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The U.S. Department of Agriculture reported that the addition of sulfur to many soils in the South was necessary to maintain or increase crop growth. Results of experiments at 24 locations in 7 States indicated that crop yields would decrease on 63 percent of the soils tested in 7 years or less if sulfur were not added. Supplementary sulfur increased yields in 15 of 22 experiments with cotton, forage, and tobacco. It was concluded that sulfur in rainwater, atmosphere, insecticides, and fertilizers could not meet crop needs in the area studied.<sup>35</sup>

One of the findings of the Nebraska Agricultural Experiment Station was that there were only slight variations in effectiveness between elemental sulfur and calcium sulfate as sulfur sources for soils, when particle size and placement were optimum for both. Elemental sulfur particle size should be less than 0.1 millimeter diameter for best results.<sup>36</sup>

<sup>35</sup> Jordan, Howard V. Sulfur as a Plant Nutrient in the Southern United States. U.S. Dept. of Agriculture Tech. Bull. No. 1297, February 1964, 45 pp.

<sup>36</sup> Sulphur Institute News. Nebraska Research Results Reported. V. 4, No. 1, January-February 1964, p. 1.

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# Sulfur and Pyrites

BY PAUL M. AMBROSE





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

BUREAU OF MINES • Frank C. Memmott, Acting Director

This publication is a chapter from the current Bureau of Mines Minerals Yearbook, comprising *Volume I, Metals and Minerals (Except Fuels)*; *Volume II, Mineral Fuels*; *Volume III, Area Reports: Domestic*; and *Volume IV, Area Reports: International*. Individual chapters from all four volumes and the separate volumes of the Yearbook are sold by the Superintendent of Documents, Washington, D.C., 20402.

concentrated in wet magnetic separators. A flow sheet with typical balances was published.<sup>26</sup> Innovations of the process were given.<sup>27</sup>

Control of the tensile strength of sulfur by regulating the time-temperature history of sulfur is possible. If molten sulfur is held at 187° C for 2 hours and cooled rapidly, a large percentage of the solid mass is amorphous sulfur with a tensile strength of 400 to 600 psi. If cooled slowly most of the sulfur will be the orthorhombic form with a tensile strength of 40 to 60 psi. These data explain why recovered sulfur is more difficult to grind than Frasch sulfur and suggest that amorphous sulfur would have less dust loss in handling.<sup>28</sup>

Pellets or large granules of sulfur were made by dropping molten sulfur from nozzles into swirling water. The sulfur droplets began to solidify on contact with the water and were forced downward in a spiral path. A recycling system forced water into the cooler at different levels. The pellets with a specific gravity of 2.1 were formed from molten sulfur with a specific gravity of 1.8.<sup>29</sup>

The Alberta Research Council developed a technique for producing foamed sulfur. When sulfur was heated beyond the melting point and foam-inducing agents added, the sulfur remained in the foamed state when solidified. The purpose was to decrease density so that transportation by pipeline (in suspension) would be easier.<sup>30</sup>

A low-cost sulfur foam that may compete with urethane and polystyrene for certain purposes is reported to have been developed by Southwest Research Institute. The foam could be used at temperatures up to 230° F, was lightweight and strong, had low shrinkage, and did not absorb much water.<sup>31</sup>

Sulfur-impregnated fiber pipes were made by depositing fiber from a water slurry on a rotating mandrel, drying, and impregnating with liquid sulfur. The dried pipes were placed in a closed heated vessel and the pressure reduced. Liquid sulfur was pumped into the vessel with the pipe under reduced pressure. The dried pipe would absorb from 50 to 500 percent by weight of sulfur. The optimum range was found to be 200 to 400 percent in making a pipe satisfactory, after cooling, for use as underground or drainage pipes.<sup>32</sup>

The need to include sulfur as a plant nutrient in fertilizer was emphasized, and desirable ratios of other plant foods to sulfur were expressed. The use of elemental sulfur and soluble sulfur compounds was discussed as well as the requirements of certain crops for sulfur.<sup>33</sup> The behavior of elemental sulfur in acid-rock mixtures during the preparation of concentrated superphosphate, and the distribution of sulfur in the final product were discussed.<sup>34</sup>

<sup>26</sup> Engineering & Mining Journal. First Commercial Magnetic Roasting Plant Utilizes Fluid Bed Reactors. V. 165, No. 11, November 1964, pp. 104-107.

<sup>27</sup> Vaccari, Italo, Pierluigi Salle, and Angelo Morra (assigned to Montecatini Società Generale per l'Industria Mineraria e Chimica). Process for Treating Iron Pyrites. U.S. Pat. 3,160,496, Mar. 27, 1962.

<sup>28</sup> Chemical & Engineering News. Concentrates. V. 42, No. 29, July 20, 1964, p. 35.

<sup>29</sup> Chemical Age. Pellet Process Eases Sulphur Transport. V. 92, No. 2371 and 2372 (combined issue), Dec. 19 and 26, 1964, p. 941.

<sup>30</sup> Chemical Engineering. V. 71, No. 7, Mar. 30, 1964, p. 31.

<sup>31</sup> Product Engineering. Developments to Watch. V. 35, No. 22, Oct. 26, 1964, p. 68.

<sup>32</sup> Chemical Trade Journal and Chemical Engineer (London). Sulphur Impregnated Fibre Pipes. V. 154, No. 4012, May 1, 1964, p. 626.

<sup>33</sup> Bixby, David W., Samuel L. Tisdale, and Delbert L. Rucker. Adding Plant Nutrient Sulphur to Fertilizer. The Sulphur Institute, Tech. Bull. No. 10, October 1964, 41 pp.

<sup>34</sup> Wiczorek, G. A., A. V. Breen, and J. O. Hardesty. Addition of Sulfur to Concentrated Superphosphate. Farm Chemicals. V. 127, No. 12, December 1964, pp. 24-32.

vanadate provided oxygen for the oxidation of hydrogen sulfide ( $H_2S$ ) to sulfur and water. Sodium metavanadate with sodium salts of anthraquinone resulted in the production of sulfur from coke oven or coal gas. Cost data were given for several different sized plants with assumed recoveries of 95 percent and 98 percent from gases containing 1 percent  $H_2S$ . A flow sheet was given.<sup>20</sup> A British patent was issued on a process for recovering sulfur from  $H_2S$  and sulfur dioxide ( $SO_2$ ). Ammonium thiosulfate was formed when the gas reacted with aqueous ammonia. It in turn reacted with  $H_2S$  to form sulfur.<sup>21</sup> The latter process for recovery of sulfur from gases containing  $H_2S$  was reported to be in use in Canada in a plant owned by Canadian Industries Ltd., Montreal, Quebec. Enough sodium hydroxide was added to bring the pH to 9. The reaction products were hydrogen peroxide and sulfur.<sup>22</sup>

A patent was granted for recovering sulfur from beds of elemental sulfur by partial combustion. The resulting molten sulfur could be pumped to the surface. Sulfur dioxide was also recovered.<sup>23</sup>

Pyrite or pyrrhotite could be roasted in a series of individual beds, each maintained at a depth of 20 to 35 cm and provided with separate supplies of gas containing oxygen. Roaster gases containing sulfur dioxide ( $SO_2$ ) were withdrawn from each bed.<sup>24</sup> A similar procedure was used at Anglo-Vaal's Hartebeestfontein Gold Mining Co., Ltd., Transvaal, Republic of South Africa, to produce 10 percent  $SO_2$  gas which was converted to sulfuric acid by autoxidation. The pyrite could be concentrated to 45 percent  $FeS_2$ , but it was difficult to control the bed depth with this grade of concentrate. For easier operations the assay value was maintained at about 40 percent  $FeS_2$ . Solids and gas were separated in a cyclone separator. The gases were further cleaned and cooled to 100° to 130° F. in a three stage gas scrubber before being mixed with air and fed to the autoxidation cells.<sup>25</sup>

The first commercial magnetic roasting of pyrites was being done by Montecatini Soc. Generale per l'Industria Mineraria e Chimica of Italy in a plant at Follonica in central Italy. The plant had a capacity to roast 1,000 metric tons per day of pyrite to produce magnetite and sulfur dioxide ( $SO_2$ ). It was planned to double the capacity of the plant and produce 1,100 tons per day of 65 percent iron pellets, 2,200 tons per day of sulfuric acid, and 700,000 kw per day of electric power using steam recovered from waste heat boilers and from cooling coils at the discharge of the fluosolids roasters. Iron sulfides were roasted to hematite and  $SO_2$  at 900° to 950° C. Excess air was used to cut down on the sulfur in the calcine. Magnetic roasting of the hematite, with fuel oil, was done at 675° C. The bottom discharge of the fluosolids magnetic roaster was treated by dry magnetic separation. Dust was collected in cyclones, water quenched, and the iron was con-

<sup>20</sup> Ellwood, Peter. Metavanadates Scrub Manufactured Gas. Chem. Eng., v. 71, No. 15, July 20, 1964, pp. 128-130.

<sup>21</sup> Chemical Trade Journal and Chemical Engineer (London). Removal of Hydrogen Sulphide and Sulphur Dioxide from Waste Gas. V. 154, No. 4017, June 5, 1964, p. 825.

<sup>22</sup> Chemical Engineering. V. 71, No. 16, Aug. 3, 1964, p. 86.

<sup>23</sup> Miller, W. S. Burning Process for Recovering Sulfur from the Earth. U.S. Pat. 3,131,914, May 5, 1964.

<sup>24</sup> Engineering and Mining Journal. Recovering Coarse-grained Roasted Ore. V. 165, No. 4, April 1964, p. 204.

<sup>25</sup> Mining Magazine (London). Pyrite Roaster Plant. V. 110, No. 6, June 1964, pp. 412-413.

## Sulfur and Pyrites

By Paul M. Ambrose<sup>1</sup>



**T**HE SULFUR industry in 1964 was marked by the initiation of transoceanic shipments of liquid sulfur, an increase in the price of sulfur, and a worldwide increase in demand that grew faster than production.

Deliveries of liquid sulfur started in 1959; in 1964, about 90 percent of shipments of domestic sulfur was in liquid form. The first shipment (25,350 tons) of liquid sulfur overseas in May was delivered by the Sulphur Export Corp. (Sulsexco) in the *Naess Texas* from Beaumont, Tex., to Rotterdam, Netherlands. Later in the year Sulsexco acquired the services of the sister ship the *Naess Louisiana*. At the end of 1964 there were 8 ships, with a combined capacity of 139,300 tons, carrying molten Frasch sulfur to North American and European markets. Other ships were planned to start operating in 1965 and 1966. Liquid sulfur from Lacq, France, was transported in railway cars to Bayonne and delivered by an 11,000-ton ship to Rouen, France, Immingham, England, and to Rotterdam, Netherlands.

Prices of sulfur increased \$2 per ton during the year.

After several years of overproduction of Frasch sulfur in the United States, a near balance between production and shipments was reached in 1963 when 4.88 million tons was produced and 4.99 million tons was shipped. In 1964, domestic production increased to 5.23 million tons while shipments were 5.86 million tons. At the same time stocks of Frasch sulfur in Mexico and of recovered sulfur in Canada were being decreased.

In the United States production of recovered sulfur started in 1943 and was more than 1 million tons in 1964.

<sup>1</sup> Commodity specialist, Division of Minerals.

**TABLE 1.—Salient sulfur statistics**  
(Long tons, sulfur content)

	1955-59 (average)	1960	1961	1962	1963	1964
United States:						
Production.....	5,429,617	5,037,292	5,477,493	5,025,418	4,881,927	5,228,365
All forms.....	6,831,537	6,660,541	7,172,479	6,757,211	6,643,802	7,092,734
Imports, pyrites and sulfur.....	558,786	884,838	966,417	1,185,073	* 1,460,680	<sup>1</sup> 1,582,211
Exports, sulfur.....	1,628,389	1,786,543	1,596,043	1,553,986	1,612,637	1,928,092
Stocks Dec. 31: Producer, Frasch and recovered sulfur.....	4,101,193	3,777,799	4,813,521	4,934,238	4,682,496	4,402,905
Consumption, apparent, all forms <sup>2</sup> .....	5,620,700	5,862,000	5,893,000	6,243,600	* 6,607,000	7,084,000
World: Production:						
Sulfur, elemental.....	8,683,000	* 10,400,000	* 11,500,000	* 12,000,000	* 12,600,000	13,800,000
Pyrites.....	7,620,000	* 8,900,000	* 8,700,000	* 9,000,000	* 9,000,000	9,000,000

\* Revised.

<sup>1</sup> Includes estimated 120,000 tons of sulfur in pyrites imports.

<sup>2</sup> Measured by quantity sold, plus import, minus exports.

## DOMESTIC PRODUCTION

**Native Sulfur.**—The 10 Frasch process mines in operation in 1964 were the 4 mines of Freeport Sulphur Co. at Grand Ecaille, Garden Island Bay, and Lake Pelto in Louisiana, and Grand Isle, 7 miles off the Louisiana coast in the Gulf of Mexico; 4 mines of Texas Gulf Sulphur Co. at Newgulf, Fannett, Moss Bluff, and Spindletop in Texas; 1 mine of Duval Corp. at Orchard Dome, Tex.; and 1 mine of Jefferson Lake Sulphur Co. (merged with Occidental Petroleum Corp. during the year), at Long Point Dome in Texas.

Production of 155,550 tons by the Duval Corp. at Orchard Dome was 18,450 tons less than in 1963 because of the lower sulfur content of the formation mined during the year. An increase in the domestic market absorbed most of the 25-percent increase in sales.<sup>2</sup>

Production and sales by Freeport Sulphur Co. were the highest in the company's history. Approximately 2.75 million tons were produced from the four mines. This production was only 50,000 tons less than the sales of 2.8 million tons. Except for temporary shut-downs during Hurricane Hilda, production might have been greater than sales. Melting equipment was provided at Joliet, Ill., so that the 200,000-ton stockpile of solid sulfur could be marketed in the liquid state if needed. About one-fourth of Freeport's sulfur was sold overseas. Additional barges were acquired to service inland waterway system markets and arrangements were made in 1964 for an ocean-going tanker, the SS *Louisiana Brimstone*, to supply coastal terminals from Florida to Maine.<sup>3</sup>

Production of sulfur by Texas Gulf Sulphur Co. was more than 2.4 million long tons in 1964. Frasch processed sulfur was the major source of production but facilities for the recovery of sulfur from sour natural gases were increased. Sulfur recovery plants were operated at Worland, Wyo., and at Okotoks and Whitecourt in Alberta, Canada. Capacity was increased from 725 to 1,225 tons per day at the

<sup>2</sup> Duval Corp. Annual Report 1964, p. 4.

<sup>3</sup> Freeport Sulphur Co. Annual Report 1964, pp. 4, 6, 8.

year in the period 1970-75.<sup>13</sup> Construction, expected to be completed in 1964, included the preparation of access roads and railway sidings and the sinking of 100 drainage wells. Development was to be completed by 1970. Most of the mine output was to go to the Tarnobrzeg sulfur processing works where a new plant would double the present 200,000-ton-per-year capacity of the works.<sup>14</sup>

**United Kingdom.**—The first United Kingdom ocean terminal for the storage of liquid sulfur, nearing completion at Immingham, for Société Nationale des Pétrolés d'Aquitaine, was to be ready for shipments in May 1964.<sup>15</sup>

## ASIA

**India.**—Consideration was being given to mining pyrites from the extensive deposits at Amjore, Bihar. A process for the production of sulfur from Amjore pyrites was being developed from a method used in Finland. Finland and the Central Fuel Research Institute of India were working on another plan. India produced over 500,000 tons of sulfuric acid in 1963. The slowly expanding fertilizer industry consumed 60 percent of acid production.<sup>16</sup>

**Japan.**—The number of producing sulfur mines declined from 19 in 1961 to 16 in 1964. Production from the 16 mines appeared to be exceeding the 1963 rate. In the period 1961-63 the sulfur output per worker increased 35 percent. This improvement in output was especially important, because the price of Japanese sulfur was considerably above the world level. The reported value of crude sulfur imported into Japan in the first half of 1964 was \$48.54 per ton.<sup>17</sup>

**Taiwan.**—Sulfur imports of 40,000 tons in 1963 were expected to be increased to 59,100 tons in 1964.<sup>18</sup>

## AFRICA

**Algeria.**—Production of pyrites at Algeria's only iron pyrite mine, near Philippeville, continued to increase after a government manager and a technical director were appointed late in 1963 to operate the mine. The labor force increased from 298 at the end of 1962 to 442 at yearend 1964. Because of increased consumption, from 8,644 tons in 1962 to 23,257 tons in 1964, Algeria was unable to fulfill all of its export contracts.

**United Arab Republic (Egypt).**—Sulfur ores were reported to have been discovered in the Maragi and Khamsia Hills of the Magaaz area adjacent to the Siwa Oasis. Neighboring hills were being examined to determine the extent of the deposits.<sup>19</sup>

## TECHNOLOGY

New methods or innovations of old ones for the recovery of sulfur from waste gases were being developed. In one process sodium meta-

<sup>13</sup> East Europe Daily Press Report. Development of Sulfur Ore Mine Started. Jan. 20, 1964.

<sup>14</sup> Chemical Age (London). Poland to Sink New Sulphur Mine. V. 91, No. 2328, Feb. 22, 1964, p. 302.

<sup>15</sup> Chemical Age (London). Imatex to Operate Liquid Sulphur Terminal. V. 91, No. 2323, Jan. 18, 1964, p. 121.

<sup>16</sup> Bureau of Mines. Mineral Trade Notes. V. 60, No. 1, January 1965, pp. 47-48.

<sup>17</sup> Bureau of Mines. Mineral Trade Notes. V. 60, No. 2, February 1965, pp. 40-41.

<sup>18</sup> Bureau of Mines. Mineral Trade Notes. V. 60, No. 2, February 1965, p. 41.

<sup>19</sup> Bureau of Mines. Mineral Trade Notes. V. 59, No. 4, October 1964, p. 46.

TABLE 17.—Sulfur recovery plants in Western Canada, 1964

Company	Location	H <sub>2</sub> S content of feed (percent)	Annual capacity (long tons)
Amerada Petroleum Corp.	Olds, Alberta		50,000
British American Oil Co., Ltd.	Pincher Creek, Alberta	10	298,000
Do	Nevis, Alberta	6	27,000
Do	Homeglen-Rimbey, Alberta	4-8	94,000
Canadian Fina Oil Ltd.	Wildcat Hills, Alberta	4	46,000
Home Oil Co., Ltd.	Carstairs, Alberta	1	14,000
Imperial Oil Ltd.	Redwater, Alberta	3	5,000
Jefferson Lake Petrochemicals of Canada, Ltd.	Taylor Flats, British Columbia	3	115,000
Do	Coleman, Alberta	14	135,000
Petrogas Processing, Ltd.	Calgary, Alberta	16	305,000
Royalite Oil Co. Ltd.	Turner Valley, Alberta	4	11,000
Shell Canada, Ltd.	Innisfail, Alberta	14	41,000
Do	Waterton, Alberta	22	530,000
Do	Jumping Pound, Alberta	3	36,000
California Standard Oil Co. Ltd.	Nevis, Alberta	6	50,000
Steelman Gas, Ltd.	Steelman, Saskatchewan	1	2,000
Texas Gulf Sulphur Co.	Whitecourt, Alberta	15-20	435,000
Texas Gulf Sulphur Co. and others	Okotoks, Alberta	35	151,000
Total			2,345,000

TABLE 18.—Mexico: Exports of sulfur by countries

(Long tons)

Destination	1963	1964
<b>North America:</b>		
Canada	25,198	
El Salvador	3,445	
United States	821,477	907,800
<b>South America:</b>		
Brazil	12,135	12,136
Colombia		1,476
Venezuela	4,921	5,500
<b>Europe:</b>		
Belgium	32,730	61,842
France	56,536	175,716
Germany, West		12,969
Netherlands	127,365	133,111
Poland		26,798
United Kingdom	130,531	254,555
U.S.S.R.		18,585
<b>Asia:</b>		
Israel	11,505	17,609
Taiwan		10,344
Thailand	1,000	
<b>Africa:</b>		
Morocco		3,148
South Africa, Republic of	74,933	75,169
Tunisia		60,080
<b>Oceania:</b>		
Australia	88,543	47,577
New Zealand	44,116	22,591
Total	1,434,435	1,847,006

**Poland.**—An important new sulfur ore mine was started at Machow, Poland, in early January 1964. It was to be second in size only to the Polish mine in Piaseczno. The new deposits, much richer than those in Piaseczno, were near a chemical combine on the Vistula River. When the mine is completed in 1970 production is expected to be 6.5 million tons of sulfur ore per year and will replace output from deposits in Piaseczno which will have been exhausted by that time. The chemical combine in Machow, now supplying 200,000 tons per year of pure sulfur, was to be expanded to provide over 1 million tons per

Whitecourt plant at a cost of \$2 million. Production in Canada by Texas Gulf Sulphur Co. increased from 316,000 tons in 1963 to 327,000 tons in 1964. The SS *Marine Texan*, with a carrying capacity of 23,760 tons of sulfur, replaced the SS *Marine Sulphur Queen*, lost in 1963. The company's number of regional distribution terminals for liquid sulfur was increased to 12.<sup>4</sup>

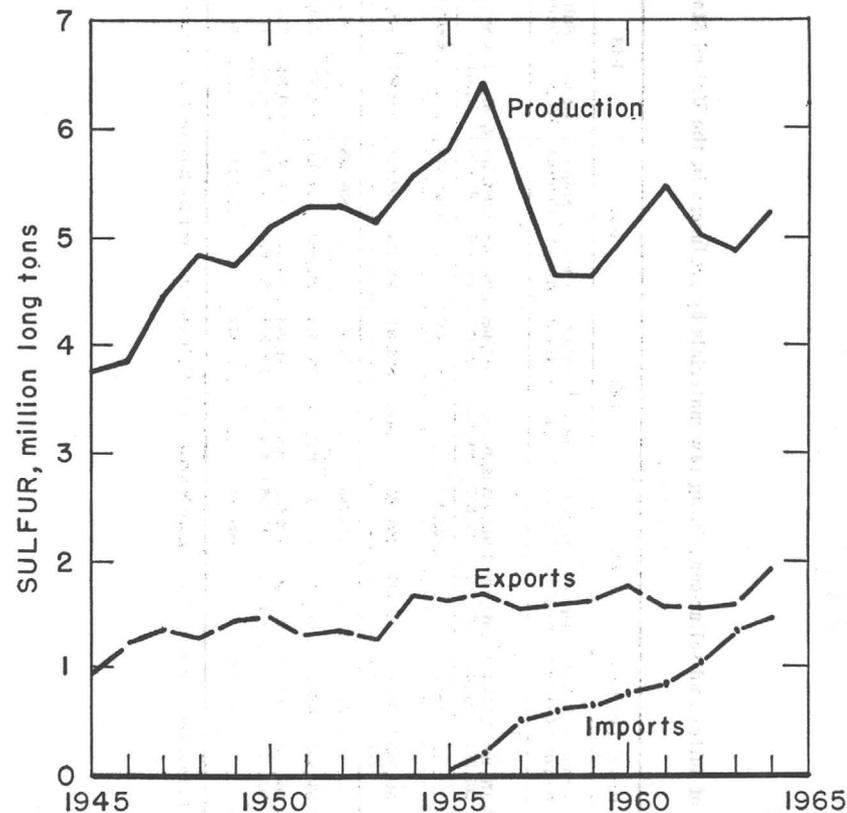


FIGURE 1.—Domestic production, imports, and exports of native sulfur.

**Recovered Sulfur.**—Production of recovered sulfur from sour natural and refinery gases exceeded 1 million tons, and was 8 percent greater than in 1963. In 1964, 72 sulfur recovery plants were operated by 46 companies in Arkansas, California, Delaware, Illinois, Indiana, Louisiana, Michigan, Minnesota, Mississippi, Montana, New Jersey, New Mexico, North Dakota, Ohio, Pennsylvania, Texas, Virginia, and Wyoming. The five leading producing States produced about three-fourths of the total. In descending order of production they were Texas, California, Delaware, Wyoming, and New Jersey.

<sup>4</sup>Texas Gulf Sulphur Co. Annual Report 1964, pp. 2, 5, 7.

TABLE 2.—Production of sulfur and sulfur-containing raw materials by producers in the United States

(Long tons)

	1955-59 (average)		1960		1961		1962		1963		1964	
	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.....	5,370,190	5,370,190	4,942,935	4,942,935	5,385,468	5,385,468	4,984,578	4,984,578	4,881,512	4,881,512	5,228,207	5,228,207
Other mines.....	205,354	59,427	379,067	94,357	400,015	92,025	162,186	40,840	1,371	415	794	158
Total.....		5,429,617		5,037,292		5,477,493		5,025,418		4,881,927		5,228,365
Recovered elemental sulfur:												
Brimstone.....	541,983	540,008	769,319	766,566	861,413	858,169	902,124	899,598	949,567	946,753	1,024,649	1,021,358
Paste.....	224	102										
Total.....		540,110		766,566		858,169		899,598		946,753		1,021,358
Pyrites (including coal brasses).....	1,034,995	423,554	1,016,263	416,213	987,309	398,519	915,890	379,046	824,800	343,566	847,493	353,831
Byproduct sulfuric acid (basis 100 percent) produced at Cu, Zn, and Pb plants.....	1,064,594	347,850	1,056,890	345,075	1,016,731	331,963	1,088,397	355,362	1,089,523	355,730	1,119,976	365,706
Other byproduct sulfur compounds <sup>1</sup> .....	104,400	90,406	114,359	95,395	126,923	106,335	115,670	97,787	136,509	115,826	143,689	123,474
Total.....		6,831,537		6,660,541		7,172,479		6,757,211		6,643,802		7,092,734

<sup>1</sup> Hydrogen sulfide and liquid sulfur dioxide. In addition, a quantity of acid sludge is converted to H<sub>2</sub>SO<sub>4</sub> but it is excluded from the above figures.

Asia:												
China.....	( <sup>e</sup> )	985	440	985	440	1,080	490	1,180	530	1,280	575	
Cyprus.....	1,006	914	439	824	396	809	388	905	440	662	323	
Japan.....	3,142	3,634	1,517	3,869	1,624	3,952	1,664	3,833	1,623	• 3,935	• 1,575	
Korea:												
North.....	( <sup>e</sup> )	245	98	295	118	345	138	395	157	415	167	
South.....	( <sup>e</sup> )	2	( <sup>e</sup> )	1	( <sup>e</sup> )			( <sup>e</sup> )	( <sup>e</sup> )	NA	NA	
Philippines.....	18	25	• 11	51	• 22	55	26	57	27	31	15	
Taiwan.....	31	42	16	47	20	45	20	46	17	46	17	
Turkey.....	51	42	20	97	46	105	51	96	44	111	51	
Africa:												
Algeria.....	20	38	17	48	22	42	19	37	17	60	28	
Morocco.....	8	13	5	14	5	20	7	23	7	21	6	
Rhodesia (formerly Southern).....	32	49	19	58	23	50	19	65	• 27	81	30	
South Africa, Republic of.....	432	492	212	440	176	434	• 175	412	• 165	426	• 175	
Oceania: Australia.....	215	239	115	213	102	149	65	194	87	• 246	• 110	
World total <sup>• 1 2</sup> .....	17,900	19,800	8,900	19,300	8,700	19,800	9,000	19,600	9,000	20,000	9,000	

<sup>e</sup> Estimate. <sup>p</sup> Preliminary. NA Not available.

<sup>1</sup> Brazil produces pyrites, but production data are not available; no estimate is included in the total.

<sup>2</sup> This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

<sup>3</sup> Average annual production 1956-59.

<sup>4</sup> 1963 data.

<sup>5</sup> Less than ½ unit.

<sup>6</sup> Data not available; estimate included in total.

<sup>7</sup> Tons of ore mined containing pyrites in thousand long tons: 1955-59 average 1,495; 1960, 1,810; 1961, 1,842; 1962, 1,860; 1963, 2,139; and 1964, NA.

<sup>8</sup> Years 1960-63 include pyrrhotite, cupreous pyrites, sulfur ore, and zinc concentrates. Pyrite data covering pyrites, cupreous pyrites, and pyrrhotite only are as follows (in thousand long tons): 1960, 2,656; 1961, 2,855; 1962, 2,977; 1963, 2,954; and 1964, 2,721—includes pyrites and pyrrhotite only.

TABLE 16.—World production of pyrites (including cupreous pyrites)<sup>1,2</sup>

Country <sup>1</sup>	(Thousand long tons)									
	1955-59 (average) gross weight	1960		1961		1962		1963		1964 <sup>2</sup>
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
North America:										
Canada (sales)	961	391	462	228	236	218	318	218	318	157
Cuba *	57	8	20	9	12	15	30	15	30	13
United States	1,035	416	987	369	379	344	847	344	847	364
South America: Venezuela										
Europe:										
Bulgaria	64	49	120	50	59	54	144	54	144	61
Czechoslovakia	352	148	365	141	155	133	342	133	355	140
Finland	277	108	270	114	219	158	408	158	589	233
France	353	117	281	118	289	109	247	109	248	107
Germany:										
East	147	46	115	40	41	43	125	43	125	43
West	566	210	524	221	404	173	398	173	423	190
Greece	197	74	185	86	142	65	148	66	138	62
Italy	1,416	694	1,555	716	1,560	711	1,577	711	1,575	619
Norway	803	89	722	319	320	314	700	315	698	314
Poland	185	83	219	76	82	85	213	85	213	86
Portugal	650	287	643	296	290	273	693	273	698	269
Rumania	193	105	239	103	120	131	328	131	328	131
Spain	2,173	1,053	2,097	1,001	2,000	997	1,895	941	2,303	1,095
Sweden	408	2,217	431	220	370	396	1,899	197	3,396	1,197
U.S.S.R. *	2,100	1,460	2,750	1,400	2,950	1,565	3,150	1,670	3,150	1,670
United Kingdom	3	(c)	368	(c)	27	11	26	10	26	10
Yugoslavia	279	164	407	143	163	140	350	140	421	168

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)
1955-59 (average)	3,225,067	2,145,123	5,370,190	5,283,336	\$133,495
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
1964	2,488,975	2,739,232	5,228,207	5,859,289	117,228

TABLE 4.—Sulfur ore (10 to 70 percent S) produced and shipped in the United States<sup>1</sup>

Year	Produced (long tons)	Shipped	
		Long tons	Value (thousands)
1955-59 (average)	205,354	172,621	\$1,544
1960	379,067	181,422	1,732
1961	400,015	177,549	1,694
1962	162,186	150,550	1,439
1963	1,371	1,371	18
1964	794	794	8

<sup>1</sup> California and Nevada.

New recovered sulfur plants reporting production in 1964 were Atlantic Refining Co. in Philadelphia County, Pa., and at Riverton Dome, Fremont County, Wyo.; Climax Chemical Co., Lea County, N. Mex.; Pan American Petroleum Corp., Edgewood plant in Van Zandt County, N. Mex.; and Warren Petroleum Corp. at the Sand Hills plant in Crane County, Tex. Reported data do not include a former producer, Texaco Inc., at the Silver Tip plant in Park County, Wyo.

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)
1955-59 (average)	541,983	540,008	513,185	511,255	\$13,663
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
1964	1,024,649	1,021,358	993,643	990,437	21,088

**Pyrites.**—As in recent previous years Tennessee was the leading producing State followed in order by Pennsylvania, Colorado, Arizona, and South Carolina. Pyrite consumption by producers was 795,000 tons having a sulfur content of 329,000 tons and valued at \$5,232,000. The grade of concentrates marketed was much higher than in 1963.

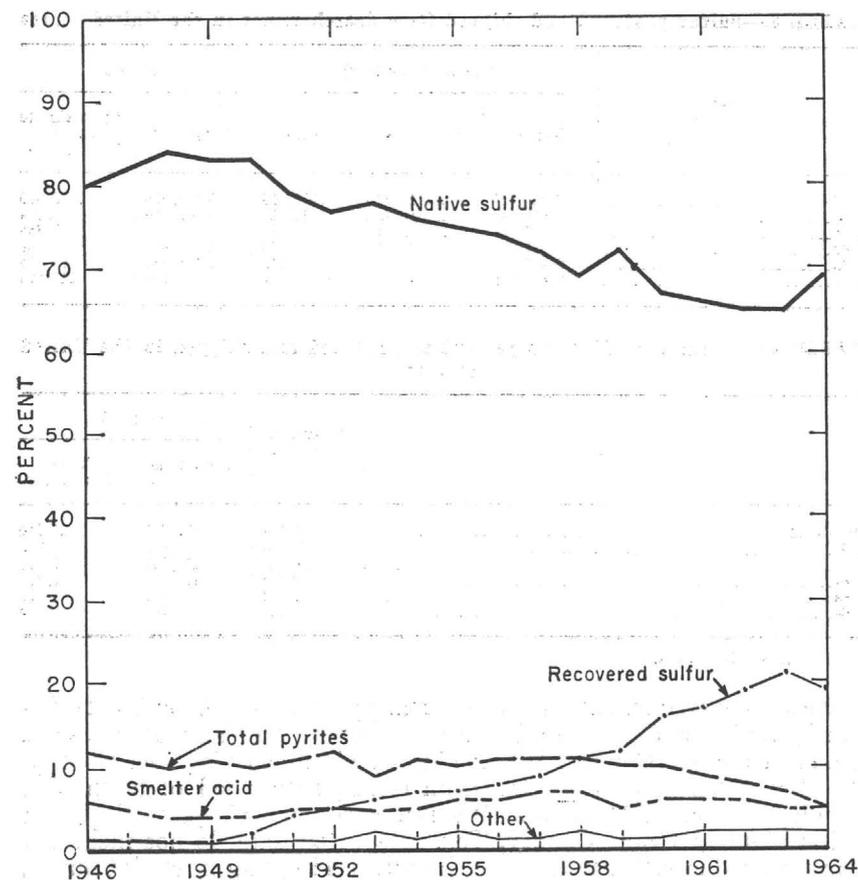


FIGURE 2.—Sulfur supply sources as a percent of total apparent consumption based on sulfur content.

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	
1955-59 (average)	1,034,995	423,554	\$8,671	140,678	67,393	\$982
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
1964	847,493	353,831	5,471	49,829	23,832	239

**France.**—England's first liquid sulfur terminal at Immingham received its initial shipment of 7,500 tons from France. The terminal was built for Société Nationale des Pétrolés d'Aquitaine (SNPA), the State-controlled company developing the sulfur and petrochemical resources of the southwestern France gas fields. The Lacq sulfur is transported in railroad tank cars to the port of Bayonne where it is stored in a 24,000-ton-capacity terminal for shipment by the sulfur tanker, *President Andre Blanchard*. The 11,000-ton-capacity tanker was expected to complete 40 trips per year to Immingham, England, Rotterdam, Netherlands, and Rouen, France. Storage capacity for French deliveries was 22,000 tons at Immingham and 20,000 tons at Rotterdam, and was expected to be 13,000 tons at Rouen when completed. Annual throughput of the three terminals could be 570,000 tons but deliveries were expected to be restricted to 350,000 to 420,000 tons by transportation facilities. Present customers for Immingham liquid sulfur were within 80 miles of the terminal. Transportation from the Rotterdam terminal was to be by barge.

**Greece.**—The discovery of a massive pyrite deposit of 500,000 tons of 45 to 48 percent sulfur in Cyprus was announced by Hephaestus Mining Co., Ltd. Geological investigations indicate that the ore body may be substantially larger. Preliminary company studies indicated that the ore could be mined and delivered to the nearest port for \$3.50 per ton. This compared favorably with a selling price of \$7.69 per ton f.o.b. Cyprus port for noncupreous coarse lump pyrite.<sup>10</sup>

According to a trade agreement, Greece will export 10,000 tons of pyrite to Poland before September 30, 1965.

**Ireland.**—Europe's third terminal for receiving and storing liquid sulfur was planned for Dublin. Plants manufacturing fertilizer would use the sulfur in making sulfuric acid. Two European firms, and Freeport Sulphur Co. and Texas Gulf Sulphur Co. of the United States were cooperating in the complex.<sup>11</sup>

**Italy.**—The European Economic Community (E.E.C.) recommended the development of an additional sulfur mine, the Lucia, in Sicily. The high-grade sulfur ore would be used at Porto Empedocle. The annual output of the Sicilian sulfur mines would be limited to 750,000 tons. The Italian sulfur industry had, for several years, faced increasing competition from Frasch sulfur from Mexico and the United States.

The Sulphur Export Corp. (Sulsexco), which handled overseas sales for U.S. Frasch producers, sold 13,000 tons to Ente Zolfi Italiani, an agency of the Italian Government. The Italian Government was modernizing the domestic sulfur industry so that it can compete in world markets.

**Norway.**—The production of sulfur as a byproduct in producing blister copper at Thambshavn, South Trøndelag County, was discontinued by Orkla Metal, A/S, Norway's only elemental sulfur producer.<sup>12</sup>

<sup>10</sup> Bureau of Mines. Mineral Trade Notes. V. 59, No. 4, October 1964, pp. 41-42.

<sup>11</sup> Chemical Trade Journal and Chemical Engineer (London). Liquid Sulphur Terminal for Dublin. V. 155, No. 4043, Dec. 4, 1964, p. 772.

<sup>12</sup> Bureau of Mines. Mineral Trade Notes. V. 60, No. 1, January 1965, p. 47.

TABLE 15.—World production of elemental sulfur by countries<sup>1,2</sup>

(Long tons)

Country	1960	1961	1962	1963	1964 <sup>p</sup>
<b>Native sulfur:</b>					
<b>Frasch:</b>					
Mexico.....	1,261,574	1,148,494	1,350,375	1,456,656	1,635,773
United States.....	4,942,935	5,385,468	4,984,578	4,881,512	5,228,207
Total.....	6,204,509	6,533,962	6,334,953	6,338,168	6,863,980
<b>From sulfur ores:</b>					
Argentina.....	39,265	22,183	22,303	22,142	18,995
Bolivia (exports).....	1,175	4,896	7,247	9,793	10,635
Canary Islands.....	4,000	5,000	6,000	6,900	*6,900
Chile.....	30,901	43,994	63,228	57,861	49,693
China <sup>a</sup> .....	120,000	120,000	120,000	120,000	120,000
Colombia.....	8,899	9,941	10,046	12,795	11,942
Italy.....	79,703	68,668	53,068	41,128	28,374
Japan <sup>b</sup> .....	243,684	238,456	220,438	219,095	237,414
Mexico.....	*17,700	25,116	26,751	28,968	25,989
Philippines.....	43	158	926	47	68
Poland.....	25,885	130,900	206,684	231,486	289,948
Spain.....	1,336				
Taiwan.....	5,725	5,732	7,462	7,144	6,389
Turkey.....	16,830	15,506	18,247	19,123	21,849
U.S.S.R. <sup>c</sup> .....	800,000	900,000	950,000	950,000	950,000
United Arab Republic (Egypt).....	3,543	8,858	*6,000	4,675	*4,675
United States.....	94,357	92,025	40,840	415	158
Total <sup>a,s</sup> .....	1,490,000	1,690,000	1,760,000	1,730,000	1,800,000
Total native sulfur.....	7,700,000	8,225,000	8,100,000	8,100,000	8,650,000
<b>Other elemental:</b>					
<b>Recovered:</b>					
Austria.....					6,000
Bulgaria <sup>e</sup> .....	5,310	4,949	5,502	6,291	*6,400
Canada (sales) <sup>7</sup> .....	244,963	352,465	620,622	1,115,968	1,438,552
China <sup>a,s</sup> .....	130,000	130,000	130,000	130,000	130,000
Finland.....				37,611	67,063
France <sup>9</sup> .....	778,157	1,080,013	1,325,538	1,386,285	1,487,141
Germany:					
East.....	110,232	115,153	118,100	118,100	*118,100
West.....	82,807	82,861	89,268	84,949	76,602
Iran <sup>a,s</sup> .....	20,000	20,000	15,000	20,000	105,000
Italy <sup>e</sup> .....	3,200	2,000	2,000	2,000	2,000
Japan <sup>b</sup> .....	8,326	8,163	8,549	11,429	18,448
Mexico <sup>9</sup> .....	33,487	51,086	46,545	43,308	36,296
Netherlands <sup>6</sup> .....	30,018	27,952	30,511	34,447	*34,447
Netherlands Antilles: Aruba and Curacao <sup>a</sup> .....	40,000	40,000	40,000	30,000	*30,000
Norway <sup>6</sup> .....	71,254	61,156	45,175		
Portugal <sup>6</sup> .....	10,915	8,813	6,677	2,953	*2,953
South Africa, Republic of <sup>8</sup> .....		2,163	1,913	1,981	5,701
Spain <sup>6</sup> .....	40,194	48,324	41,836	68,036	*68,036
Sweden <sup>10</sup> .....	39,368	30,511	29,920	25,885	*25,885
Taiwan <sup>8</sup> .....	876	1,968	2,130	2,310	2,780
Trinidad <sup>a,s</sup> .....	5,000	5,000	5,000	7,000	*7,000
U.S.S.R. <sup>c</sup> .....	210,000	275,000	370,000	400,000	400,000
United Arab Republic (Egypt).....	2,369	2,545	2,039	2,355	2,427
United Kingdom <sup>11</sup> .....	62,402	58,405	51,929	46,600	*46,600
United States.....	766,566	858,169	899,598	946,753	1,021,358
Total other elemental.....	2,700,000	3,270,000	3,890,000	4,525,000	5,140,000
World total <sup>a,s</sup> .....	10,400,000	11,500,000	12,000,000	12,600,000	13,800,000

<sup>p</sup> Estimate. <sup>p</sup> Preliminary.<sup>1</sup> This table incorporates some revisions.<sup>2</sup> Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.<sup>3</sup> Includes sulfur from mixed sulfur-sulfide ore.<sup>4</sup> 1963 data.<sup>5</sup> In some years Iran produces mine sulfur equivalent to 250-1,500 tons of sulfur. No estimates in total.<sup>6</sup> From sulfide ore.<sup>7</sup> Produced from natural gas, includes a small quantity derived from treatment of nickel-sulfide matte at Port Colborne, Ontario.<sup>8</sup> From refinery gases.<sup>9</sup> From natural gas.<sup>10</sup> From shale oil.<sup>11</sup> Including sulfur recovered from petroleum refineries.

**Byproduct Sulfur Compounds.**—Copper and zinc plants in the United States produced sulfuric acid from smelting sulfide ores. Either hydrogen sulfide or sulfur dioxide was recovered from 10 plants owned by 9 companies in California, Louisiana, New Jersey, Pennsylvania, and Tennessee. The hydrogen sulfide production was from oil refineries and the sulfur dioxide was from smelter gases.

TABLE 7.—Byproduct sulfuric acid<sup>1</sup> (basis, 100 percent) produced at copper, zinc, and lead plants in the United States

(Short tons)

Plants	1955-59 (average)	1960	1961	1962	1963	1964
Copper <sup>2</sup> .....	394,798	412,845	362,630	403,683	358,503	330,273
Zinc <sup>3</sup> .....	797,547	770,872	776,109	815,322	861,763	924,100
Total.....	1,192,345	1,183,717	1,138,739	1,219,005	1,220,266	1,254,373

<sup>1</sup> Includes acid from foreign materials.<sup>2</sup> Includes acid produced at a lead smelter. Excludes acid made from pyrite concentrates in Arizona, Montana, Tennessee, and Utah.<sup>3</sup> Excludes acid made from native sulfur.

## CONSUMPTION

U.S. consumption of sulfur in all forms attained a new record of 7.1 million long tons, 7 percent greater than in 1963. The increase in apparent consumption of native sulfur was 6 percent; recovered sulfur consumption increased 9 percent and pyrite consumption increased 9 percent.

Estimates of free world consumption of all forms of sulfur prepared late in 1964 by the two leading producing companies of the world were essentially in agreement at 21.7 and 21.775 million tons compared with 19.62 and 19.725 million tons by the same estimators for 1963. The greatest percentage increases were of recovered sulfur from western Canada and Frasch sulfur from Mexico. The 1964 reduction in free world sulfur stocks was about 1 million tons.<sup>5</sup>

## STOCKS

On December 31, producer stocks of Frasch sulfur totaled 4,301,000 tons, 8.6 percent less than at yearend 1963. Stocks comprised 3,454,000 tons at the mines and 847,000 tons elsewhere. Producer stocks of recovered sulfur were 102,000 tons, an accumulation of 13,000 tons during the year. Pyrite stock data were unavailable.

Since approximately 90 percent of the elemental sulfur shipped by producers was in the liquid state, storage capacity for this form of sulfur became increasingly more important. At the end of the year there were 28 producer-owned distribution terminals with 49 tanks having a combined capacity of 462,000 tons. There were also 2 producer-storage terminals near the mines with 18 tanks with a combined storage capacity of 165,000 tons. Consumers at 26 locations had 32 storage tanks with a capacity of approximately 165,000 tons.

<sup>5</sup> Gittinger, L. B., Jr. Sulphur—1964. Eng. and Min. J., v. 165, No. 2, February 1965, pp. 150-152.

Levitsky, Serge L. Sulfur. Min. Eng., v. 17, No. 2, February 1965, pp. 131-132.

**TABLE 8.—Production of new sulfuric acid<sup>1</sup> (100 percent H<sub>2</sub>SO<sub>4</sub>) by geographic divisions and States**

(Short tons)

Division and State	1960	1961	1962	1963	1964
New England <sup>2</sup> .....	192,664	179,341	184,142	183,956	192,629
Middle Atlantic:					
New York and New Jersey.....	1,681,302	1,652,868	1,684,590	1,749,165	1,826,309
Pennsylvania.....	754,703	770,272	797,207	877,120	941,270
Total.....	2,436,005	2,423,140	2,481,797	2,626,285	2,767,579
North Central:					
Illinois.....	1,355,647	1,399,349	1,464,064	1,562,320	1,696,501
Indiana.....	485,297	456,372	( <sup>3</sup> )	( <sup>3</sup> )	( <sup>3</sup> )
Michigan.....	324,318	307,979	331,901	355,824	347,386
Ohio.....	742,287	684,312	661,535	659,090	674,819
Other <sup>3</sup> .....	715,137	781,046	1,361,113	1,474,984	1,597,865
Total.....	3,622,686	3,629,058	3,818,613	4,052,218	4,316,571
South:					
Alabama.....	312,996	242,996	319,218	350,396	436,631
Delaware and Maryland.....	1,119,452	1,077,644	1,114,025	1,016,809	1,043,077
Florida.....	2,272,039	2,518,215	3,087,431	3,822,364	4,405,556
Georgia.....	337,140	345,775	384,010	420,765	442,942
Kentucky and Tennessee.....	997,379	1,024,717	( <sup>4</sup> )	( <sup>4</sup> )	( <sup>4</sup> )
Louisiana.....	595,232	598,534	675,159	699,985	763,214
North Carolina.....	131,221	133,115	140,591	144,864	156,176
South Carolina.....	142,652	149,493	143,250	154,281	168,423
Texas.....	1,593,303	1,585,307	1,885,553	1,925,948	2,273,982
Virginia.....	460,098	448,839	467,122	495,366	518,032
Other <sup>4</sup> .....	584,181	606,031	1,759,087	1,802,141	1,908,632
Total.....	8,545,693	8,730,666	9,975,446	10,832,919	12,116,665
West <sup>5</sup> .....	2,288,142	2,095,837	2,322,500	2,342,159	2,565,621
Total United States.....	17,085,190	17,058,042	18,782,498	20,037,537	21,959,065

<sup>1</sup> Includes data for Government-owned and privately operated plants.<sup>2</sup> Includes data for plants located in Maine, Massachusetts, and Rhode Island.<sup>3</sup> Includes data for plants located in Iowa (1961-64), Indiana, Kansas, Minnesota, Missouri, and Wisconsin. Data for Indiana for prior years were reported separately.<sup>4</sup> 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.<sup>5</sup> Includes data for plants located in Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Utah, Washington, and Wyoming.

Source: U.S. Department of Commerce.

**TABLE 9.—Apparent consumption of native sulfur in the United States**

(Long tons)

	1955-59 (average)	1960	1961	1962	1963	1964
Apparent sales to consumers <sup>1,2</sup>	5,311,406	5,129,300	4,854,809	4,873,021	5,050,923	5,599,018
Imports.....	395,886	607,235	648,910	745,772	863,385	890,604
Total.....	5,707,292	5,736,535	5,503,719	5,618,793	5,914,308	6,489,622
Exports:						
Crude.....	1,604,139	1,775,526	1,585,531	1,537,419	1,603,438	1,920,392
Refined.....	24,200	11,017	10,512	16,567	9,199	7,000
Total.....	1,628,339	1,786,543	1,596,043	1,553,986	1,612,637	1,927,392
Apparent consumption.....	4,078,953	3,949,992	3,907,676	4,064,807	4,301,671	4,562,230

<sup>1</sup> Revised.<sup>2</sup> Production adjusted for net change in stocks during year.<sup>3</sup> Includes native sulfur from mines that do not use Frasch process.**WORLD REVIEW****NORTH AMERICA**

**Canada.**—Cansulex Ltd., the Canadian sulfur marketing organization, announced a contract to supply Hungary with 100,000 tons of sulfur in 1965. Sales of 60,000 tons in France, Belgium, Netherlands, and West Germany were assured. Australia remained the largest overseas market for Canadian sulfur. It was anticipated that 1964 sales would be 100,000 tons greater than production, thus decreasing stocks by that amount.<sup>6</sup>

The Alberta Sulphur Research Ltd., a new sulfur research group, was formed by eight natural gas producers to increase the technical knowledge of sulfur and its compounds. The member companies include Shell Canada Ltd., Standard Oil of California, Canadian Fina Oil Ltd., Home Oil Co. Ltd., Hudson Bay Oil and Gas Co. Ltd., Imperial Oil Ltd., Pacific Petroleum Ltd., and Texas Gulf Sulphur Co. It is likely that cooperation will exist between this group and two other groups of similar interests, The Research Council of Alberta and the Sulphur Institute, Washington, D.C.<sup>7</sup>

The Independent Petroleum Association of Canada predicted that over the next 10 years western Canada's natural gas industry will require an average of at least three new processing plants per year. It was expected that there would be a need for 20 or more plants between 1966 and 1972 to process new gas reserves, and 8 or 10 plants to handle established reserves.<sup>8</sup> Sulfur production from sour natural gas is closely tied to gas production.

A sale of more than 300,000 long tons of Canadian sulfur to Australia by Cansulex Ltd., and East Asiatic Co. Ltd. of Canada was the largest Canadian sale of sulfur to be exported over a 3-year period.

New markets in 1964 included Brazil, Greece, Hong Kong, Hungary, Italy, Lebanon, Mozambique, the Netherlands, Poland, Tunisia, and Venezuela. Canadian producers have been interested in the U.S.S.R. and Japanese markets for some time. Japanese imports were to offset sulfur shortages but the long range Japanese objective was to remain self-sufficient in sulfur. The U.S.S.R. expects to triple fertilizer production and the increased sulfuric acid needed may require further imports. Poland, expected to emerge as a large producer from sulfur ores, may help supply these needs.

**EUROPE**

**Austria.**—Sulfur was being produced in Austria from crude oil from the Soviet Union at the 25,000-barrel-per-day Schwechat refinery near Vienna. About 500,000 tons of crude oil containing 1.8 to 2.0 percent sulfur was brought to Austria from the Soviet Union in 1963. Sufficient oil was not available in early 1964 to permit starting the sulfur recovery plant completed in October 1963.<sup>9</sup>

<sup>6</sup> European Chemical News (London). Hungary to Buy 100,000 Tons of Canadian Sulphur. V. 6, No. 152, Dec. 11, 1964, p. 6.<sup>7</sup> European Chemical News (London). V. 5, No. 124, May 29, 1964, p. 8.<sup>8</sup> Chemical Engineering. V. 71, No. 3, Feb. 3, 1964, p. 40.<sup>9</sup> Chemical Engineering. Austrians Recover Sulfur From Soviet Petroleum. V. 71, No. 22, Oct. 26, 1964, p. 80.

TABLE 14.—U.S. exports of sulfur by countries

Destination	Crude				Crushed, ground, refined, sublimed, and flowers			
	1963		1964		1963		1964	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
North America:								
Canada.....	141,710	\$3,811	136,207	\$3,790	2,090,309	\$191	2,060,973	\$230
Central America.....	6,757	159	18,408	374	669,419	32	853,584	39
Mexico.....	444	14	197	4	324,800	57	404,151	80
West Indies.....	16,798	360	1,000	19	19,500	1	5,590	(1)
Total.....	165,706	4,344	155,812	4,187	3,104,028	281	3,324,298	342
South America:								
Argentina.....	8,001	147	45,301	912	118,900	27	197,950	41
Bolivia.....					43,780	2		
Brazil.....	134,843	2,855	128,723	2,591	656,578	94	1,002,823	163
Chile.....	2,000	41	8,874	183	22,655	6	20,000	3
Colombia.....	1,476	32			1,956,371	63	152,106	23
Ecuador.....	40	1	76	3	101,210	8	90,900	9
Paraguay.....			159	5	66,623	1	224,100	3
Peru.....	13,370	270	15,726	319	268,015	24	228,525	29
Uruguay.....	4,716	93	10,176	203	2,700	(1)	10,000	2
Venezuela.....	5,293	150	162	5	744,703	33	763,964	65
Total.....	169,739	3,589	209,197	4,221	3,981,535	258	2,690,368	338
Europe:								
Austria.....	16,464	309	38,215	778				
Belgium-Luxembourg.....	49,500	986	46,000	932	3,100	1	60,050	12
Czechoslovakia.....	38,000	776	28,500	507				
France.....	53,719	1,079	52,710	1,059			148,635	13
Germany, West.....	72,200	1,460	106,910	2,192	64,850	6	40,500	4
Ireland.....	40,707	838						
Netherlands.....	116,495	2,270	456,562	9,203	8,718	(1)	34,878	1
Norway.....	1,800	35			42,200	1	80,000	2
Spain.....	5,612	117	5,406	110	39,900	9	98,900	20
Sweden.....	4,627	92			67,200	9	78,000	13
Switzerland.....	35,600	711	25,650	501				
United Kingdom.....	247,875	4,844	21,170	464				
Yugoslavia.....			7,000	128	22,050	3	22,050	3
Other.....	587	10	33,090	646	17,642	2	1,800	1
Total.....	683,186	13,527	821,213	16,580	265,660	31	564,813	68
Asia:								
Bahrain.....	130	5	40	1	120,385	12	89,910	1
India.....	247,755	5,340	296,400	5,832	5,047,680	157	2,954,539	130
Indonesia.....	600	14	3,000	79	424,469	14	159,400	7
Iraq.....	1,833	62	8,020	301	322,000	5	332,992	5
Israel.....	55,750	1,089	60,900	1,201	192,521	12	337,952	17
Japan.....					20,100	5	31,200	7
Jordan.....					1,544,164	35	1,125,367	25
Korea, South.....	4,407	102	9,142	201	1,031,109	30		
Lebanon.....			3,000	62	305,200	7	460,400	17
Malaysia.....			1,000	20	4,500	1	26,600	4
Pakistan.....	3,055	61			148,830	6	489,504	12
Philippines.....	627	14	109	3	877,915	32	1,308,025	64
Saudi Arabia.....	1,419	55	2,808	87	592,797	10	732,398	14
Turkey.....					205,975	15	380,175	25
Other.....	5,376	100	7,634	158	398,053	11	412,201	15
Total.....	320,952	6,842	392,053	7,945	11,235,698	352	8,840,723	343
Africa:								
South Africa, Republic of.....	3,632	86	11,169	426	1,258,500	58	1,013,481	97
Tunisia.....	29,250	554	9,600	203				
Other.....	5,428	103	8,478	172	83,800	3	164,220	7
Total.....	38,310	743	29,247	801	1,342,300	61	1,177,701	104
Oceania:								
Australia.....	129,562	2,545	165,244	3,127	378,538	48	409,116	58
New Zealand.....	95,983	1,941	147,626	2,790	298,077	26	240,152	34
Total.....	225,545	4,486	312,870	5,917	676,615	74	649,268	92
Grand total.....	1,603,438	33,531	1,920,392	39,651	20,605,836	1,057	17,247,171	1,287

<sup>1</sup> Less than ½ unit.

Source: Bureau of the Census.

TABLE 10.—Apparent consumption of sulfur in all forms in the United States<sup>1</sup>

	(Long tons)					
	1955-59 (average)	1960	1961	1962	1963	1964
Native sulfur.....	4,079,000	3,950,000	3,907,700	4,064,800	4,301,700	4,562,200
Recovered sulfur:						
Sales.....	517,000	775,200	831,000	907,300	929,400	987,600
Imports.....	(?)	134,100	182,600	294,700	487,800	571,200
Pyrites:						
Domestic production.....	423,560	416,200	398,500	379,000	343,600	353,800
Imports.....	162,900	146,000	134,900	144,600	93,000	120,000
Total pyrites.....	586,460	562,200	533,400	523,600	436,600	473,800
Smelter-acid production.....	347,860	345,100	332,000	355,400	335,700	365,700
Other productions <sup>2</sup> .....	90,380	95,400	106,300	97,800	115,800	123,500
Grand total.....	5,620,700	5,862,000	5,893,000	6,243,600	6,607,000	7,084,000

<sup>1</sup> Estimate. <sup>2</sup> Revised.

<sup>3</sup> Crude sulfur or sulfur content.

<sup>4</sup> Data included with imports on table 9. Not separately available before 1960.

<sup>5</sup> Hydrogen sulfide and liquid sulfur dioxide. In addition, a quantity of acid sludge is converted to H<sub>2</sub>SO<sub>4</sub>, but is excluded from the above figure.

TABLE 11.—Liquid sulfur regional storage and transshipment terminals in operation in 1964

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	9.8
Nitro, W. Va.....	2	18.0
Tampa, Fla.....	4	40.0
Tuscaloosa, Ala.....	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.....	2	22.0
Total.....	3	32.0
Pan American Sulphur Co.:		
Baltimore, Md.....	1	10.0
Newark, N.J.....	1	10.0
Tampa, Fla.....	4	40.0
Total.....	6	60.0
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
Nashville, Tenn.....	1	8.0
Newell, Pa.....	1	10.0
Norfolk, Va.....	2	20.8
Paulsboro, N.J.....	2	24.0
Savannah, Ga.....	1	11.0
Tampa, Fla.....	2	19.5
Wilmington, N.C.....	1	8.0
Total.....	19	189.1

## PRICES

For the first 6 months the published prices for Frasch sulfur were unchanged from 1963. Prices f.o.b. gulf ports were \$25 per long ton for bright sulfur and \$24 for dark sulfur. Mine prices were \$1.50 below port prices. In 1964 price increases on new business came first in the overseas markets. A domestic price increase of \$2 per ton became effective on new business on July 1, and as of January 1, 1965, on business under contract. Posted prices at yearend 1964 were \$27.50 per long ton f.o.b. gulf ports for bright sulfur to be exported, \$25.50 per long ton f.o.b. mines, and \$27 per long ton f.o.b. gulf ports for domestic markets. The published price for acid grade on dark sulfur at any point, or for any market, was \$1 less than that for bright sulfur. Prices for sulfur delivered from storage terminals in or near major consuming areas included transportation costs and terminal charges and tended to reflect competitive conditions within the distribution area.

## FOREIGN TRADE

Both imports and exports of sulfur for 1964 increased, with the increase in exports much greater than the increase in imports. Exports to the United Kingdom decreased sharply, due to the loss of the National Sulphuric Acid contract, but exports to the European continent increased sharply.

Information from Canadian and U.S. consumers indicate that 1964 imports of pyrites totaled about 250,000 tons. Official Census Bureau data reported a much lower figure which was being examined.

TABLE 12.—U.S. imports for consumption and exports of sulfur

Year	Imports		Exports			
	Long tons	Value (thousands)	Crude		Crushed, ground, refined, sublimed and flowers	
			Long tons	Value (thousands)	Long tons	Value (thousands)
1955-59 (average).....	395,886	\$9,176	1,604,139	\$44,087	24,200	\$1,929
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.....	1,040,473	20,310	1,537,419	35,498	16,567	1,799
1963.....	1,351,216	23,942	1,603,438	33,531	9,199	1,057
1964.....	1,462,211	26,100	1,920,392	39,651	7,700	1,287

Source: Bureau of the Census.

TABLE 13.—U.S. imports for consumption of sulfur by countries

Country	1963		1964	
	Long tons	Value (thousands)	Long tons	Value (thousands)
North America:				
Canada.....	480,355	\$6,650	568,372	\$7,779
Mexico.....	863,385	17,101	890,604	18,249
Total.....	1,343,740	23,751	1,458,976	26,028
South America: British Guiana.....			284	4
Europe:				
France.....	7,431	184	2,863	63
Germany, West.....	45	7	25	4
United Kingdom.....			( <sup>1</sup> )	( <sup>1</sup> )
Total.....	7,476	191	2,888	67
Asia: India.....			63	1
Grand total.....	1,351,216	23,942	1,462,211	26,100

<sup>1</sup> Less than 1/2 unit.

Source: Bureau of the Census.





# **BERYLLIUM: *The Space Age Metal***

sists primarily of bertrandite ores located at Spor Mountain, Utah, and beryl ores located in the coarse-