, p. 4482.
[56] Halík, J. Contribution to Radiotoxicity Estimation of Luminous Radioactive Paints. Pracovni Lekar., v. 15, December 1963, pp. 419–422 (in Czech); Nuclear Sci. Abs., v. 18, No. 7, Apr. 15, 1964, abs. 9828, p. 1316.
[57] Granger, Harry C. Radium Migration and Its Effect on the Apparent Age of Uranium Deposits at Ambrosia Lake, New Mexico. Geol. Survey Prof. Paper 475–B, 1963, pp. B60–B63.

RHENIUM [58]

Domestic Production.—A secondary byproduct, rhenium concentrate, was recovered entirely as a byproduct of molybdenite derived from Southwestern porphyry copper ores. Chase Brass & Copper Co., Inc., Waterbury, Conn. (a subsidiary of Kennecott Copper Corp.), and the Department of Chemistry, University of Tennessee, Knoxville, Tenn., were the only domestic producers of rhenium metal in 1963. Rhenium salts were produced by the Shattuck Chemical Co., Denver, Colo. Production, consumption, and shipments of domestic rhenium metal, alloys, and compounds were the highest ever reported.

Uses.—The most promising application of rhenium was as an alloying element for the refractory metals tungsten and molybdenum. These rhenium alloys have exceptionally good high-temperature strength properties and sufficient ductility to be formed at room temperature. Other applications of rhenium were in electrical contacts, thermocouples, catalysts, and coatings. One of the first commercial applications of rhenium was as a tungsten-3 percent rhenium alloy wire for flashbulb filaments which has a higher resistivity and faster ignition than does pure tungsten.

The Atomic Energy Commission (AEC) announced that it was using thin-walled tungsten-26 percent rhenium alloy tubing in advanced research reactors as thermocouples to measure temperatures up to 3,000° C.

Although less active than platinum, rhenium catalysts are more resistant to poisoning and are highly selective hydrogenation catalysts. Rhenium catalysts are being used in the U.S.S.R. for petroleum refining, but their qualities suit them best for small-scale organic reactions and hydrocracking.[59]

Prices.—Chase Brass & Copper Co., Inc., quoted the following prices for various rhenium materials, minimum order $50. Ammonium perrhenate (NH_4ReO_4), $425 per pound up to 5 pounds, and $400 per pound for larger quantities; potassium perrhenate ($KReO_4$), $395 per pound up to 5 pounds, and $370 per pound for larger quantities; first-grade rhenium powder, $650 per pound up to 1 pound, and decreasing prices to $580 per pound for lots of 20 or more pounds; and rhenium-sintered bar (melting stock), $800 per pound up to 1 pound and decreasing prices to $750 per pound for lots of 5 or more pounds. Also available were rhenium rod and wire and molybdenum-rhenium and tungsten-rhenium rod, wire, and sheet.

Foreign Trade.—*Imports.*—Small quantities of high-purity rhenium were imported from West Germany and the United Kingdom during 1963, principally for use in electronics applications. Rhenium imported from West Germany cost approximately $20 per pound less than domestic rhenium.

Resources.—Rhenium is recovered principally from molybdenite obtained from certain low-grade porphyry copper ores in which molybdenite itself is a byproduct. The rhenium content in molybdenite is so low that determinations are made on the concentrates rather than on

[58] Prepared by Richard F. Stevens, Jr.
[59] Chemical & Engineering News. Rhenium Finds Market as Alloying Element. V. 41, No. 40, Oct. 7, 1963, pp. 31–32.

the ores. In the United States the reserve of rhenium in copper ores is estimated at 200 tons. At 50 to 80-percent recovery, about 6 tons of rhenium could be produced annually if all presently recovered domestic byproduct molybdenite was treated. The free world reserve of rhenium from molybdenite is estimated at 360 tons. Additional resources of rhenium may become obtainable from other molybdenum, uranium, manganese, tungsten, zirconium, columbium, tantalum, and gadolinium ores.

Technology.—A Bureau of Mines report was published on the sources and methods of recovering rhenium. These studies described a procedure developed for recovering rhenium in the form of electrolytic flakes by electrowinning the metal from a solvent extraction strip solution of molybdenite.[60]

In cooperation with AEC, the Bureau of Mines investigated the effects of rhenium as a deoxidizing additive to zirconium during electron-beam melting. Research also is being conducted on the development of seamless tungsten-27 percent rhenium alloy tubing for use at elevated temperatures.

Studies conducted by Soviet scientists have indicated that small additions of rhenium (1 percent) considerably increase the corrosion resistance of stainless steels.[61] Technetium, a radioactive element created as a reactor and fission-product, has the same chemistry as its sister element, rhenium, and has also been used as a strong corrosion inhibitor in steels.[62]

The nuclear properties of rhenium offer potential as a reactor-shielding material for thermal neutrons. Tests disclosed that almost no thermal neutrons would penetrate a rhenium shield, while about 70 percent of the thermal neutrons would be transmitted through the same thickness of lead. Thus, significant weight savings would be obtained with a rhenium shield.[63]

The inherent brittleness of tungsten and molybdenum metals is reported to be inhibited and the ductility improved by alloying with 20 to 50 weight percent rhenium.[64]

Rhenium was studied as one of several metals in connection with high-temperature coatings and phase diagrams of columbium, tantalum, molybdenum, and tungsten.[65]

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[60] Churchward, P. E., and J. B. Rosenbaum. Sources and Recovery Methods for Rhenium. BuMines Rept. of Inv. 6246, 1963, 16 pp.

[61] American Metal Market. V. 70, No. 50, Mar. 14, 1963, p. 14.

[62] Nucleonics. Technetium in Quantity. V. 22, No. 4, April 1964, p. 86.

[63] Karam, R. A., T. F. Parkinson, and W. H. Ellis. Final Technical Report on the Nuclear Properties of Rhenium. Defense Documentation Center AD 402668, Mar. 1, 1963, 72 pp.

[64] Jaffee, R. I., and G. T. Hahn. Structural Considerations in Developing Refractory Metal Alloys. Defense Documentation Center AD 407394, Jan. 31, 1963, 30 pp.

[65] Dickinson, C. D., and L. L. Seigle. Experimental Study of Factors Controlling the Effectiveness of High-Temperature Protective Coatings for Tungsten. (Rept. prepared by General Telephone & Electronics Laboratories, Inc., Bayside, N.Y., for the U.S. Air Force) ASD-TDR-63-744. July 15, 1963, 42 pp.

English, J. J. Binary and Ternary Phase Diagrams of Columbium, Molybdenum, Tantalum, and Tungsten. Defense Metals Inf. Center, Battelle Memorial Inst. (Columbus, Ohio), DMIC Rept. 183, Feb. 7, 1963, 131 pp.

Ratliff, J. L., D. J. Maykuth, H. R. Ogden, and R. I. Jaffee. Further Development of Ductile Tungsten-Base Sheet Alloy. Defense Documentation Center AD 405857, May 8, 1963, 10 pp.

Schmidt, F. F., E. S. Bartlett, and H. R. Ogden. Investigation of Tantalum and Its Alloys. Defense Documentation Center AD 406757, May 1963, 128 pp.

Schmidt, F. F., and H. R. Ogden. The Engineering Properties of Tungsten and Tungsten Alloys. Defense Metals Inf. Center, Battelle Memorial Inst. (Columbus, Ohio), DMIC Rept. 191, Sept. 27, 1963, 133 pp.

Technetium, element 43, is closely related to rhenium in its chemistry and properties. Although technetium does not occur naturally in nature, a long-lived radioisotope, technetium 99, is recovered in relatively large proportions from the waste fission products of uranium and plutonium reactors.[66] The half life of technetium 99 is 2.12×10^5 years and the specific activity is 20 microcuries per gram.[67] Technetium is being studied as an alloying addition to tungsten to replace rhenium.[68] The slight beta radioactivity of technetium is shielded by alloying.

SCANDIUM [69]

Domestic Production.—American Scandium Corp., Newtown, Ohio, was the only producer of scandium metal in 1963. Production and shipments of the metal were small. Output figures are not available for publication.

Uses.—No new large use for scandium was reported. The principal use for scandium was in radioisotope tracers for application in oil-well drilling and in analytical work.

Prices.—Table 4 shows prices for various grades of scandium oxide as quoted by Vitro Chemical Co.

TABLE 4.—Prices for various grades of scandium oxide in 1963

Quantity	Purity of scandium oxide				
	50 percent	90–95 percent	99 percent	99.5 percent	99.8 percent
1 to 99 grams, per gram	----------	$1.83	$2.79	$3.14	$3.89
100 to 453 grams, per gram	$1.17	1.46	2.23	2.51	3.11
1 to 4 pounds, per pound	425.00	525.00	810.00	910.00	1,130.00
5 pounds and up, per pound	395.00	485.00	750.00	850.00	1,050.00

Technology.—The Bureau of Mines continued its research studies on developing methods to recover scandium from various source materials and on purification of scandium compounds. The entropy of scandium sesquioxide at 298.15° K was determined at 18.4±0.1 calories per degree-mole.[70] Heat-content values of scandium sesquioxide were measured over the temperature range 298° to 1,800° K, thus filling in gaps in thermodynamic information of this compound.[71]

Identification of thortveitite, $(Sc,Y)_2Si_2O_7$, in the Crystal Mountain fluorite deposit in Ravalli County, Mont., was the first such association reported for the Western Hemisphere.[72]

[66] Hogerton, John F. The Atomic Energy Deskbook. Reinhold Pub. Corp., New York, 1963, p. 542.
[67] Oak Ridge National Laboratory. Radio and Stable Isotopes. April 1963, 98 pp.
[68] Nucleonics. Space Contracts Boost Hanford's Diversification Effort. V. 22, No. 5, May 1964, p. 26.
[69] Prepared by Donald E. Eilertsen.
[70] Weller, W. W., and E. G. King. Low-Temperature Heat Capacities and Entropies at 298.15° K of the Sesquioxides of Scandium and Cerium. BuMines Rept. of Inv. 6245, 1963, 6 pp.
[71] Pankratz, L. B., and K. K. Kelley. Thermodynamic Data for Gallium and Scandium Sesquioxides. BuMines Rept. of Inv. 6198, 1963, 7 pp.
[72] Parker, Raymond L., and Raymond G. Havens. Thortveitite Associated With Fluorite, Ravalli County, Montana. Geol. Survey, Prof. Paper 475–B, 1963, pp. B10–B11.

A comprehensive report on the geochemistry and mineralogy of scandium was published.[73]

A method to produce high-purity scandium by electrolysis was patented.[74]

Studies on the scandium-yttrium and scandium-zirconium systems by thermal and X-ray methods were reported.[75] A phase equilibrium diagram for the scandium sesquioxide-gallium sesquioxide system was determined.[76]

Scandium, iron, and cobalt were readily extracted by solvent extraction from the thiocyanate solutions in contact with methyl isobutyl ketone as the organic solvent.[77]

SELENIUM [78]

Worldwide interest in selenium was emphasized by two events during the year. The Selenium-Tellurium Development Committee changed its name to Selenium-Tellurium Development Association, Inc., and the formation of the European Selenium-Tellurium Committee was initiated by Boliden Mining Co., Stockholm, Sweden; Norddeutsche Affinerie, Hamburg, West Germany; and Société Générale Métallurgique de Hoboken, Belgium.

Selenium remained in group I of the National Stockpile List of Critical and Strategic Materials. The Office of Minerals Exploration included selenium among minerals and mineral products eligible for government financial participation up to 50 percent of approved costs.

The U.S. Department of Agriculture revised the barter program February 13, 1963. U.S. firms were invited to submit offers for commercial-grade selenium produced from raw materials originating in free world countries, in exchange for Commodity Credit Corporation (CCC)-owned agricultural commodities for export to CCC-approved destinations.

Domestic Production.—Output of primary selenium was 928,000 pounds, 7 percent less than in 1962. No selenium was recovered from secondary sources in 1963 or 1962.

Companies reporting selenium production, shipments, and stocks during 1963 were American Metal Climax, Inc., Carteret, N.J.; American Smelting and Refining Company, Baltimore, Md.; International Smelting and Refining Co., Perth Amboy, N.J.; Kawecki Chemical Co., Boyertown, Pa.; and Kennecott Copper Corp., Magna, Utah. Kawecki Chemical is a manufacturing chemical company. The other four companies produced selenium as a byproduct of the electrolytic refining of copper.

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[73] Borisenko, L. F. Scandium, Its Geochemistry and Mineralogy. Consultants Bureau Enterprises Inc., New York, 1963, 78 pp. (English trans.).

[74] Vickery, Ronald C (assigned to Nuclear Corp. of America, Denville, N.J.). Production of Scandium and Yttrium. U.S. Pat. 3,111,467, Nov. 19, 1963.

[75] Beaudry, B. J., and A. H. Daane. The Scandium-Yttrium and Scandium-Zirconium System. Trans. AIME, v. 227 (Met. Soc.), 1963, pp. 865–868.

[76] Schneider, S. J., and J. L. Waring. Phase Equilibrium Relations in the Sc_2O_3–Ga_2O_3 System. NBS J. Res., v. 67A (Phys. and Chem.), No. 1, January–February 1963, pp. 19–25.

[77] Bautista, Renato G., and Robert A. Hard. Solvent Extraction of Transition Metals From Thiocyanate Solutions. Trans. AIME, v. 227 (Met. Soc.), 1963, pp. 124–130.

[78] Prepared by Arnold M. Lansche.

TABLE 5.—Salient selenium statistics

(Thousand pounds of contained selenium)

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Production [1]	922	728	539	1,022	999	928
Shipment to consumers	823	790	552	787	741	679
Imports for consumption	189	224	162	117	159	339
Consumption, apparent [2]	1,012	1,014	714	904	900	1,018
Stocks, Dec. 31, producers	313	339	273	515	773	1,022
Price per pound, commercial-grade	$6.55–$9.90	$7.00	$6.50–$7.00	$5.75–[3] $6.25	$5.75–$6.25	$4.50–$5.75
World: Production	1,772	1,650	1,671	[3] 2,095	[3] 2,131	2,110

[1] Includes small quantity of secondary selenium, 1954–61.
[2] Measured by shipments plus imports.
[3] Revised figure.

Consumption and Uses.—Shipments to consumers declined 9 percent compared with 1962 figures, but apparent consumption increased 13 percent.

High-purity selenium was used primarily in electronic applications, such as rectification of an alternating electric current.

Small quantities were used in xerography, photoluminescence products, glass, rubber, and alloy steel, and as a catalyst in resin preparation, oil and rosin treatment, and hydrocarbon processing.[79]

Stocks.—Producers' stocks of marketable-grade selenium on December 31 increased 32 percent over those of 1962. These stocks on hand at yearend were equal to requirements as reported by apparent consumption. Total Government-owned inventories were 404,000 pounds, 100.1 percent of the maximum objective. Inventories showed 97,000 pounds in the national (strategic) stockpile, 150,000 pounds in the CCC stockpile, and 157,000 pounds in the supplemental stockpile.

Prices.—The price of selenium at the start of 1963 was $5.75 to 6.25 per pound for commercial grade and $6.75 for the high-purity grade. Price changes during the year and the date of change follow:

Date:	*Commercial grade, 99.5 percent*	*High-purity, 99.99+ percent, f.o.b. shipping point*
January 15	$5.25 to $5.75	$6.25
February 8	5.00 to 5.50	6.00
February 15	4.50 to 5.00	5.50
February 19	------------	6.00
April 26	4.50	------------

The price of the two grades continued at $4.50 and $6.00, respectively, for the remainder of the year. Ultra-high-purity selenium (99.999+ percent) sold for $13 to $20 per pound; on the basis of contained selenium, ferroselenium was quoted at $4.50 per pound.

Foreign Trade.—Imports for consumption of selenium metal and compounds totaled 339,200 pounds. The selenium content of selenium compounds was not available. Total imports from Canada were 249,900 pounds valued at $1,170,200. Total imports from other coun-

[79] Kollonitsch, Valerie, and Charles H. Kline. Catalytic Activity of Selenium. Ind. and Eng. Chem., v. 55, No. 12, December 1963, pp. 18–26.

tries were Japan, 11,000 pounds; Norway, 21,000 pounds; Peru, 10,600 pounds; Sweden, 40,000 pounds; the United Kingdom, 4,500 pounds; and West Germany, 2,200 pounds.

World Review.—*Canada.*—Production of selenium declined less than 1 percent. It was a byproduct of the electrolytic copper refineries of The International Nickel Company of Canada, Ltd., Copper Cliff, Ontario, and Canadian Copper Refiners, Ltd., Montreal East, Quebec.

Belgium.—About 15 to 20 tons of selenium was recovered from anode slimes resulting from the electrolytic refining of copper. Copper-bearing raw materials were received principally from the Republic of the Congo.

Finland.—Output of selenium at Outokumpu Oy at Pori was up 31 percent.

Japan.—Selenium was removed from the lists of Export Approval Items on April 1. The official Japanese export cartel for selenium was ended on April 2. Uncertainty of selenium prices and increasing competition made the cartel agreement outmoded. Formed by 11 companies to prevent price cutting and to establish orderly export of the commodity, the selenium cartel came into existence in August 1958.

Japan exported 53 short tons of selenium metal in 1963 compared with 56 in 1962.

Japan exported about 1,500 pounds of selenium rectifiers to North Korea in the first half of 1963.

Mexico.—Selenium was a byproduct of lead flue dusts obtained at the American Smelting and Refining Company smelter at Chihuahua. The selenium was refined in the United States.

Peru.—Output of byproduct selenium increased 8 percent at the Cerro de Pasco Corp. Oroya electrolytic refinery.

Rhodesia and Nyasaland, Federation of.—Anode slimes (from the electrolytic refining of copper in Northern Rhodesia) containing selenium were shipped to Belgium and the United States for refining.

TABLE 6.—Free world production of selenium, by countries [1]

(Pounds)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	341,882	368,107	521,638	430,612	487,066	482,960
Mexico	126,475	8,891	6,944	5,642	6,953	6,336
United States	922,305	728,000	539,000	1,022,000	999,000	928,000
South America:						
Argentina	[2] 634	(3)	(3)	(3)	(3)	(3)
Peru	6,142	8,155	10,681	16,305	18,382	19,790
Europe:						
Belgium-Luexmbourg (exports)	56,218	124,560	72,531	51,808	29,542	[4] 52,900
Finland	8,764	13,196	11,358	13,296	11,797	15,417
Sweden	140,409	133,158	176,809	213,471	[4] 225,000	[4] 225,000
Asia: Japan	143,811	229,486	278,234	300,262	309,314	313,494
Africa: Rhodesia and Nyasaland, Federation of: Northern Rhodesia	22,432	33,448	50,119	38,292	40,526	62,891
Oceania: Australia	2,896	[4] 3,000	[4] 3,500	[4] 3,000	[4] 3,500	[4] 3,500
World total [1]	1,772,000	1,650,000	1,671,000	2,095,000	2,131,000	2,110,000

[1] This table incorporates a number of revisions of data published in previous Selenium chapters. Data do not add exactly to totals shown because of rounding.
[2] Average annual production 1955–58.
[3] Data not available; no estimate included in world total.
[4] Estimate.

Technology.—The formation of selenium sulfide globular inclusions in steel was given as the explanation for the improved machining performance of resulfurized leaded steels.[80] The selenium sulfide accumulations were said to act as the lubricant for the process. Tungsten diselenide was studied for possible use as a lubricant in outerspace vehicles.[81]

A quantitative analytical method was reported for determination of selenium gravimetrically, spectrophotometrically, and fluorometrically in biological materials.[82] Several patents were issued relating to selenium.[83]

The gradations in reactivity of organic oxygen, sulfur, and selenium compounds of equivalent structure were reviewed, and modern methods were described for the preparation of organoselenium compounds.[84]

Technical articles and reports concerning selenium and tellurium were compiled and abstracted.[85]

STAUROLITE [86]

Staurolite, an aluminum-iron silicate, was recovered in Clay County, Fla., by E. I. du Pont de Nemours & Co., Inc. in 1963 as a byproduct of processing Florida sands for production of titanium minerals. The staurolite was sold as a raw material for use in manufacturing portland cement, where it supplies needed alumina and iron. Production of staurolite declined 22 percent in quantity and 21 percent in value compared with that of 1962.

TELLURIUM [87]

World attention was more sharply focused on the very rare element tellurium by incorporation of the Selenium-Tellurium Development Committee into the Selenium-Tellurium Development Association, Inc., and formation of the European Selenium-Tellurium Committee.

The Office of Minerals Exploration included tellurium among minerals and mineral products eligible for Government financial participation up to 50 percent of approved costs. Tellurium is not included in the National Stockpile List of Critical and Strategic Materials.

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[80] Iron Age. Selenium Forms Lubricant. V. 191, No. 8, Feb. 21, 1963, p. 15.

Metal Progress. Selenium-Leaded Steels Cut Machining Time. V. 83, No. 3, March 1963, p. 11.

Steel. How Selenium Improves Steel. V. 152, No. 6, Feb. 11, 1963, p. 20.

[81] American Metal Market. Tungsten Diselenide Lubricant Under Study at Westinghouse. V. 70, No. 101, May 27, 1963, p. 20.

[82] Chemical & Engineering News. Methods Determine Selenium in Submicrogram Amounts. V. 41, No. 11, Mar. 18, 1963, pp. 45–46.

[83] Blakney, Robert M., Eugene Fuerst, Mortimer Levy, and John B. Wells (assigned to Xerox Corp., Rochester, N.Y.). Process for Treating Selenium. U.S. Pat. 3,077,386, Feb. 12, 1963.

Buchanan, Sylvester Clingman (Mineral El Cubo, Guanajuato, Mexico). Method of Recovering Selenium and/or Germanium From Their Ores. U.S. Pat. 3,090,671, May 21, 1963.

Yomiyama, Akira, and Shigeru Yonekawa (assigned to Asahi Kasei Kogyo Kabushiki Kaisha, Osaka, Japan). Method for Recovery of Selenium From a Selenium or Its Compounds—Enriched Solution. U.S. Pat. 3,084,994, Apr. 9, 1963.

[84] Gosselck, J. Some Aspects of the Chemistry of Organoselenium Compounds. Angew. Chem., v. 2, No. 11, November 1963, pp. 660–667.

[85] Battelle Memorial Institute (Columbus, Ohio). Selenium and Tellurium Abstracts 1963. V. 4, pp. 719–886.

[86] Prepared by James D. Cooper.

[87] Prepared by Arnold M. Lansche.

Domestic Production.—Production of tellurium decreased 24 percent compared with the 1962 figures. Output was a byproduct of electrolytic copper refining and lead refining, except for a small quantity recovered from scrap.

Companies reporting production, shipments, and stocks were American Metal Climax, Inc., Carteret, N.J.; American Smelting and Refining Company, Baltimore, Md.; International Smelting and Refining Co., Perth Amboy, N.J.; Penn Rare Metals, Inc., Revere, Pa.; Phelps Dodge Refining Corp., New York, N.Y.; and United States Smelting, Refining and Mining Co., East Chicago, Ind.

TABLE 7.—Salient tellurium statistics

(Thousand pounds of contained tellurium)

	1954–58 (average)	1959	1960	1961	1962	1963
United States:						
Production, primary and secondary	167	177	271	205	264	201
Shipments to consumers	177	257	228	231	233	134
Stocks, Dec. 31, producers	121	58	126	64	87	141
Imports, general	(1)	16	15	(1)	(1)	2
Price per pound, commercial grade	$1.63–$1.75	$1.65–$3.00	$3.00–$4.00	$4.00–$5.25	$6.00	$6.00
World: Production	190	255	380	[2] 375	[2] 396	316

[1] Data not available.
[2] Revised figure.

Consumption and Uses.—Shipments were 42 percent lower than in 1962. Consumption of tellurinm as additives in free-machining steels and for production of tellurium-copper alloys was below that of 1962. The quantity used in the ceramic, chemical, and rubber industries was down. The use of tellurium for thermoelectric devices declined.

Stocks.—Producers stocks of marketable-grade tellurium metal and compounds on December 31 were 141,000 pounds, 62 percent more than at the end of 1962.

Prices.—Commercial-grade tellurium (99.7 percent) was quoted at $6 per pound for the entire year. The 99.99-percent grade was quoted at yearend at $11 to $15 per pound, and the 99.999-percent grade at $21 to $30 per pound, depending on quantity.

Foreign Trade.—Imports for consumption of tellurium unwrought metal and compounds totaled 2,400 pounds, valued at $44,400. In the last quarter of 1963, Canada and the United Kingdom supplied 1,800 pounds and 50 pounds, respectively, of unwrought tellurium; and Canada supplied 500 pounds of tellurium compounds.

World Review.—*Canada.*—Tellurium production increased 28 percent over that of 1962. Tellurium was a byproduct of electrolytic copper refining at The International Nickel Company of Canada, Ltd., Copper Cliff, Ontario; and Canadian Copper Refiners, Ltd., Montreal East, Quebec.

Japan.—Tellurium was produced at the Osaka refinery, Mitsubishi Metal Mining Co., Ltd.; the Takehara refinery, Mitsui Mining & Smelting Co., Ltd.; and the Hitachi and Saganoseki refineries, Nippon Mining Co., Ltd.

Peru.—Tellurium was a byproduct at the Cerro de Pasco Corp. refinery at Oroya.

TABLE 8.—Free world production of tellurium, by countries [1]

(Pounds)

Country	1954–58 (average)	1959	1960	1961	1962	1963
North America:						
Canada	18,965	13,023	44,682	77,609	58,725	74,942
United States	166,515	177,000	271,000	205,000	264,000	201,000
South America: Peru	3,459	62,600	59,343	76,279	50,472	26,634
Asia: Japan	628	2,761	13,671	16,486	23,168	13,256
Free world total [1]	189,600	255,400	388,700	375,400	396,400	315,800

[1] This table incorporates a number of revisions of data published in previous Tellurium chapters. Data do not add exactly to totals shown because of rounding.

Technology.—Bureau of Mines reports of investigations in 1962 and 1963 included work done on volatilization studies and field tests for tellurium and selenium.[88]

Patents were issued on a process for purifying tellurium and on a method of making thallium telluride.[89] A process was developed to extract tellurium and selenium from copper refinery anode slimes by pressure leaching under oxidizing conditions in the presence of sodium hydroxide.[90] A paper was published that compared bismuth telluride thermoelectric cooling devices and mechanical refrigeration as to efficiency, size, cost, and utilization.[91]

It was reported that lead telluride thermoelectric elements produced about 0.5 watt of electric power by converting the heat from radioactive thulium 170 into electricity.[92] This telluride is said to be the most efficient converter of heat to electricity at low temperatures currently known.

THALLIUM [93]

Domestic Production.—American Smelting and Refining Company at Denver, Colo., was the only domestic producer of thallium. This firm produced more, consumed more, and shipped less of the metal than in 1962. The company's thallium sulfate production and shipments were smaller than in 1962.

Uses.—The largest use of thallium was as the sulfate, a poisonous rodenticide and insecticide. Thallium has a significant use in electronics, such as for thallium-activated sodium iodide crystals in photomul-

[88] Anderson, W. L., and H. E. Peterson. Determination of Tellurium. BuMines Rept. of Inv. 6201, 1963, 9 pp.
Batty, J. V., A. M. Poston, Jr., and H. L. Gibbs. Radioisotopes as Tracers in Volatilization Studies of Selenium and Tellurium. BuMines Rept. of Inv. 6004, 1962, 9 pp.
Niebuhr, Philip E., and Allan H. Macmillan. Field Test for Tellurium and Selenium. BuMines Rept. of Inv. 6006, 1962, 6 pp.

[89] Conn, John B. (assigned to Merck & Co., Inc., Rahway, N.J.). Process for the Purification of Tellurium. U.S. Pat. 3,091,516, May 28, 1963.
Rabenau, Albrecht Karl Heinrich Theodor (assigned to North American Philips Co., Inc., New York). Method of Making Tl_2Te_3. U.S. Pat. 3,096,287, July 2, 1963.

[90] Elkin, E. M., and P. R. Trembley (assigned to Canadian Copper Refiners, Ltd., Montreal, Quebec, Canada). Process for Separating and Recovering Selenium and Tellurium. Canadian Pat. 664,883, June 11, 1963.

[91] Crump, Ralph. Design-in Your Own Thermoelectric Cooling. Product Eng., v. 34, No. 19, Sept. 16, 1963, pp. 81–89.

[92] Lead Industries Association, Inc., New York. Lead, v. 27, No. 4, 1963, p. 7.

[93] Prepared by H. J. Schroeder.

tiplier tubes. Other uses of thallium were in low-melting alloys, in optical glass, and in glass seals for the protection of electronic components.

Technology.—A paper presented to the Association of German Metallurgists and Miners included information on occurrence and extraction of thallium.[94]

Thermodynamic properties of thallium compounds in crystalline state and partially in solution were described in a translation of a Soviet paper.[95]

A patent was granted for the use and method of preparation of a single phase of thallium telluride for a semiconductor material.[96]

WOLLASTONITE [97]

Wollastonite sales increased by 1 percent in volume and 2 percent in value in 1963. Essentially all of the high-quality wollastonite used in the United States was produced by Cabot Minerals Division of Cabot Corp from the Willsboro mine in Essex County, N.Y. A small amount was produced by Adirondack Development Corp. for experimental use from a large ore body near Lewis, N.Y. Wollastonite was produced by two firms in California for ornamental building stone.

Prices for wollastonite were quoted by Oil, Paint and Drug Reporter in 1963 as follows: Fine, paint-grade, bags, carlots, works, $41 per ton, less than carlots, $51 per ton; medium, paint-grade, bags, carlots, works, $29 per ton; less than carlots, ex warehouse, $39 per ton.

The wollastonite deposit at Lappeenranta, Finland, is one of only two deposits producing high-quality wollastonite in the free world. A description of the Lappeenranta deposit was published, including data on the geology of the area, description of the wollastonite and associated minerals, and discussion of possible methods of wollastonite formation. The wollastonite was apparently formed at relatively low pressure and at 600° to 700° C by contact metamorphism of a siliceous limestone with heat supplied by an underying granite magma.

The Lappeenranta deposit contains approximately 800,000 tons of wollastonite, of which about 200,000 tons could be recovered using present methods; 500,000 tons could be recovered by froth flotation. The present product is high in calcite and is not comparable in quality to the Willsboro, N.Y., material.[98] Production of wollastonite in Finland in 1963 was 2,200 short tons.

Pigment-grade wollastonite was an ingredient in a thermal insulating material patented in 1963.[99]

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[94] Kleinert, R. (Thallium, A. Rare Metal, A Co-Product.) Ztschr. Erzbergbau u. Metallhuettenwesen, v. 16, No. 2, 1963, pp. 67–76 (in German).
[95] Maslov, P. G. Thermodynamic Characteristics of Calcium, Gallium, Indium, and Thallium Compounds. Zhur. Obshchei (U.S.S.R.), v. 29, No. 5, 1959, pp. 1413–1423; trans. TVA 3870.
[96] Rabenau, Albrecht Karl Heinrich Theodor (Aachen, Germany) (assigned to North American Philips Co., Inc., New York). Semiconductor Tl_2Te_3 and Its Method of Preparation. U.S. Pat. 3,096.151, July 2, 1963.
[97] Prepared by James D. Cooper.
[98] Keeling, P. S. The Wollastonite Deposit at Lappeenranta (Willmanstrand), S. E. Finland. Trans. Brit. Ceram. Soc., v. 62, No. 10, October 1963, pp. 877–894.
[99] Taylor, W. C. (assigned to Owens-Corning Fiberglas Corp.). Thermal Insulating Materials and Method of Making. U.S. Pat. 3,116,158, Dec. 31, 1963.

YTTRIUM[1]

Increased sales of high-purity metal and oxide, as well as increased shipments of fabricated forms, were noted. The development of the use of yttrium in nodular iron showed little change, largely because of cost. Other research, however, has uncovered possible applications wherein cost is less of a factor.

Domestic Production.—Yttrium oxide production and refinement, mostly from monazite but including some extracted from euxenite, was increased about 40 percent. Shipments of high-purity oxide, worth over $350,000, were about 80 percent greater than in 1962.

Producers and refiners of the oxide were American Potash & Chemical Corp., Rare Earth Division, West Chicago, Ill.; Michigan Chemical Corp., St. Louis, Mich.; Research Chemicals Division, Nuclear Corporation of America, Phoenix, Ariz.; and Vitro Chemical Co., Chattanooga, Tenn.

Metal production and shipments by Lunex Co., Pleasant Valley, Iowa—the only known supplier in 1963—rose nearly 10 percent to about 38 pounds worth $11,000. Total metal production by other companies probably exceeded that of 1962. Dresser Products, Inc., Great Barrington, Mass., increased shipments of yttrium metal which it had fabricated from 27 grams in 1962 to 1,274 grams.

The Bureau of Mines Metallurgy Research Center, Reno, Nev., was the site of both processing and utilization research on yttrium metal. Ferroyttrium alloys were electrowon, high-purity yttrium metal was electrorefined, and physical tests were made to ascertain the useful qualities of the metal.

Uses.—Information from some of the firms processing and supplying yttrium in oxide or metal form indicated that the greatest usage was in nuclear applications and in electrical equipment, with some use in alloys. The most important established use for yttrium has been as a component of crystals used in transducer or transmitter microwave devices, usually as the well-known YIG (yttrium iron garnet). The need for very high purity yttrium for these applications is still comparatively small, and the only large potential use to date appears to be that in which yttrium in some form—perhaps as an yttrium misch metal—might serve in the commercial production of nodular iron. Advances in this direction have been held up, however, by the unavailability of satisfactory yttrium-bearing materials at a generally acceptable low price. Nevertheless, recent research in iron nodularization has given further indications of the value of yttrium in controlling subversive effects of other elements present.

The relatively high melting point and low neutron capture cross section of yttrium indicate its value as a container material for molten fuel in advanced nuclear reactor concepts. The low cross-section value of the oxide and its complete solid solubility with uranium oxide may permit its use as a diluent in nuclear fuels. Because of its high melting point, yttria (yttrium oxide) may be used as a protective refractory coating. Also, in special refractories, yttria in solid solution with zirconia (zirconium dioxide) stabilizes the cubic structure.

[1] Prepared by John G. Parker.

The high resistance of yttrium to hydrofluoric acid suggests its use as a structural material in fluoride processing. As an additive, yttrium acts as a scavenger and makes vanadium ductile, promotes grain refinement in certain ferrous alloys, and restricts oxidation and reduces nitrogent absorption in chromium.

Prices.—High-purity yttrium oxide was available in 10-gram lots at prices ranging from 20 cents per gram for 99-percent-pure material up to $1 per gram for 99.9999-percent-pure material. A large processor quoted somewhat higher prices for similar material. The marketing emphasis was on multipound-size lots, however, and the largest concern quoted prices of $30 per pound for production-grade yttrium oxide in lots of 50 to 99 pounds. This same company listed high-purity oxides, ranging in purity from 99 to 99.9999 percent, at $50 to $295 per pound in lots from 2 to 99 pounds. Another company offered 99-percent-pure oxide at $45 per pound in 10-pound lots with higher purity oxides almost 10 to 20 percent cheaper than the comparable products listed above. Salts, usually sulfates, chlorides, nitrates, and oxalates, cost 20 to 50 percent less than oxides of comparable grade.

New lists quoted by American Metal Market showed pound prices for yttrium metal or alloy produced by two firms. In one case, 99.9+ percent pure metal sold for $325 per pound in lots from 1 to 25 pounds. Yttrium-magnesium alloy prices from the two companies varied widely. Ingots of 99-percent purity in 10-pound lots were listed at $180 per pound by another producer. Higher purity metal in sponge and ingot form, of comparable size lots, was listed by two refiners at $270 to $325 per pound. Minimum lot sizes of metal were 10 grams, or a minimum monetary value, usually $25, was required.

Technology.—Scientists of the Bureau of Mines collected thermochemical data on yttrium metal, described a technique for determining heat content values, and used amine extractants in solvent extraction methods under carefully selected operating conditions. Vacuum-distilled yttrium halide feed materials were reduced by alkali or alkaline-earth metals to easily workable high-purity metal.[2]

Dialkyl phosphoric acid was used to extract heavier rare-earth metal values, including yttrium, from an acidified aqueous solution. The resulting organic phase, enriched in yttrium, was contacted with a 5 to 6 normal aqueous mineral acid. Then a water-soluble thiocyanate was incorporated into the aqueous strip solution and a solvent such as trialkyl phosphate or an alkyl phosphonate was used to extract the heavier rare-earth metal values, leaving the yttrium values in the aqueous strip solution.[3] Another method was disclosed for separating yttrium from rare-earth metals of the terbium group. Addition of an aqueous solution of potassium hydroxide and ammonium hy-

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[2] Bauer, D. J., and A. C. Rice. Yttrium Behavior in Rare-Earth-Amine Extraction Systems and Effect of Sequestrants. BuMines Rept. of Inv. 6242, 1963, 16 pp.
Mussler, R. E., T. T. Campbell, F. E. Block, and G. B. Robidart. Metallothermic Reduction of Yttrium Halides. BuMines Rept. of Inv. 6259, 1963, 21 pp.
Welty, James R., Charles E. Wicks, and Herbert O. Boren. Thermodynamic Properties of Yttrium Metal and Iron Pentacarbonyl at High Temperatures. BuMines Rept. of Inv. 6155, 1963, 10 pp.

[3] Peppard, Donald F., and George W. Mason (assigned to the U.S. Atomic Energy Commission). Process for Separating Yttrium From the Rare Earths by Solvent Extraction. U.S. Pat. 3,110,556, Nov. 12, 1963.

droxide precipitated most of the terbium group ions from an ore digestion solution, leaving yttrium in the solution.[4]

Yttrium metal was electrowon and mechanically separated from a melt consisting of an oxide feed material and a sodium double fluoride of the metal.[5] High-purity yttrium metal containing less than 150 parts per million oxygen and less than 1,000 parts per million total impurities was produced by distilling at 2,000° to 2,200° C. The physical and chemical properties compared favorably with those described in previous literature, and the metal was easily cold-rolled into thin sheets.[6]

Measurement of magnetic and electrical properties dictated a need for large single crystals of yttrium and heavy rare-earth metals. Yttrium crystals were produced in arc-melted buttons by annealing from 1,100° to 1,350° C in 50° increments, maintaining each heating step for 8-hours.[7]

Single-crystal techniques were used to determine the structure of YCu_2. The parameters of its body-centered orthorhombic structure agreed closely with those described previously; the material had a calculated X-ray density of 6.62 grams per cubic centimeter.[8]

Yttrium phosphide, prepared by heating a mixture of yttrium filings and red phosphorus in a vacuum for 30 hours, had a cubic structure; the lattice constant was 5.661 angstrom units. This was nearly identical with that determined for the original synthesis several years ago. The investigators believed the compound had homeopolar and metallic bonding because the measured constant was smaller than that calculated for ionic radii.[9]

X-ray and differential thermal studies were used to show the purity of yttrium vanadate prepared from 99.9-percent-pure yttrium oxide and vanadium pentoxide at 950° C. The vanadate had a high thermal stability, not showing any detectable change at 1,600° C.[10]

Thermal and X-ray investigations of the scandium-yttrium system showed complete solid solubility for the low-temperature hexagonal (α) form and for the high-temperature (β) body-centered cubic form. The minimum in the solidus is at 50 atomic percent yttrium and 1,365° C, and the α form changes to β at 43 atomic percent yttrium and 1,175° C.[11] Seven compounds, including three with congruent melting points, exist in the yttrium-zinc system. One of the former compounds—YZn_2 in the two-phase region YZn-YZn_2—shows an allotropic transformation from α to β at about 750° C, but has a lower transformation point where it exists at higher zinc concentrations.[12]

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[4] Bril, Kazimierz Jozef and Pawel Krumholz. Process for Separating Yttrium and Rare Earths. U.S. Pat. 3,078,142, Feb. 19, 1963.

[5] Vickery, Ronald C. (assigned to Nuclear Corporation of America, Denville, N.J.). Production of Scandium and Yttrium. U.S. Pat. 3,111,467, Nov. 19, 1963.

[6] Habermann, C. E., and A. H. Daane. The Preparation and Properties of Distilled Yttrium. J. Less-Common Metals (Amsterdam, Netherlands), v. 5, No. 2, April 1963, pp. 134–139.

[7] Nigh, H. E. A Method for Growing Rare-Earth Single Crystals. J. Appl. Phys., v. 34, No. 11, November 1963, pp. 3323–3324.

[8] Kejriwal, Prabhat K., and Earle Ryba. The Crystal Structure of YCu_2. Acta Crys. (Short Comm.), v. 16, pt. 8, Aug. 10, 1963, p. 853.

[9] Parthé, Erwin, and Edda Parthé. Note on the Structure of Scp and YP. Acta Crys. (Short Comm.), v. 16, pt. 1, Jan. 10, 1963, p. 71.

[10] Gambino, J. R., and C. J. Guare. Yttrium and Rare Earth Vanadates. Nature (London), v. 198, No. 4885, June 15, 1963, p. 1084.

[11] Beaudry, B. J., and A. H. Daane. The Scandium-Yttrium and Scandium-Zirconium System. Trans. AIME, v. 227 (Met. Soc.), 1963, pp. 865–868.

[12] Chiotti, P., J. T. Mason, and K. J. Gill. Phase Diagram and Thermodynamic Properties of the Yttrium-Zinc System. Trans. AIME, v. 227 (Met. Soc.), 1963, pp. 910–916.

Yttrium metal surfaces were protected from oxidation by coating with a suspension of a fritted glass mixture and firing. The frit was composed of ground phosphate-base and silicate-base glass mixtures to which 5 to 35 percent by weight of cerium dioxide had been added.[13]

As protection against certain corrosive atmospheres or vapors, yttrium-tungsten metallizing mixtures coated on high-purity alumina bodies were found to have excellent adherence and to contribute increased tensile strengths to the bodies. It was found, also, that yttrium could be used as an intermediate active metal layer in forming a metallurgical bond between yttria and rhenium, thereby making the product usable at 2,000° C.[14]

Yttrium oxide formed part of a solid ceramic electrolyte in a new fuel cell using hydrogen as a fuel. Developed under Air Force auspices for use in a space environment, this small prototype cell of simple construction is not affected by gravity, delivers the equivalent of 150 watts per pound, and operates at 780 amperes per square foot of cell area.[15]

Barium titanate doped with yttrium formed a new class of ceramic conductors, thermally sensitive resistors (thermistors) having large positive temperature coefficients of electrical resistance. Because their sensitivities to temperature changes are at maxima within specific temperature ranges, thermistors with the proper physical parameters may find use as switches in thermal protection of polyphase induction motors and in current and voltage limiters.[16]

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[13] Wilder, David R., and Cecil Denton Wirkus (assigned to the U.S. Atomic Energy Commission). Oxidation-Resistant Coating on Articles of Yttrium Metal. U.S. Pat. 3,109,752, Nov. 5, 1963.

[14] Bendix Corporation, Red Bank Division. Ceramic to Metal Seals for High-Temperature Thermionic Converters. Contract AF 33(657)–10038, 3d Quarter Tech. Rept., Apr. 1–June 30, 1963, Defense Documentation Center AD 410101, July 15, 1963, 44 pp.

[15] American Metal Market. V. 70, No. 201, Oct. 17, 1963, p. 12.

[16] Ichikawa, Y., and W. G. Carlson. Yttrium-Doped Ferroelectric Solid Solutions With Positive Temperature Coefficients of Resistance. Am. Ceram. Soc. Bull., v. 42, No. 5, May 7, 1963, pp. 312–316.

INDEX

The index consists of two parts: A commodity index and a company index. Because nearly all commodity chapters in Minerals Yearbook, volume I, follow a standard outline (Introductory Summary, Domestic Production, Consumption and Uses, Stocks, Prices (and specifications), Foreign Trade, World Review, World Reserves, and Technology), references to such data have been omitted under the various headings.

Readers seeking information on mine production for States, Territories, or possessions should refer to tables in the Statistical Summary chapter, starting on page 129. These tables show the commodities produced in each area, thus guiding the reader to the appropriate commodity chapters. For complete area information, however, the reader should refer to volume III.

Commodity Index

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