Sodium and Sodium Compounds

By William H. Kerns 1

Natural sources of sodium carbonate (soda ash) supplied a greater portion of the total national requirements of this basic manufactured and natural chemical than ever before. The Green River area of Wyoming was the center of the increased activity in expanding plants for processing and in new property development or acquisition. Major plant enlargements were completed and plans were announced for additional plant capacity expansions, and several major chemical companies conducted work on their holdings or acquired property in the Green River area. Primarily because of the increased natural soda ash output, total production (manufactured and natural soda ash) advanced to a record high.

Total output of sodium sulfate (salt cake) increased substantially to a new high. Of this total, more than half was recovered as a byproduct of chemical processes, and the remainder was produced from naturally occurring brines and semidry lake beds in California, Texas, and Wyoming.

DOMESTIC PRODUCTION

Total production of sodium carbonate, including manufactured and natural soda ash, was 6.4 million tons in 1965, 3.2 percent above the previous record of 1964.

Synthetic or manufactured soda ash, produced at 11 eastern and midwestern plants, supplied 77 percent of the total quantity of soda ash sold or used by producers. These plants, two each in Louisiana, Michigan, Ohio, and Texas, and one each in New Jersey, New York, and Virginia, were strategically situated both in regard to mineral raw materials supplies of salt and limestone and to chemical markets. Their estimated annual production capability of manufactured soda ash was 5.85 million tons.

Natural soda ash, produced by five plants from natural lake brines at three operations in California, and underground bedded trona (sodium sesquicarbonate) deposits at two operations in Wyoming, supplied the remaining 23 percent of the total sodium carbonate output. Production of natural soda ash again was the source of a greater portion of the total market and supplied a major part of the annual increase in total soda ash requirements, as it has each year during the last decade.

In California, American Potash & Chemical Corp. and Stauffer Chemical Co. recovered sodium carbonate and other minerals from natural brines of Searles Lake at the Trona and Westend plants, respectively. Pittsburgh Plate Glass Co. produced sodium carbonate from Owens Lake brine at its plant near Bartlett.

In Wyoming, FMC Corp., which in 1947 was the pioneer in mining and processing trona from the extensive underground deposits near Green River, was again the largest U.S. producer of natural soda ash. Soon after a program for increasing plant capacity by 85,000 tons to 835,000 tons of soda ash per year was completed, company officials announced in May that the company would begin immediately an expansion project on the Westvaco plant to enlarge its capacity to 900,000 tons per year. The latest plant expansion was to be completed by early 1966. Then, in December another announcement was made

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1 Commodity specialist, Division of Minerals.
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)

<table>
<thead>
<tr>
<th>Year</th>
<th>Manufactured soda ash (ammonia-soda process)</th>
<th>Natural sodium carbonates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quantity</td>
<td>Quantity</td>
</tr>
<tr>
<td>1956-60 (average)</td>
<td>4,689</td>
<td>696</td>
</tr>
<tr>
<td>1961</td>
<td>4,856</td>
<td>806</td>
</tr>
<tr>
<td>1962</td>
<td>4,607</td>
<td>978</td>
</tr>
<tr>
<td>1963</td>
<td>4,832</td>
<td>1,119</td>
</tr>
<tr>
<td>1964</td>
<td>r 4,945</td>
<td>1,275</td>
</tr>
<tr>
<td>1965</td>
<td>p 4,981</td>
<td>1,494</td>
</tr>
</tbody>
</table>

p Preliminary.
r Revised.
1 Includes quantities used to manufacture caustic soda, sodium bicarbonate, and finished light and dense soda ash.
2 Soda ash and trona (sesquicarbonate).

Table 2.—Sodium sulfate produced and sold or used by producers in the United States (Thousand short tons and thousand dollars)

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (manufactured and natural)</th>
<th>Sold or used by producers (natural only)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Salt cake (crude)</td>
<td>Glauber salt (100 percent Na₂SO₄·10H₂O)</td>
</tr>
<tr>
<td>1956-60 (average)</td>
<td>717</td>
<td>110</td>
</tr>
<tr>
<td>1961</td>
<td>780</td>
<td>64</td>
</tr>
<tr>
<td>1962</td>
<td>826 (r)</td>
<td>368</td>
</tr>
<tr>
<td>1963</td>
<td>887 (f)</td>
<td>386</td>
</tr>
<tr>
<td>1964</td>
<td>r 1,002 (f)</td>
<td>r 389</td>
</tr>
<tr>
<td>1965</td>
<td>p 1,003 (f)</td>
<td>p 389</td>
</tr>
</tbody>
</table>

p Preliminary.
r Revised.
1 Includes glauber salt converted to 100 percent Na₂SO₄.
2 Included with salt cake (crude).

that the company would further expand the Westvaco production facilities to a capacity of 1.25 million tons per year. Scheduled for completion by the fourth quarter of 1966, the added capacity will make the plant the largest single soda ash producing facility in the world, and the company will become the second largest producer of soda ash in the United States.

Stauffer Chemical Co., which in 1962 opened the second mine and processing plant in the Green River area and in 1964 doubled its plant capacity to 400,000 tons of refined soda ash per year, announced plans in December 1963 to again double the production capacity at this operation, Big Island mine and plant, to 800,000 tons per year. Completion of the latest expansion program was scheduled for the fall of 1967.

Allied Chemical Corp., a major U.S. producer of synthetic soda ash and the third company to enter the natural soda ash-producing field of mining and refining trona from underground beds in the Green River area, completed its shaft to below 1,500 feet, started developing its trona deposit for mining, and began constructing a pilot plant scheduled for completion in the spring of 1966. Allied proposed a plant with a capacity of 300,000 tons per year of refined soda ash.

Other chemical companies, that were interested in trona production, acquired trona mining rights on lands, or conducted core drilling in the Green River area, included Texas Gulf Sulphur Co., Phillips Petroleum Co., Duval Corp., Diamond Alkali Co., American Potash & Chemical Corp., and Olin Mathieson Chemical Corp.

Total production of sodium sulfate (manufactured and natural salt cake) increased 6 percent to 1.4 million tons. More than half (55 percent compared with 56 percent in 1964) of this total salt cake output was recovered as byproducts of
chemical processes that produced rayon, cellophane, hydrochloric acid, sodium bichromate, boric acid, phenols, and miscellaneous chemicals at 37 plants in 17 States. The remainder (45 percent compared with 44 percent in 1964) of the total salt cake output was produced from natural sources at four operations each in California and Texas and one in Wyoming.

In California, American Potash & Chemical Corp. and Stauffer Chemical Co. recovered sodium sulfate from Searles Lake brines at Trona and Westend, respectively, and United States Borax & Chemical Corp. and Stauffer Chemical Co. recovered sodium sulfate as coproducts at plants in Wilmington and San Francisco, respectively.

In Texas, Ozark-Mahoning Mining Co. recovered salt cake from subterranean brines at its Brownfield and Monahans operations throughout 1965 and at its Sea-graves operation for the last 5 months of the year. In September, American Cyanamid Co. completed and placed in operation a unit to recover sodium sulfate from waste water from its Fort Worth plant that manufactures catalysts for the petroleum and chemical industries. The unit not only provided for the recovery of a valuable byproduct but upgraded the quality of the water discharge to the Trinity River. In Wyoming, William E. Pratt recovered a small quantity of sodium sulfate from semidry lake beds near Casper.

Sodium metal production increased 8 percent from 139,313 tons (revised) in 1964 to 149,946 tons in 1965. Three companies produced sodium and its coproduct, chlorine by electrolysis of molten salt at five plants: E. I. du Pont de Nemours & Co., Inc., with plants at Niagara Falls, N.Y., and Memphis, Tenn.; Ethyl Corp., with plants at Baton Rouge, La., and Houston, Tex.; and National Distillers & Chemical Corp. at Ashtabula, Ohio.

CONSUMPTION AND USES

Consumption and use of sodium carbonate, sodium sulfate, and sodium metal followed closely the patterns of the past 5 years. About 44 percent of the total output of sodium carbonate was used in producing glass, 26 percent in chemicals, 9 percent in pulp and paper, 5 percent in soap detergents, 4 percent in alumina and for water treatment, and 8 percent for miscellaneous purposes. Despite sizable inroads of plastics and other materials into the container markets, an increased production of nonreturnable glass beverage bottles maintained the quantity of sodium carbonate used in glassmaking. Use of caustic soda rather than soda ash in glassmaking was reported to have several advantages: (1) An immediate fluxing reaction due to intimate wetting of individual silica grains, (2) a lower melting temperature, and (3) lower fuel costs for same tank flow.2 Substitution of caustic soda for soda ash in any large quantities for this use would have a major effect on the total soda ash demand because the use of soda ash in glassmaking is one of the principal uses of this commodity.

An estimated 70 percent of the sodium sulfate output was consumed in manufacturing kraft paper. Kraft paper production growth was sufficient to offset the decline in salt cake consumption per ton of paper produced, which resulted from increased efficiencies and the recovery and reuse of sodium sulfate in the process. Sodium sulfate also was used in manufacturing glass, ceramic glaziers, detergents, stockfeeds, dyes, textiles, medicines, and miscellaneous chemicals.

Metallic sodium was used chiefly in producing tetraethyl lead (TEL) and tetramethyl lead (TML), two compounds added in small quantities to motor fuels to increase their antiknock characteristics. TEL was reported to have 85 to 90 percent of the antiknock market and TML to have the remaining 10 to 15 percent. Use rate of these antiknock compounds, now up to an average 2.3 grams per gallon in premium-grade gasoline, gained steadily as refiners increased their sales of more top-line fuels. Premiums made up 35 percent of the gasoline market of 4.5 million barrels per day, compared with 31 percent 2 years ago.3 Other primary uses of metallic sodium include metal descaling, ore reduction, and manufacture of such sodium compounds as the peroxide, hydride, amide, cyanide, borohydride, and

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3 Chemical Week. $300-Million Market on Wheels. V. 96, No. 15, Apr. 10, 1965, pp. 71–72, 74, 76.
other chemicals. Sodium is also used to cool nuclear reactors, atomic piles, and the valves in some internal combustion engines.

PRICES

Prices quoted for sodium carbonate, sodium sulfate, and metallic sodium by Oil, Paint and Drug Reporter in 1965 were unchanged from those quoted at the close of 1958. Dense soda ash (58 percent Na₂O) in carlots and at the works sold for $1.60 per 100 pounds in bulk and $1.90 in paper bags. On the same basis light soda ash was quoted at $1.55 and $1.85 respectively.

Domestic salt cake (100 percent Na₂SO₄) in bulk and at the works sold for $28 per ton. Sodium sulfate of technical de-
tergent and rayon grade sold for $34 per ton in bulk at the works and for $38 per ton in bags and in carlots. Technical anhydrous sodium sulfate was priced at $56 per ton in bags and carlots.

Sodium metal in bulk, in tank cars, at works, was quoted at $0.17 per pound. Fused metallic sodium in lots of 18,000 pounds or more at the works was $0.195 per pound and in 5- or 12-pound bricks on the same basis was quoted at $0.21 per pound.

FOREIGN TRADE

Exports of sodium carbonate represented 4 percent of the U.S. total output of manufactured and natural sodium carbonate and were practically the same as in 1964. Of the total exports 39 percent went to Canada, 36 percent to Mexico, 7 percent to the Republic of Korea, 6 percent to Venezuela, 3 percent each to Argentina and New Zealand, 2 percent to South Viet-Nam, 1 percent to Colombia, and the remaining 3 percent to 47 other countries.

Imports of sodium carbonate were negligible.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sodium carbonate</th>
<th>Sodium sulfate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quantity</td>
<td>Value</td>
</tr>
<tr>
<td>1966-60 (average)</td>
<td>166</td>
<td>$5,313</td>
</tr>
<tr>
<td>1961</td>
<td>132</td>
<td>4,045</td>
</tr>
<tr>
<td>1962</td>
<td>132</td>
<td>4,698</td>
</tr>
<tr>
<td>1963</td>
<td>184</td>
<td>5,722</td>
</tr>
<tr>
<td>1964</td>
<td>276</td>
<td>5,555</td>
</tr>
<tr>
<td>1965</td>
<td>277</td>
<td>9,030</td>
</tr>
</tbody>
</table>

* Revised.

<table>
<thead>
<tr>
<th>Year</th>
<th>Crude (salt cake)</th>
<th>Anhydrous</th>
<th>Total¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quantity</td>
<td>Value</td>
<td>Quantity</td>
</tr>
<tr>
<td>1966-60 (average)</td>
<td>119</td>
<td>$2,259</td>
<td>3</td>
</tr>
<tr>
<td>1961</td>
<td>193</td>
<td>4,089</td>
<td>3</td>
</tr>
<tr>
<td>1962</td>
<td>181</td>
<td>3,646</td>
<td>7</td>
</tr>
<tr>
<td>1963</td>
<td>189</td>
<td>3,084</td>
<td>1</td>
</tr>
<tr>
<td>1964</td>
<td>288</td>
<td>5,035</td>
<td>2</td>
</tr>
<tr>
<td>1965</td>
<td>261</td>
<td>4,521</td>
<td>12</td>
</tr>
</tbody>
</table>

¹ Includes glauber salt, as follows: 1968, 12 tons ($839); 1969, 227 tons ($4,339); 1960, 7 tons ($479); 1961-62 none; 1963, 3 tons ($555); 1964, 4 tons ($555); 1965, 1 ton ($262).

Sodium sulfate exports declined drastically so that they were less than a third of those in 1964 and accounted for less than 1 percent of the sodium sulfate produced (manufactured and natural) and sold and used in the United States during 1965. Exports to Canada dropped from over 20,000 tons in 1964 to nearly 12,000.
tons in 1965 primarily because sodium sulfate production in Canada increased. Exports to Mexico dropped from over 21,000 tons in 1964 to about 100 tons in 1965. Exports to Canada accounted for 93 percent of total exports in 1965; Mexico, Venezuela, Philippines, and New Zealand each 1 percent, and 24 other countries the remaining 3 percent.

Imports of sodium sulfate declined 6 percent, compared to those of 1964, but represented one-fifth of the U.S. total output of manufactured and natural sodium sulfate. Nearly half of the imports came from Belgium-Luxembourg; 43 percent, from Canada; 7 percent, from West Germany; 1 percent, from the United Kingdom; and less than 0.5 percent each from Mexico and The Netherlands.

Tariff rates of sodium carbonate and sodium sulfate were the same as those reported in 1964.

WORLD REVIEW

Brazil.—Cia. Agro-Industrial Igarassu, the only caustic soda producer in northeastern Brazil, announced that it will expand its plant and diversify production to include caustic soda in flake as well as in liquid form, sodium hypochlorite, and hydrochloric acid.4

Canada.—An increased demand for sodium sulfate, used extensively in producing kraft paper and glass, which are exported in large quantities to the United States, resulted in the announcement of major expansions in the sodium sulfate industry in Saskatchewan, Canada. Construction was to begin soon on a $1.5 million sodium sulfate plant at Ingebright Lake, Saskatchewan. This plant was planned for an initial output of 150,000 tons per year and was to be operated by the Sodium Sulfate Division of the Province’s crown-owned company, Saskatchewan Minerals. A second company, Sodium Sulfate Saskatchewan Ltd., announced that it would construct a $300,000 sodium plant near Alsask, Saskatchewan, about 160 miles west of Saskatoon. Saskatchewan is the only Canadian Province with reserves of naturally occurring sodium sulfate. These reserves are estimated at 200 million tons. The sodium sulfate is harvested from lake deposits.5

Chile.—Anglo-Lautaro Nitrate Corp. began trial production of sodium sulfate as a byproduct of its nitrate-producing operations. Plans called for an output of 50,000 tons annually for the local paper industry.6

India.—An announcement was made by the Indian Minister for Industries that new soda ash plants of at least 11,000-ton-per-year capacity were to be built in Madras, Maharashtra, and Orissa.7

Japan.—Asahi Glass Co., Ltd. bought the rights to use a new process developed by Britain’s Imperial Chemical Industries Ltd., and Belgium’s Solvay et Cie for producing chlorine without caustic soda as a coproduct. The company announced that next year it would build a 3,500-ton-per-month plant, using this process, at its Chiba Works near Tokyo. The process involves decomposition of ammonium chloride with a ferric oxide catalyst and can be run to produce chlorine from the chloride, hydrogen chloride from the chlor- ride, or chlorine from the hydrogen chloride. Economics favor this process over electrolytic processes only when salt and power are relatively costly, and chlorine and caustic are not in balance.8

Malaysia.—Fourteen months after the site at Padang Jawa was cleared of rubber trees, the Imperial Chemical Industries Ltd., Mond Division completed construction of a chlorine plant for the Chemical Company of Malaysia Ltd. Initially the plant will produce liquid chlorine, and nearly all of its output will be used for water purification and for producing hydrochloric acid and sodium hypochlorite.9

Pakistan.—Toyo Engineering Co. and Gosho Ltd., of Japan, signed an agreement with Hirjina Salt & Chemicals (Pak.) Ltd., to supply machinery and equipment for a $15.75 million soda ash plant at

Karachi. This plant, scheduled for completion in 1967, will have an annual capacity of about 67,200 tons each of soda ash and ammonium chloride.10

South-West Africa—South West Africa Co. Ltd., began producing trona from salt pans at Otjivalunda, northwest of Etosha Pan and began shipping it to the Johannesburg area. South-West Africa’s supply of this material, used in glassmaking and papermaking, had been obtained from Kenya until late 1963 and subsequently from the United Kingdom.

U.S.S.R.—Demand for sodium sulfate in the Soviet Union increased with the growth in the kraft pulp, glass, and detergent industries. This material has been supplied from natural sodium sulfate deposits in the Aral and Caspian depressions, in the Kalunda steppe in Kazakhstan, in the Caucasus Mountains region, and throughout Soviet Central Asia. In addition, sodium sulfate has been supplied as a byproduct at manmade fiber plants at Ryazan and Kalinin. Surplus production from both natural and byproduct sources were exported to Finland, Hungary, Bulgaria, Yugoslavia, Sweden, Japan, and the United Kingdom.11

United Arab Republic (Egypt).—Rumania and the United Arab Republic entered into a technical and economic agreement whereby the Industrial-Export Company of Bucharest will supply the design, equipment, materials, and technical assistance for the erection of a soda ash plant at Elmes, Alexandria. The plant will use the traditional Solvay process with supplementary causticization to produce 32,500 tons per year of soda ash, 45,000 tons per year of caustic soda, and 5,000 tons per year of pharmaceutical quality sodium bicarbonate.12

TECHNOLOGY

The distribution of stress adjacent to each of 25 mine openings in the FMC Corp. Westvaco trona mine at Westvaco, Wyo., was determined by the borehole stress-relief method by the Brueau of Mines, and a report of the findings was published.13 The purpose of the stress determinations was twofold: First, to study the effect on these distributions of various factors such as opening shape, stress level, and loading history; and second, to estimate the distribution of stresses adjacent to extensive high-extraction areas.

Laboratory studies, sponsored by the Bureau of Reclamation and the Missouri River Basin Field Committee and conducted by the Bureau of Mines, indicated that an inexpensive technique significantly reduced seepage in irrigation canals.14 Laboratory tests simulating optimum field conditions determined that easily applied sodium carbonate solutions made test beds of canal-lining materials virtually impermeable for long periods.

Claims were made that a salable commodity, sodium sulfate suitable for kraft pulpmills, can be recovered from spent liquor at sulfite mills.15 Sodium-based sulfite pulpers, who have long sought an economical chemical-recovery process to use in existing mills, may choose among three fluid-bed systems to oxidize their black liquor. Because sodium sulfate can not be recycled to a sulfite mill, complete oxidation to sulfate is only partial relief for sulfite pulpers. Developers of the three systems were reported to be working on modifications that would produce sodium sulfite instead of sodium sulfate. However, even at the present stage, the process is attractive because the sulfate recovered can be sold at a profit, and it is a method by which sulfite chemical and semichemical pulpmills can meet antipollution pressures.

According to a General Electric Co. spokesman, a new light source that ranks in importance with the fluorescent lamp was developed by company employees.16 The lamp has a ceramic arc tube that con-

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tains sodium vapor at higher pressure and temperatures than previous sodium lamps. The new unit has the high efficiency of the sodium lamp, but produces light of an acceptable golden color instead of the monochromatic yellow of the old lamp.

Patent applications were filed in the United States and overseas by Union Carbide Corp. for producing an electrical cable using a sodium metal core encased in polyethylene insulation. The company and three power utility companies conducted field trials on the cable. To produce and use the cable, Union Carbide filled polyethylene tubes with sodium metal at its pilot plant at Bound Brook, N.J., Simplex Wire & Cable Co. finished the filled tubes into various sizes and types of electrical cable, and Burndy Corp. furnished special terminals and splices for installing the cable. Production of the cable went entirely into field tests, and none was available to the commercial market.

Sodium metal was used in this radically new type of electrical cable because of three desirable physical properties, low specific gravity, high ductility, and good electrical conductivity. One pound of sodium metal costing approximately 17 cents was reported to conduct as much electrical current as 3.5 pounds of copper costing $1.26 or 1.75 pounds of aluminum costing 43 cents. Sodium cables were reported to weigh 50 percent less than conventional cables but were 45 percent larger in diameter than a conventional insulated copper conductor of equal current carrying capacity. Because sodium metal is flexible, it can be used in solid form as the cable core and does not have to be stranded as with other metals to achieve flexibility.

Sodium metal also has two objectionable physical properties; it is highly reactive, particularly with oxygen and water; and it is toxic to the skin. Use of sodium in the cable therefore posed safety problems that required more study in the field applications.

Scientists from Argonne National Laboratory, while discussing ways of converting heat directly into electricity, described the operation of the first engineering cell of the sodium-bismuth type.17 This cell operates with molten sodium as the anode, molten bismuth as the cathode, and molten sodium salts as the electrolyte. In the power-generating step, sodium metal reacts with bismuth metal, generating power as it forms an intermetallic compound that dissolves in the liquid bismuth cathode.

Construction was started late in 1965 on the Southwest Experimental Fast Oxide Reactor. The 20-thermal-megawatt sodium-cooled reactor at Cove Creek, about 20 miles southwest of Fayetteville, Ark., was scheduled for completion in 1968. This international research and development program on the fast breeder reactor system using plutonium oxide-uranium oxide fuel and sodium coolant was sponsored by the U.S. Atomic Energy Commission, Atomic Energy Associates of Little Rock, Ark., Gesellschaft für Kernforschung of the Federal Republic of Germany, and the European Atomic Energy Community.

17 Chemical Engineering. Distillation, Power, and Fibers Are Highlights of Detroit ACS Meeting. V. 72, No. 9, Apr. 26, 1965, pp. 61, 63.